Department of Scientific and Industrial Research

REPORT FOR THE YEAR 1953-54

Presented by the Lord President of the Council to Parliament
by Command of Her Majesty
February 1955

LONDON
HER MAJESTY'S STATIONERY OFFICE
NINE SHILLINGS NET
Cmd. 9386

CONTENTS

REPORT OF THE COMMITTEE OF THE PRIVY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT OF THE ADVISORY COUNCIL

SUMMARY OF WORK

(*a*) RESEARCH ESTABLISHMENTS OF THE DEPARTMENT

(*b*) RESEARCH ASSOCIATIONS

(and other Co-operative Research Organizations)

(c) OTHER GRANT-AIDED ORGANIZATIONS

APPENDICES

REPORT OF THE COMMITTEE OF THE PRIVY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH FOR THE YEAR 1953-54

TO THE QUEEN'S MOST EXCELLENT MAJESTY

MAY IT PLEASE YOUR MAJESTY

WE, the Lords of the Committee of Your Majesty's Privy Council for Scientific and Industrial Research, humbly submit to Your Majesty the Thirty-Ninth Report of our proceedings, covering the period from 1st October, 1953, to 30th September, 1954. We subjoin the Thirty-Ninth Report of our Advisory Council, to which is appended a general review of the work carried out by the Department and the Research Associations.

THE ADVISORY COUNCIL

We appointed Mr. W. L. Heywood, O.B.E., to be a member of the Advisory Council from 1st October, 1953.

Sir Ian Heilbron, D.S.O., D.Sc., LL.D., F.R.I.C., F.R.S., who had been Chairman of the Advisory Council since November, 1949, retired on 30th September 1954. We record our great appreciation of his valuable services to the Council and to the Department during his period of Chairmanship and also during the previous four years when he served as a member. We have appointed Sir Hugh Beaver, M.I.C.E., M.I.Chem.E., to succeed him as Chairman.

Sir Wallace Akers, C.B.E., D.Sc., D.C.L., F.R.I.C., retired from membership on 30th September, 1954, on account of ill-health, and we record, with deep regret, his death on 1st November, 1954.

Professor R. S. Edwards, Lord Halsbury, F.R.I.C., F.Inst.P., Sir Henry Hinchliffe, D.L., J.P., and Mr. A. H. Wilson, F.R.S., retired on 30th September, 1954, on completion of their period of appointment. We record our appreciation of the valuable services rendered by these five members.

RESEARCH BOARDS AND ESTABLISHMENTS

We learned with great pleasure that Your Majesty had been graciously pleased to confer the honour of Knighthood on Mr. H. J. Manzoni, C.B.E., M.I.C.E., a member of the Building Research Board, and on Mr. W. G. Radley, C.B.E., Ph.D., M.I.E.E., a member of the Radio Research Board.

Their Majesties the King and Queen of Sweden, honoured the Department by visiting the National Physical Laboratory on 29th June, 1954, and inspecting some of the work in progress.

Mr. W. K. Wallace, C.B.E., M.I.C.E., M.I.Struct.E., retired from the Chairmanship of the Building Research Board on 31st March, 1954, and we appointed Sir Herbert Manzoni as his successor.

Professor Sir Frank Engledow, C.M.G., F.R.S., retired from the Chairmanship of the Food Investigation Board on 31st March, 1954, and we appointed Dr. R. Holroyd as his successor.

It was with much regret that we received from Sir Arthur Trueman, K.B.E., D.Sc., F.G.S., in December, 1953, his resignation, on account of ill-health, from the Chairmanship of the Geological Survey Board, which office he had held since December, 1943. We appointed Sir Walter Drummond, M.I.C.E., M.I.Mech.E., to succeed him.

Sir Frank Smith, G.C.B., G.B.E., D.Sc., LL.D., F.R.S., retired from the Chairmanship of the Road Research Board on 31st March, 1954, and we appointed Mr. E. John Powell, M.I.C.E., M.I.Mun.E., as his successor.

We wish to record our appreciation of the valuable assistance given by Mr. Wallace, Sir Frank Engledow, Sir Arthur Trueman and Sir Frank Smith during the time they served as Chairmen of these Boards.

Changes in the membership of the Research Boards are shown in Appendix I.

INTERNATIONAL CONGRESSES AND FOREIGN VISITS

During the year a considerable number of the staff of the Department made visits to various countries overseas to take part in international conferences, to obtain first-hand information on recent scientific and technical advances in those countries, and to maintain the close touch, which is so desirable, with research workers in other parts of the world.

RESEARCH ASSOCIATIONS

We learned with great pleasure that Your Majesty had been graciously pleased to confer the honour of Knighthood on Mr. Frederick Scopes, President of the British Cast Iron Research Association and member of Council of the British Coke Research Association.

On 19th November, 1953, the research establishment of the British Iron and Steel Research Association at Sheffield was honoured by the presence of His Royal Highness the Duke of Edinburgh, K.G., who performed the opening ceremony of the new laboratories. These laboratories, which form the fourth research centre belonging to this Research Association, will be devoted to steel-making, mechanical working and metallurgy.

On 14th October, 1953, the Shirley Institute of the British Cotton Industry Research Association was graced by the presence of Their Royal Highnesses the Duchess of Kent and the Princess Alexandra, who visited the research laboratories during their tour of Lancaster.

On 21st May, 1954, The Rt. Hon. A. T. Lennox-Boyd, M.P., Minister of Transport, formally opened the Laboratory and Proving Ground of the Motor Industry Research Association at Nuneaton.

One new Research Association, the Chalk Lime and Allied Industries Research Association has been formed since we last reported and another which was already in existence, the British Steel Castings Research Association, applied for and has accepted grant-aid within the Government scheme.

New or revised terms of grant have been accepted by ten Research Associations, research organizations, and other bodies. No special grants for capital purposes have been offered. Further particulars will be found in the Report of the Advisory Council (pp. 20–21) and in the Summary of Work (p. 107).

TECHNICAL ASSISTANCE FROM THE UNITED STATES OF AMERICA

Since September, 1949, the Establishments of the Department and the Research Associations have shared in the generous assistance which the Government of the United States of America have made available for the acquisition from that country of scientific and technical equipment and publications. This particular form of assistance is now coming to an end, and it is estimated that, when outstanding deliveries are completed, its total value to the Department and the Research Associations will have amounted

to about $1 400 000. We desire to express our sincere appreciation for this help and for the further assistance which is currently being given for investigations of problems involved in increasing industrial productivity.

PATENTS

During the year 31 British and, in certain cases, corresponding Colonial and foreign patent applications have been filed and 10 British patents have been allowed to lapse.

Eleven British patent applications were abandoned and 5 foreign patents and patent applications were allowed to lapse or were abandoned.

EXPANSION OF THE DEPARTMENT

We referred in our last Report to the schemes which we had been able, with the concurrence of the Lords Commissioners of Your Majesty's Treasury and with the co-operation of the Minister of Works, to formulate for the steady growth, over the five years 1954–59, of the resources available to the Department for staff and other purposes and to the Ministry of Works for the erection of new buildings for the Department. The first stage of this expansion has been reflected in the Estimates for the Department for 1954–55, which, as approved, provide for a net expenditure of £6 267 210; an increase of £578 379 over the provision for 1953–54.

STAFF

The total number of staff of all grades, industrial as well as non-industrial, employed in the Department on the 1st October, 1954, was 4220 (including 164 part-time), an increase of 147 compared with the previous year. In addition, 36 members of the permanent staff were serving in Your Majesty's Forces, and 2 were on loan to other Departments.

EXPENDITURE

The net expenditure of the Department during the year ended 31st March, 1954, was £5 254 342 as compared with £5 207 455 in the previous year. Details may be found in Appendix II.

B. LOCKSPEISER,
Secretary.

SALISBURY,
Lord President of the Council.

7th February, 1955.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH,
Charles House,
5-11, Regent Street,
London, S.W.1.

ADVISORY COUNCIL

(1953-54)

PROFESSOR SIR IAN HEILBRON, D.S.O., D.Sc., LL.D., F.R.I.C., F.R.S. (*Chairman*)

SIR WALLACE AKERS, C.B.E., D.Sc., D.C.L., F.R.I.C., F.R.S.

SIR HUGH BEAVER, M.I.C.E., M.I.Chem.E.

J. CRAWFORD, Esq., J.P.

PROFESSOR R. S. EDWARDS, B.Com.

PROFESSOR T. R. C. FOX, M.I.Mech.E., M.I.Chem.E.

THE RT. HON. THE EARL OF HALSBURY, F.R.I.C., F.Inst.P.

W. L. HEYWOOD, Esq., O.B.E.

SIR HENRY HINCHLIFFE, D.L., J.P.

SIR PHILIP JOHNSON

PROFESSOR SIR ERIC RIDEAL, M.B.E., D.Sc., F.R.I.C., F.R.S.

SIR GEORGE THOMSON, D.Sc., LL.D., F.R.S.

A. H. WILSON, Esq., F.R.S.

SIR BEN LOCKSPEISER, K.C.B., F.R.S. (*Secretary*)

REPORT OF THE ADVISORY COUNCIL FOR THE YEAR 1953-54

MAY IT PLEASE YOUR LORDSHIPS

WE, your Advisory Council, beg leave to present our Thirty-ninth Annual Report.

In our last Report we recorded our satisfaction at the acceptance by your Lordships and the Chancellor of the Exchequer of a plan for a steady increase in the resources of the Department over the five years beginning 1st April, 1954. We referred briefly to the scope of the plan, but we should like again to record its nature, in the words of a statement made to the House of Commons on 8th December, 1953, by the Parliamentary Secretary to the Ministry of Works, on behalf of the Lord President:

> "This agreement provides for the gradual expansion of the Department's activities over the next five years, subject, of course, to necessary reservations, in particular to this House voting the necessary funds.
>
> "Plans for the development of the work of the Department of Scientific and Industrial Research and for the expansion of its resources were described in the Annual Report of the Department for 1947-48 (Cmd. 7761). For a variety of reasons the expansion which has so far taken place is less than was then envisaged.
>
> "The recent understanding provides for a programme for the next five years on the basis of which the total resources of the Department should by 1959 be adequate to cover some 95 per cent of the activities projected in the plans covered by its 1947-48 Report, together with some additional responsibilities which it has since taken over from other Departments. Its principal provisions are for an increase of staff over five years of 1000 (bringing the total in 1959 to about 5100); for an increase of about £900 000 or about 20 per cent in the annual net Vote of the Department over that period (exclusive of provisions now made or to be made for certain services which are not a permanent part of the Department's activities or which may be added thereto as additional liabilities); and for a building programme (the cost of which will be borne on the Vote of the Ministry of Works) of about £6 million.
>
> "The financial provisions are, of course, subject to the necessary funds being voted annually by Parliament and must be subject, also, to review in the event of a marked change in the economic situation or of major changes in costs. Moreover, since the incidence of expenditure on many projects cannot be forecast with precision as between one financial year and another, regard will be had to the finance of the arrangement as a whole. Ways and means will be sought for making good in later years of the plan any deficiencies in expenditure in its earlier years which may have resulted from unforeseeable delays in the fulfilment of planned development. The new arrangement does not involve any change in Parliamentary practice and the Estimates of the Department of Scientific and Industrial Research will accordingly be presented to Parliament in the usual way."

We are now happily able to report the first results of the new plan as formally expressed in the Estimates of the Department and of the Ministry

of Works approved by Parliament for the financial year 1954-55.* These Estimates made provision for an increase in net expenditure by the Department from £5 688 831 in 1953-54 to £6 267 210. They provided £91 500 more for annual and capital grants to Research Associations expected to fall due for payment during the year; and £373 933 more for the maintenance and extension of the work of the Department's own Research Establishments, including the cost of increasing the numbers of staff from 3822 to 4022, an increase of 200 of whom about 50 would be industrial staff.

As we noted in our last Report (p. 26), the plan provided for the net annual resources of the Department to rise to "rather more than £6m." by the end of the five years, i.e. by 1959. That it is already £6¼m. in this, the first year, is due to the operation of two special and most valuable provisions of the plan, viz., that account can be taken of major changes in costs and of new services which the Department is called upon to undertake. Increases in rates of salaries and wages awarded in 1953 have accordingly been reflected in the provision for staff; and substantially increased provision (£360 000) has been made for H. M. Government's contribution to the European Organization for Nuclear Research, which was not covered by the plan and for which only relatively small initial provision (£43 000) had been necessary in the previous year.

The Ministry of Works' Estimate for building and other services for the Department rose from £1 342 975 to £1 497 500. This increase of £154 525 was almost wholly in the provision (£831 100) for major building works, of which the principal items are for the Mechanical Engineering Research Laboratory (£254 600), the Hydraulics Research Station (£159 800), the Water Pollution Research Laboratory (£115 000), the National Physical Laboratory (£111 700) and the Radio Research Station (£92 500).

Our most important task during the year under review has been to study the needs of the various branches of the Department's work in the light of the conditions of today, and to advise where the increased effort provided for in the plan is most urgently needed—in particular, how should the increases of about 150 non-industrial staff per annum, with about one-third that number of industrial staff, be distributed as they become available? The need for the total increase of 1000 over five years and its objects were established by the post-war plans of which a lengthy account was given in our predecessors' Report for 1947-48; but in the years which have since elapsed new needs have arisen and new circumstances have come to bear. It therefore became necessary to consider afresh the many problems confronting the Establishments and the Department as a whole, in order to take the fullest advantage of the increased resources and their assured continuity.

A quick decision on staff allocations was necessary, as an interim measure, for the current financial year. In January 1954, on the basis of our general acquaintance with the work of the Establishments through consideration of their annual reports and our periodic visits to them, and with the help of a preliminary survey by the Department of current objectives and distribution of effort, we advised on the distribution of the additional 150 non-industrial staff to be available by 1st April, 1955, and your Lordships approved our proposals. The broad effect was to distribute rather more than two-thirds of the total between the Mechanical Engineering Research Laboratory, the Road Research Laboratory, the Water Pollution Research Laboratory, the Hydraulics Research Station and the Fuel Research Station, as being for various reasons most urgently

* *Civil Estimates*, 1954–55, Class IX, pp. 64–81, H.M. Stationery Office, 1954.

in need of increased resources. Such a decision necessarily meant that only relatively trifling additions of staff, or none at all, could be authorized at that stage for the remaining Establishments, and we shall say something about the particular case of Building Research later in this Report.

At the end of the session to which this Report relates, we had not concluded our consideration of the larger and more exacting problem of the distribution of the extra staff to become available during the remaining four years of the plan. We had before us, however, at the last meeting of the session, in July, a more detailed analysis by the Department of the Establishments' current programmes and objectives and the distribution of effort between them. With the help of this document to reinforce our own knowledge and experience of the Establishments, we are confident of being able to submit proposals to your Lordships before the end of the calendar year.

Six of our nine meetings during the year were devoted mainly to the affairs of the fourteen Establishments. We considered their Annual Reports, and in the cases of the National Physical Laboratory, the Road Research Laboratory and the Food Investigation Organization we discussed them with the Directors of Research, and, except in the case of Food Investigation, with the Chairmen of the Research Boards. In addition, we paid corporate visits to the Building Research Station, the Mechanical Engineering Research Laboratory and the Fuel Research Station, where in each case we had the pleasure, and the great advantage, of meeting the Chairmen or members of the Research Boards, and the Directors of Research, and of discussing their problems with them, as well as of inspecting some of the work in progress. We also had a long and most encouraging discussion of the First Report of the new Joint Committee on Human Relations in Industry (set up by the Medical Research Council and the Department) with the Chairman of the Committee, Mr. A. B. Waring.

Our work in relation to other phases of the Department's activities has continued normally, and in particular our Industrial Grants Committee and Scientific Grants Committee have had heavy agenda, to which we shall refer later, in relation to grants to Research Associations and to universities and individuals respectively. Nevertheless, our main work has been on questions of policy in relation to the Establishments, and we think it opportune to refer to some general considerations affecting them, as well as to make observations upon some of them individually.

There are now fourteen separate Directorates of Research in the Department, with, in addition, work on human factors in industry and other problems of productivity which are developing under the Intelligence Division of the Headquarters Office. There are also 42 co-operative Research Associations or similar bodies in receipt of grants from the Department. It is our task to endeavour to maintain a proper balance in advising your Lordships what support should be given to each of these, and what assistance for more basic research in university institutions and the training of scientific research workers. In such a complex task we cannot hope to attain any semblance of perfection; least of all can we expect the balance to appear even to those with special interests who are not required to take so wide a view as ourselves. In the case of Research Associations our difficulties are great, but they are somewhat eased by the very basis that the Department's help must be related to the readiness of the industry concerned to support its Association. With many industries there are also yardsticks, such as capital or numbers of staff employed or turnover, as well as the breadth of scientific endeavour needed, which

help to decide upon the magnitude of the effort which the industry should make and what share in it the Government should take. But for the most part the considerations affecting the Department's Establishments are less readily assessable, and it is a hard task indeed to find any quantitative basis on which to decide that the Department ought to throw more weight in one direction rather than in another; for example, into Pest Infestation Research rather than into Water Pollution Research, or vice versa. If there were no limit to what we might reasonably advise, our difficulties would be less, for we should have no hesitation in saying, at present, that there is no Establishment in the Department to which considerably greater resources could not, with profit, be assigned. But the shortage of scientists sets its own limit, and we are too conscious of the vital needs of industry, universities and schools to claim more than a fair share of scientific manpower for the work which it is the Department's direct concern to foster. It is against this sort of background that we have accepted the five-year plan—not regarding it as an arbitrary "dole" of resources to be applied to the Department's work, but as an acceptable current assessment of the share of Government expenditure and of the country's scientific manpower to be devoted to this purpose. We turn now to some observations on particular Establishments, while noting that details of their work and of that of the Research Associations will be found in the Summary of Work.

D.S.I.R. RESEARCH ESTABLISHMENTS

BUILDING RESEARCH STATION

The scope of the Building Research Station's work is wide, including studies of building materials, foundations and structures, services such as heating, lighting and ventilation, site operations and the economics of building and allied branches of civil engineering. The accumulated value of the work which the Station has undertaken since its establishment in 1921 has been well exemplified in the contributions it has made to the series of Government publications issued under the title of "National Building Studies". Through these and in other ways, notably in its contribution to the formulation of Codes of Practice, the Station has undoubtedly been instrumental in introducing marked improvements into building practice, often pointing the way simultaneously to better quality and to economy in effort and materials. Examples in recent years have been its work on the development of materials, on school buildings, on methods of handling materials and organizing work on the site, and on plumbing practice. We believe there is widespread, and still growing, appreciation of the Station's work among Government departments, some of which rely heavily on the Station's services in determining their policy, and among professional men and all branches of the building industry. The large number of enquiries which the Station continues to receive certainly suggests that it is widely known as being able and willing to help in the solution of the industry's problems.

The staff of the Building Research Station increased steadily up to 1939, but in the early years of the war it was reduced somewhat to provide manpower for other work. Long before the end of the war, however, it was apparent that building, especially the building of houses, would be a major problem immediately the war was over. Consequently, the first major expansion in the Department to meet post-war needs was made for building research. Moreover, in the immediate post-war period the Ministry of Works developed a Chief Scientific Adviser's Division, which was concerned with the study of the economic, sociological and productivity aspects of the building industries. This Division was transferred to the Department in

1950 and the proportion of the Department's resources devoted to building research then became very large. Subsequently it was somewhat reduced during a period of assimilation, and, in 1952, by economy decisions. The non-industrial staff of the Station—more than 400—is still about 14 per cent of the total for all the Department's Establishments. We have no doubt that there is justification for extending research on building, but looking at the problem as one of many within the Department's scope, we cannot but recognize that there must be a limit to the proportion of the resources available for the Department's Establishments which can be devoted to this activity. We hope there will be some further expansion, but we do not expect that the staff can, or should, continue to increase, at government expense, proportionately to the total increase in the Department as a whole. We feel it incumbent upon us therefore to suggest that any further substantial increase in the resources for building research, within the Department or elsewhere, must be sought outside the Department. In saying this we do not overlook the fact that many of the larger firms in the industry undertake research, and that there are several Research Associations which are concerned with materials used in building and of which many manufacturers of building materials are members; nevertheless, the building industry as a whole does not appear to make so large a contribution to research for its benefit as do most industries, and as it might do.

We discussed some aspects of this question with members of the Building Research Board and the Director of Building Research when we visited the Station in April last. We were glad to feel assured then that technical collaboration between the Station and the building industries is generally good, and we were especially pleased to learn of an arrangement by which the National Federation of Building Trade Employers had recently agreed to provide means for the full-scale trial of the results of certain studies at the Station—a most useful form of collaboration. A minor but attractive way in which it might be possible to add to the Station's resources was the suggestion that larger firms, or collective bodies, in the industry might create research studentships or fellowships tenable at the Station, or send to the Station, for research apprenticeships as it were, young men whom they proposed to take on their own staffs. This would confer benefits all round. An occasional arrangement of this kind has already been made.

TECHANICAL ENGINEERING RESEARCH LABORATORY

We referred in our last Report (p. 16) to the slow progress in the building of the new Mechanical Engineering Research Laboratory at East Kilbride. We were all the more glad, therefore, when we visited the Laboratory in May, 1954, to find that substantial progress had been made. The fourth major building, the hydraulic machinery laboratory, was approaching completion, and new laboratories for the Heat Division and for the Mechanisms and Metrology Divisions were likely to be started soon. In fact, although much remained to be done to complete the building programme, the Laboratory already had the appearance of an active and well-established, though incomplete, organization. It was started with a good, though small, nucleus of staff from the National Physical Laboratory, and we learned that the recruitment at East Kilbride of mainly ancillary staff had not presented any great difficulty. At the time of our visit the non-industrial staff had reached 190. It must continue to grow over the next few years as new buildings become available, and the recruitment of an additional 40 non-industrial staff in the current financial year has, on our recommendation, been authorized. While we should be glad to see growth of this order continue for so long as is necessary, we shall have to weigh the needs against those of the other branches of the Department's work. We think it important that there should be no relaxation of the care hitherto taken to ensure that, in aiming at targets for recruitment, standards of quality should not be sacrificed.

We were impressed by the importance of the work in hand, and with the way in which it is being done. The Laboratory shows every promise of making those valuable contributions to scientific and technical knowledge for which it was set up, and which are so necessary for the continued efficiency of the engineering and allied industries and their ability to keep pace with, indeed to move in advance of, the rapidly extending needs of the times. Altogether, we are satisfied that a sound and lively research establishment is being created.

FUEL RESEARCH STATION

When work began at the Fuel Research Station in 1919, very little organized research on fuel was in progress in this country. The initial main objectives were the production of oil from coal, especially for the Navy, coupled with the production of smokeless solid fuel for domestic use, and the establishment of the physical and chemical survey of the national coal resources. From these beginnings the Fuel Research Station had to face innumerable problems arising over practically the whole of the wide field of fuel treatment and utilization. Since then the Station has done, and is doing, much valuable work on combustion, carbonization, gasification, methods of producing oil from coal, domestic heating, atmospheric pollution, coal constitution and methods of analysis.

In the 35 years since the Station was established, its position and its outlook have been altered by the formation of industrial research associations such as the British Coal Utilisation Research Association, the British Coke Research Association, the Coal Tar Research Association and the Gas Research Board (now taken over by the Gas Council), and by the increased interest in fuel research shown by other industrial organizations. Moreover, the new nationalized industries, viz. the National Coal Board, the Gas Council and the British Electricity Authority, have each established, under statutory obligation, their own departments to undertake research in their own fields. The National Coal Board took over from the Department in 1947 responsibility for the physical and chemical survey of the national coal resources.

A further development since the War is the responsibility vested in the Ministry of Fuel and Power "for the co-ordinated development of all sources of fuel and power and for promoting their economical and efficient use. In those scientific matters which affect policy, the Minister is advised by a Chief Scientist, and by a Scientific Advisory Council. . . . The nationalized fuel industries are responsible for research in their own fields, their programmes being arranged in consultation with the Minister. This procedure helps to co-ordinate their own scientific work with that undertaken by Government establishments and by industrial research associations."*

As a result of all these developments, the Fuel Research Board have had to keep the programme of the Fuel Research Station under constant review, having regard to the desirability of handing over to the new industrial research organizations, as soon as practicable, such sections of the work as are appropriate to their responsibilities, while maintaining the ability of the Station to advise on all fuel problems of national interest. We realize that the shedding of such programmes is bound to be gradual because time must be given to the new organizations to acquire the necessary accommodation, equipment, staff and experience.

Consideration of the problems of fuel research has been made more urgent by the fact that the present premises at Greenwich are old and unsatisfactory, and that the effects of age, accentuated by bomb-damage, have

* *Government Scientific Organization in the Civilian Field*, page 30, H.M. Stationery Office, July 1951.

recently shown themselves in serious problems of maintenance of buildings and services, to meet which considerable expenditure must be incurred. Since the Department's post-war plans included the transfer of the Station to a new site (though hitherto this move has not been given high priority) it is naturally desired to keep expenditure on maintenance of the existing Station to a minimum.

In spite of the establishment of the new organizations, the demands on the Fuel Research Station are still heavy and difficult to meet satisfactorily, and in the light of these facts we were not surprised to learn from Sir Cyril Hinshelwood, Chairman of the Fuel Research Board, that he and his colleagues on the Board were acutely conscious of two major needs, viz., more staff and the rapid provision of a new research station. We are therefore giving careful attention to the special problems of this Station.

We have already recommended that the Station should be given an immediate increase in staff in order to accelerate work on atmospheric pollution and domestic heating. We have no doubts of the urgent need of a new Station, but it must be planned on the basis of a clearly defined policy. In our view the presence of various research organizations in the fuel field in no way reduces the necessity for the Station to maintain its position as "a national centre for the study of fuel problems."

ROAD RESEARCH LABORATORY

In our discussion of the Report of the Road Research Board for 1953 we were fortunate enough to have the help of Sir Frank Smith, who retired from the chairmanship of the Board on 31st March, 1954, after having given outstanding service in that capacity over a long period. We were impressed by the account which he and Dr. Glanville, the Director of Road Research, gave us of the Laboratory's work. It was particularly gratifying to receive evidence that the work on safety is helping to reduce accidents and save lives, grave though the problem of such accidents remains. We were glad to learn also of the Laboratory's further contributions to economy in the construction and surfacing of roads both at home and in the colonies. Sir Frank Smith convinced us that much more money could be spent to advantage on Road Research if it could be provided.

In our last Report (p. 17) we referred to the recommendation in the Fifth Report from the Select Committee on Estimates, 1952-53, that immediate consideration be given to the expansion of the Laboratory's work, and we stated that we would respond to the best of our ability to this recommendation, whilst keeping in mind the claims of other branches of the Department on available resources. As we have already stated, the Road Research Laboratory has in fact been given priority, with some other Establishments, in the distribution of the increased resources available to the Department this year under the five-year plan.

Since the present Road Research Laboratory has become inadequate and its work there is, moreover, increasingly affected by the proximity to London Airport, provision is being made for a new station, on a much larger site, at Crowthorne, Berks. The site includes space for a much-needed experimental road circuit, and this is being provided as a first step in advance of the general building of the new station.

NATIONAL PHYSICAL LABORATORY

Last year we reviewed at some length the work of the National Physical Laboratory, the largest of the Department's Establishments. In considering the Report of the National Physical Laboratory for 1953 we were able

to discuss recent trends in its work with Sir Ben Lockspeiser, Chairman of the Executive Committee (who is also our Secretary), and with Sir Edward Bullard, the Director.

We were interested to learn that the Executive Committee had approved the formation of a new Division for Electronics and Control Mechanisms, with a small group to study the possibilities of increasing the mechanization of large-scale office work. Whilst most large offices have introduced mechanical methods to some extent, the number of clerks employed in offices is still rising. The systematic study of the application to clerical work of the immensely powerful new electronic methods of computation will undoubtedly lead to the development of systems which could be used with great advantage in large, and it may be to some extent in smaller, offices and perhaps make a major contribution to economy in use of man-power and so to increased productivity.

A few years ago, some of the routine testing done by the Laboratory—for example of thermometers, volumetric glassware and engineering gauges—was centralized and housed in a separate Test House, instead of being undertaken by small individual sections in the various Divisions of the Laboratory. We are glad to learn that this has been most successful. While test work which is closely akin to research must no doubt be retained in the Divisions, experience has shown that further transfers of work to the Test House can now justifiably be made.

The two symposia held in 1953 at the Laboratory, dealing respectively with "Automatic Digital Computation" and "Engineering Dimensional Metrology", were most successful and we are glad to know that it is intended to hold two such symposia annually. We have repeatedly urged the need for the Department's Establishments to use every possible means of disseminating knowledge of their work, and we are sure that these symposia will prove a most useful further means to this end, as well as of fostering the interchange of ideas between the N.P.L. staff and outside scientists and technologists.

FOOD INVESTIGATION ORGANIZATION

In their Report for 1953 the Food Investigation Board made a special review of the objectives and programme of the Food Investigation Organization, and the arrangements for co-operation with allied organizations. We had the advantage of discussing the Report with Dr. Kidd, the Director of Food Investigation. A formidable number of organizations—industrial, scientific, professional and government—is concerned with the various aspects of food production, manufacture, storage, preservation and marketing, and we were glad to be able to satisfy ourselves that the arrangements for liaison are on the whole satisfactory and that efforts are constantly being made to improve them. A result of these efforts is the establishment this year, as an experiment, of a standing consultative committee on food research which includes as members the Director of Food Investigation, the Superintendents of the Low Temperature Research Station, Ditton Laboratory and Torry Research Station, the Director of the Pest Infestation Laboratory and officers of the Department's Headquarters, together with the Directors of the Baking, Flour-Millers, Food and Canning Research Associations. The Committee meets quarterly in turn at the laboratories of the members for discussion of common problems and of work in progress.

We are glad too to note the close co-operation which has been established with the White Fish Authority and the Herring Industry Board. One form which this co-operation takes is mentioned below; another is by their maintaining at the Torry Research Station a group of staff working on problems

of common interest, in the most intimate association with the Department's own staff.

We were somewhat concerned at the large number of items on the Food Investigation Board's programme, but Dr. Kidd assured us that he and the Board are fully conscious of the danger of attempting to do more than is fully practicable within available resources, and that they are continually alert to reduce the number of projects, a task that is far from easy in view of the demands made upon the Organization.

Among the researches in progress we took special note of three: first, that on the freezing and storage of beef, and particularly the trials with carcase beef which are being carried out in Australia, in co-operation with the Commonwealth Scientific and Industrial Research Organization; second, the full-scale trials of the freezing of fish at sea that are being carried out with the collaboration of the White Fish Authority and the trawler owners; third, the co-operative work with the horticultural research stations on the effects of orchard factors upon the storage of apples and pears. We understand that the new trawler which is being built and equipped to assist in the work of the Torry Research Station should be completed early in 1955. This is required, as the previous vessels attached to the Torry Research Station were required, to meet the special purposes of the Station, which are quite different from those for which the Ministry of Agriculture and Fisheries and the Scottish Home Department maintain vessels. The new trawler, with its much improved facilities as compared with the old one, and with the new cold-storage block that is being built, will greatly enhance the Station's ability to tackle the special problems associated with the maintenance of quality in fish caught in distant waters, from which so much of the United Kingdom's supplies of fish must now come.

OTHER D.S.I.R. ESTABLISHMENTS

We do not propose to refer in this Report to the work of the other Departmental establishments, but we should like to express our satisfaction at the completion and occupation of the new Water Pollution Research Laboratory at Stevenage, and at the opening of the new biochemistry laboratory at the Pest Infestation Laboratory for research on residues of insecticides in foodstuffs and on the mechanism of insecticidal action. We are glad too at the progress that is being made with building, not only at the Mechanical Engineering Research Laboratory to which we have already referred, but also at the Hydraulics Research Station; and to know that a start has been made on the new permanent buildings at the Radio Research Station which are so urgently needed to replace the existing temporary and inadequate hutments.

RESEARCH ASSOCIATIONS

An important event during the year was a conference, held in London on 27th November, 1953, to discuss the role which Research Associations could play in advancing technological and technical education. It was attended by the Chairmen and Directors of Associations, by most of our own members, and by a number of invited representatives of Government departments, universities, technical colleges, and other interested organizations. Our Chairman, Sir Ian Heilbron, and Secretary, Sir Ben Lockspeiser, presided at morning and afternoon sessions respectively and, in the absence of the Lord President, the Rt. Hon. Lord Woolton addressed the delegates at luncheon. Many Associations, by reason of both geographical location and common specialist interest, are closely associated with particular

university departments and technical colleges, and the fullest possible liaison and co-operation in these and other cases could not fail to be of great advantage to the country in increasing the number and quality of trained technologists. We are confident that the lively exchange of views which took place at the conference was of great value. The conference devoted considerable attention to the form of post-graduate instruction best suited to meet the requirements of industry and to the relative merits of the training available in universities and Research Associations. As a preliminary to further consideration of this topic the Department has ascertained what statistics are available on the distribution of graduates between industrial, academic and other posts, but these are incomplete and we welcome the survey which P.E.P. (Political and Economic Planning) are carrying out in this field.

With the help of the Ministry of Education, the Department has provided Associations with details of training courses in technical subjects available at training colleges throughout the country and has arranged for information about Associations to be circulated by the Ministry of Education to all technical colleges.

The Department has also established closer contacts with the Association of Technical Institutions, the Association of Principals of Technical Institutions, and the City and Guilds of London Institute in their work for technological and technical training.

A second conference, held in July 1954, was of special importance to ourselves and the Department. In 1947-48 our predecessors described a scheme for appointing a panel of "Visitors" to the Associations who would be chosen from prominent scientists and industrialists. The scheme was put into operation, and for some five years now two Visitors, usually one chosen specially for his scientific and the other for his industrial experience, have assisted us in advising the Department on the work and progress of each of the grant-aided Associations. At the conference in July, which was presided over by the late Sir Wallace Akers, we were able to take stock of the working of the scheme.

The conference, which was attended by more than 80 per cent of the present Visitors, and preceding discussions held with the Associations, provided ample evidence that the experiment had been successful and should be continued. The Associations themselves have benefited from the counsel and advice of independent experts, and our own task, particularly when grants have come up for re-assessment, has been eased by the Visitors' intimate knowledge and understanding of the affairs of their respective Associations. The conference confirmed that the basis of the scheme was sound and agreed on a number of recommendations covering the length of service of Visitors, their relations with the councils of the Associations, the scope of their reports, and other points of administration on which the Associations are now being consulted with a view to increasing the usefulness and smooth working of the scheme.

During the year, through our Industrial Grants Committee, we have considered and discussed with representatives of the Associations and the Visitors, applications for renewal of grants from the following 10 Associations: the Research Association of British Rubber Manufacturers, the British Coke Research Association, the Lace Research Association, the British Hat and Allied Feltmakers Research Association, the Research Association of British Flour-Millers, the British Shipbuilding Research Association, the British Welding Research Association, the Hosiery and Allied Trades Research Association, the British Cast Iron Research Association and the British

Launderers' Research Association. The new terms of grant offered on our recommendation to, and accepted by, these Associations, are given in the relevant sections of the Summary of Work. In the case of the Flour-Millers' Research Association the new terms embody a return to normal conditions of grant in place of the special arrangements begun during the war when the Association's activities were taken under control by the Ministry of Food. The remaining nine cases were normal reassessments of terms of grant for new quinquennia, having regard to the circumstances of the Associations and their industries. In some cases we have recommended a change of terms in the course of the quinquennium. The overall effect of our recommendations for this group of nine Associations is slightly to increase the maximum amount of government support which they can receive, but to require them to raise substantially more industrial income to qualify for it. The aggregate of the minimum incomes which these Associations are now required to raise from their industries in order to qualify for block grants has been raised by about 40 per cent and the total of the block grant by about 20 per cent. The aggregate of the additional grants for which they can qualify by raising additional income has been somewhat reduced.

We have also recommended initial grants to two Associations new to the Government scheme. One of these, the British Steel Castings Research Association, was already in existence though it had not so far received grant. On examination of its application we were satisfied that the circumstances of the branch of the steel industry concerned, and the magnitude of the organization it could maintain, were sufficient to justify an existence independent of the British Iron and Steel Research Association, which we consulted, and which concurred in that conclusion. The other was a new organization, the Chalk Lime and Allied Industries Research Association. In this case we were less well satisfied of the justification, on a long-term basis, for existence independent of the Research Council of the British Whiting Federation, which also receives grants from the Department, having in mind that neither is established on more than a minimum scale acceptable. We accepted the view that current conditions of the industries concerned justify the Department in giving initial support to the new Association, though we have made it clear to both bodies that we look to their amalgamation within a short period.

We have welcomed this new Association for another reason. Elsewhere we have expressed our desire to see the building and associated industries increasing their own efforts on research, and stated the difficulties we foresee in any substantial increase of the resources the Department can devote to research in this field. We hope that the formation of the Chalk Lime and Allied Industries Research Association will afford some relief to the Building Research Station in dealing with problems affecting the manufacture and use of lime as a building material, and in particular that it will reduce the volume of technical enquiries on that subject that the Station is called upon to deal with. We also anticipate that the new Association will co-operate closely with the Building Research Station in planning and carrying out its research and development programame.

SCIENTIFIC GRANTS

We have continued during the year, through our Scientific Grants Committee, to advise on the applications received by the Department for Maintenance Allowances to post-graduate students for training in research in science, engineering and technology; for Senior Research Awards; and

for the financial support of researches in universities and similar institutions. Under the latter head are included applications for large capital and maintenance grants for research in nuclear physics.

MAINTENANCE ALLOWANCES TO POST-GRADUATE STUDENTS

These allowances are being awarded at the rate of about 400 a year. They are normally awarded for two years, with extension in many cases to three years but no longer. The number of allowances current at the beginning of the year exceeded 1000 and the annual cost exceeds £300 000. In 1954, 1064 applications were received (exclusive of applications for renewal of existing awards), and we have recommended 381 new allowances to take effect from the autumn of 1954.

The allowances are for training in research in all branches of science, engineering and technology, and the basis for an award is not the research the student proposes to pursue under his supervisor's guidance, but his suitability for training as a research worker; though it is, of course, essential that the problem proposed and the circumstances in which he will tackle it should be such as to provide effective training. For some years now the allowances have been distributed among scientific disciplines roughly in the proportions of 40 per cent for chemistry, 30 per cent for physics, 10 per cent for engineering, 10 per cent for biology and 10 per cent for other sciences. These percentages broadly reflect the distribution of the applications received.

A small but important matter which we have considered during the year arose from consideration of this distribution. We are not satisfied with the number of applications in engineering, and at the same time we share the widely held view that the first thing for the young graduate in engineering to do is to acquire practical experience and training in industry. But when he has done this he will normally have reached an age and have acquired capabilities which would enable him to earn an income considerably more than the standard Maintenance Allowance. This acts as a strong deterrent to his return to the university for post-graduate training in research, and unduly restricts the supply of fully-trained research workers in engineering. We have accordingly recommended that, for post-graduate students in engineering, the normal rates of allowance should be supplemented by £50, £100 and £150 in academic years in which the recipients reach the ages of 26, 27 and 28 respectively.

Another development during the year has been an agreement between the Department and the Commonwealth Scientific and Industrial Research Organization (C.S.I.R.O.) of Australia by which a few post-graduate students from the United Kingdom will be able to pursue their training for research in the Commonwealth of Australia with grants for maintenance, while there, from C.S.I.R.O., while D.S.I.R. accepts them as titular holders of Maintenance Allowances and pays the costs of their travel and subsistence during the outward and home journeys.

Statistical information about the Maintenance Allowances is given in Appendix V.

SENIOR RESEARCH AWARDS

Senior Research Awards are intended for those (preferably between 24 and 27 years of age) who have completed the normal course of post-graduate training in research, and have shown outstanding promise as research workers. The standard is high and only a few awards can be made each

year. In the three years 1951-53 an average of 34 applications was received and an average of seven awards was made. In 1954 there was a marked drop in the number of applications to 17, and we could recommend only four awards; and, of these four, two were not taken up. This change may be of no long-term significance; but it may also, and not undesirably, reflect the general high demand for the best qualified young scientists and their ability to secure posts in which they can find full outlet for their knowledge and powers, whether by pursuing their already established lines of work or breaking new ground.

GRANTS FOR SPECIAL RESEARCHES

Appendix VI includes a list of grants for researches current at the beginning of the year, i.e. on 1st October, 1953, and a further list of new grants approved to come into operation during the year. Excluding nuclear physics, with which we deal separately below, 50 new applications were received during the year, and 26 awards have been made, for periods ranging from one to three years, at a total estimated cost of £117 000. The present annual cost of these grants for special researches is over £60 000 (excluding the exceptional current expenditure, expected to be £60 000 in the financial year 1954-55, out of the Department's large grant to Manchester University towards the cost of the radio-telescope under construction at Jodrell Bank).

NUCLEAR PHYSICS

Assistance to universities for the construction and operation of large particle-accelerating machines for research in nuclear physics continues to be a heavy charge on the Department's resources. New needs and rising costs have resulted in applications during the year for new or increased assistance, and in a number of cases we have recommended approval. On the other hand, we have endorsed a proposal not to proceed, in view of changed circumstances, with the construction, at Cambridge University, of an electron linear accelerator for which a grant had previously been approved. The present annual cost of the Department's support of nuclear research in universities is about £300 000.

Until this year, our advice on nuclear physics research was given by a Nuclear Physics Sub-Committee of our Scientific Grants Committee. With the addition to the Department's responsibilities of the representation of the United Kingdom in the European Organization for Nuclear Research (p. 24), we decided to reconstitute the Sub-Committee as a full Committee with the following terms of reference:

> (*a*) To consider all aspects of applications for grants for research in nuclear physics involving the use of high energy particle accelerating equipment, and closely related research at the university concerned, and to submit recommendations to the Advisory Council on behalf of the Scientific Grants Committee except when the chairman of the Scientific Grants Committee desires an application to be considered by that body in the first instance.
>
> (*b*) To keep under review the scientific aspects of the Department's responsibilities arising from the United Kingdom's membership of the European Organization for Nuclear Research and to report to the Advisory Council as may be necessary.

The membership of the Scientific Grants Committee and the Nuclear Physics Committee is given in Appendix I (p. 225).

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

In our last Report we mentioned that in July, 1953, the United Kingdom, with other European Governments, had signed a Convention setting up a European Organization for Nuclear Research, with resources to include a laboratory near Geneva for fundamental research. The Convention, which was ratified by Her Majesty's Government in December, 1953, and since then by other signatory States, is now in force. Meanwhile the Department has given the interim Organization continuous and substantial administrative help, in addition to contributing to the cost of preparing the necessary plans. The Secretary of the Department, Sir Ben Lockspeiser, and the Chairman of our Nuclear Physics Committee, Sir John Cockcroft, are the United Kingdom's delegates to the Council of the Organization. We are pleased to learn that Sir Ben Lockspeiser has now been elected its President. The designs of the Laboratory and of the two accelerators are well advanced, preliminary work has begun on the site, and large-scale construction of the buildings and of one of the accelerators will soon begin.

HUMAN FACTORS IN INDUSTRY

In our last Report, we referred briefly to the programmes of research in the social sciences which were to be undertaken on the advice of the two Joint Committees of the Department and the Medical Research Council, largely with the support of Conditional Aid* counterpart funds. During the last year, most of the Conditional Aid programme has been finalized. One hundred and four projects, estimated to cost £580 000, were submitted for consideration by the two Committees, and of these 35, to cost £184 027, have been approved. We would call attention here to the links between this new work and the fields of natural science and technology with which the Department has been predominantly concerned in the past. A major section of the programme is on problems of management and of human relations arising from technological change; the design of equipment from the point of view of efficiency and the comfort of the user is also to be studied; and there is to be research into both the technical aspects of work-study and the problems of human relations arising from its application. In view of these growing links between technology and research on human factors in industry, we are pleased to note that several of the Research Associations are undertaking research in this new field.

Though the Conditional Aid programme has dominated the first year's work of the two Joint Committees, the decision to appoint them was prior to Conditional Aid, and their primary task is to establish a continuing programme in relation to industrial needs in this country. This they have started to do, and research to be paid for from the general funds of the Department or the Medical Research Council has been authorized on subjects such as the human and social implications arising from the introduction of automatic control techniques in industry, and the social and management problems arising from the large-scale employment of married women in industry.

* That part of the sterling counterpart of funds derived from U.S. Economic Aid which, by agreement between H.M. Government and the U.S. (Foreign Operations Administration) is being spent on activities shaped to the economic needs and structure of British industry.

Arrangements for the expenditure of Counterpart Funds derived from United States Economic Aid under Section 9 (c) of the Mutual Security Act of 1952 (Cmd. 8776), H.M. Stationery Office, February 1953.

Programme of Expenditure of Counterpart Funds derived from United States Economic Aid (Cmd. 8918), H.M. Stationery Office, July 1953.

In the immediate future a major obstacle to the development of this programme of work is likely to be the shortage of well-trained workers. How this difficulty might be overcome is therefore engaging attention. Furthermore, the extensive application of results in this field, on which the ultimate usefulness of the programme will depend, involves problems of effectively disseminating information which are even more acute than in the technological field.

In the spring we received the First Report of the Joint Committee on Human Relations in Industry,* which has been published, and we were grateful for an opportunity to discuss it at some length with the Chairman, Mr. A. B. Waring. Our discussion ranged widely, not only over the projects which the Committee had already considered, but also over other problems in the field which we ourselves were led to raise out of our individual experience. We came to feel, very strongly, that much good may come from systematic study in this field and that there are many individual problems which should amply repay investigation. Looking ahead we may well be encouraged by the history of the development of the natural sciences to expect that out of numerous discrete investigations there will some day emerge a useful body of knowledge, and some general principles, which together will enable industrial progress and development, not merely to satisfy economic needs, but also to make a full contribution to social welfare and personal happiness. However that may be—and we must recognize that the methods of experimental science may be able to do no more than contribute to the attainment of such an object—we are sure that all and more than the work now being done or planned is well worth while. As our Secretary, Sir Ben Lockspeiser, pointed out in the course of a television broadcast during the recent meeting of the British Association at Oxford, this field is one in which the student of the humanities in their factual and historical aspects may well collaborate with the experimental scientist to produce results which neither alone could achieve.

PRODUCTION ECONOMICS

The Committee (Professor Edwards, Chairman, Sir Hugh Beaver and Mr. Fletcher) which we appointed to recommend on our behalf suitable projects in the field of production economics also completed proposals, since approved, for the allocation of Conditional Aid funds, totalling some £65 000, to projects covering the two main fields of (*a*) technical innovation and the economic factors helping or hindering it and (*b*) the measurement of industrial productivity.

The small economics section within the Intelligence and Information Division of the Department's Headquarters is, in addition to servicing this programme, providing a general research service to the Department which should grow steadily in importance. During the past year, they have begun economic surveys in collaboration with the Food Investigation Organization, the Pest Infestation Laboratory and some of the Research Associations.

THE STUDY OF INDUSTRIAL OPERATIONS

The other new section of the Intelligence Division reported last year—the Industrial Operations Unit which was set up to study and advise on the application of improved industrial engineering techniques—has now settled down to a full and useful programme of work, and it is already clear that

* Human Relations in Industry, March 1953 to March 1954. *First Report of a Joint Committee of D.S.I.R. and the Medical Research Council*, H.M.S.O. 1954 (1*s.* 0*d.*).

the demands on its services from research and trade associations are much more than can be coped with by the present staff. During the year the Unit has worked effectively with the Retail Distributors' Association, the Furniture Development Council, the British Cast Iron Research Association and the Food Investigation Organization, and the officers have also made a considerable contribution to the better understanding of work study and other industrial engineering techniques by participating in and organizing lectures, study courses and international symposia.

The end of the year of this Report brought an unusually large measure of change in our membership. In September 1954 Sir Wallace Akers resigned on account of ill health and, to our very deep regret, died a few weeks later. Four of our members—Professor Edwards, Lord Halsbury, Sir Henry Hinchliffe and Mr. A. H. Wilson—retired on the completion of their terms of office. Lastly, the term of office of our Chairman, Sir Ian Heilbron, also expired. Those of us who remain would like to express our deep sense of the valuable and strenuous work which all of them have done as members of the Council and of how much we, their juniors in that capacity, have owed to their guidance and example. Above all this recognition must be accorded to Sir Ian Heilbron, who retires after nine years' service in all, more than half of it as Chairman. He alone among us has served through the whole of the post-war period which will rank as of such great import in the history of the Department. He has seen the formulation and acceptance of the post-war plans described in our predecessors' Report for 1947-48 for the expansion and redirection of the Department's work; he has suffered the acute feelings of frustration caused by the slowness with which these plans developed, owing first to shortages of resources for capital investment and of scientific man-power and later to economic stringency; and it is to his unremitting advocacy of the need for assured resources to complete the approved expansion of the Department's work, and to enable it to play its rightful part in the new fields of scientific endeavour which continually present themselves, that we must attribute in large measure the greater hope with which we can now look forward, and the firmer foundation on which we can advise your Lordships on plans for the next few years.

HUGH BEAVER,
Chairman.

B. LOCKSPEISER,
Secretary.

15th November, 1954.

SUMMARY OF WORK

RESEARCH ESTABLISHMENTS OF THE DEPARTMENT

This section contains brief reviews of some of the work carried out by the Research Establishments of the Department.

In the past few years, their expanding activities have been reflected in the constantly increasing length of the section. This year an attempt has been made to reduce the length by reviewing only selected items in their programmes in order to keep the overall size of the Report within bounds.

Further details of the activities of the Research Establishments will be found in the Annual Reports and other publications listed in Appendix VII.

BUILDING RESEARCH

Following a research conference convened by the National Federation of Building Trades Employers, at which the Secretary of the Department spoke, the National Federation has co-operated with the Building Research Station in a scheme designed to help bridge the gap between research and practice. The scheme, which is a welcome addition to the arrangements which the Station makes with individual builders, aims to encourage full scale trials by the industry of promising ideas that have already been fully investigated both in the laboratory and in such full scale trials as the Station's facilities permit. In the organization of this scheme, the Station has worked closely with the Research and Technical Information Committee of the National Federation, through which member firms have been invited to find appropriate occasions to put selected proposals into practice and to report their observations and comments to the Committee for communication to the Station.

The first two of these trials are mentioned below. The remainder of the summary describes a selection of the more immediately interesting parts of the work of the Station; no attempt has been made to give a balanced picture of all that is in hand.

MATERIALS

Two items have been chosen in the first instance for the full-scale trials scheme in conjunction with the National Federation of Building Trades Employers. They are the use of air-entrained sand-cement mixes for external renderings and internal undercoats to plaster, and the use of zinc oxychloride paint as an additional means of attempting to prevent the spread of dry rot in timber. This latter was referred to in the Report for 1952-53 (p. 28). Working instructions have been provided for both these proposals and invitations to participate have been extended, through the National Federation's Research and Technical Information Committee, to the different areas of the country covered by the several regions of the National Federation. An immediate response from some 40 firms expressing a desire to participate was coupled with a request that further items be submitted for their consideration. Each trial must of necessity await a suitable occasion and is also contingent on securing the approval of the client. Reports of their experiences are still awaited, but it is apparent that members of the National Federation are most anxious to contribute their part to the development of the scheme, the successful outcome of which will also demand a liberal and receptive attitude on the part of their clients.

In the summary for 1952-53 (p. 27), a large scale investigation on brick-making using pulverized fuel ash was mentioned. The laboratory and pilot scale stage is now virtually completed and the British Electricity Authority are considering the establishment of two brickworks to be designed in co-operation with the Station to process a mixture of 85 per cent ash with 15 per cent clay to give a combined output of 15 million bricks per year. Some further laboratory work is required before ash containing more than about 5 per cent carbon can be used for brickmaking. On the other hand such ashes can very easily be sintered without the use of additional fuel to form a lightweight aggregate for concrete. Such a process is being studied in co-operation with the British Electricity Authority. It is of importance not only in providing an outlet for the ash; supplies of lightweight aggregate are badly needed by the makers of concrete blocks. A little work is also in hand on the substitution of pulverized fuel ash for part of the cement in normal concrete. These investigations promise to make a substantial contribution towards solving the problem of disposal of the increasing production of ash in electricity generation.

DESIGN OF STRUCTURES

Research in prestressed concrete has been continued during the year with particular emphasis on the investigation of fire resistance, which is being made in collaboration with the Joint Fire Research Organization (cf. p. 28). The results of tests on beams of large size, which were conducted by the National Bureau of Standards in Washington at the request of the Department as part of this programme, have confirmed and extended the conclusions drawn from the tests on beams of smaller size carried out in this country. It is now clear that sufficient protection can be given to prestressed concrete to allow its use in larger structures where fire resistance is important. Further guidance on the requirements for different degrees of fire resistance can now be given to the designer. The results of these tests also showed several aspects of the problem which require further examination. This will be done in the new and larger furnace shortly to be erected at the Fire Research Station.

Measurements of the magnitude of the losses of prestress, due to creep of steel and creep and shrinkage of concrete, were referred to in the last report (p. 28). As these losses take place over a period of years, the measurements are not yet complete, but the present indications suggest that slightly larger allowances than are usually made should be adopted in design; it would probably be wise to assume that the prestress will be reduced in time to about 80 per cent of its initial value. An underestimation of these losses of prestress does not lead to an appreciable reduction in the margin of security against collapse of the structure but does give a greater risk of cracking in the concrete for normal working conditions.

Experimental work on the behaviour of reinforced concrete floor slabs acting in structural combination with the encased steel girders on which they are supported has shown that the degree of flexibility of the girders has an important effect on both the distribution of stresses at working loads and on the method of failure of the system. The experiments have borne out the conclusions of earlier analytical work and indicate the possibility of producing simple design rules when more is known about the patterns of major cracks which develop at failure. Small scale tests are being made to obtain information about these crack-patterns for a wide range of conditions, particularly with regard to the flexibility of the beams and the extent to which the slab is continuous over several spans.

SOIL MECHANICS

Field investigations of practical problems in foundations, earthworks and earth pressures form an important part of the work in soil mechanics.

The soil under some oil tanks at a site in the Thames Estuary is so poor in bearing capacity that it is not possible to fill the tanks to the full height without risk of the tank breaking into the surface of the ground. In time the foundations will strengthen and permit the tank to take its full load but the question is how long to wait before this can be safely attempted. To answer this a loading test on a tank has been carried out, in which in addition to measuring settlements a novel feature has involved readings of the pressure developed in the water in the pores of the soil under the foundations and has enabled the rate at which this pressure falls off with time to be followed. It is hoped that the insight which these readings give into what is happening in the ground beneath the tank will enable a definite answer to be given as to the time needed before permitting full use of the tanks.

In another investigation, carried out in collaboration with the Metropolitan Water Board, instruments were installed in a 9-ft diameter water tunnel located with its axis at 90 ft below ground level in London clay to measure the stresses in the tunnel lining and the distortion of the tunnel. The tunnel was filled with water and emptied in stages a number of times and readings were successfully taken with the instruments with a water head up to 160 ft. The results suggest that it may be possible to dispense with expensive steel lining in a proposed new deep-water tunnel some twenty-six miles long, with a large saving in money.

EFFICIENCY OF BUILDINGS

Although much of the work of the Station on heating and ventilation, lighting and sound insulation, is concerned with the special needs of buildings such as schools, hospitals, factories, etc., a substantial effort is made each year on the special problems of flats and houses.

Following the extensive experimental work on heating small houses, which was carried out on the experimental building site at Abbots Langley, special attention is now being paid to the problems of heating and ventilation in flats. Central heating by radiators is efficient, but in low cost flats may well prove expensive to the tenant since he has at present no way of being credited with any saving of fuel due to careful use of heat. Tests have accordingly been made on a form of evaporative heat meter, which is clamped to the radiator, the heat emission from the radiator being registered by the evaporation of liquid in a graduated tube. The meter appears to be technically promising, but the problems of organization of meter readings and of tariffs remain to be considered. Further work concerned with flats has been the examination of theoretical work and continental experience on shunt flues (a method of avoiding building a separate flue for each flat), and on the natural ventilation of internal bathrooms and w.c's.

During the year, the work on sound insulation, which has a special importance in flats, has been consolidated on the basis of the long-term studies carried out in the three experimental blocks of flats at Abbots Langley, and of measurements made in over 1000 flats and houses all over the country. The relation of the measurements to the impressions and complaints of the tenants has been investigated by two surveys. A system of grading has been drawn up which relates the type of construction to the degree of disturbance (if any) experienced by the tenant.

The year has been noticeable for the completion of a major stage in the investigation of single stack plumbing and the publication of design rules applicable to flats of up to five storeys. Cost investigation shows that savings of 40 to 50 per cent are achieved in the cost of the pipework over conventional plumbing arrangements.

Inquiries are continuing, in conjunction with the Social Survey, and at the request of the Ministry of Fuel and Power, into domestic expenditure on heating. Preliminary results relate to a survey, conducted in 1952, which covered two samples of town dwellers in England and Wales. The first comprised households in dwellings of fairly low rateable values, and the second consisted of post war local authority houses. Analysis shows that although houses in the North were allotted and used more coal, the cost of this was more than outweighed in the South by additional expenditure on gas and electricity. For the country as a whole expenditure on fuel appears to have absorbed about 15 per cent of the wages of the head of the household in the poorest families and about 6 to 8 per cent in the case of typical families in the sample. Total spending on fuels has been found to be more sensitive to the number of occupants of a dwelling than to any other known factor, and greater average fuel expenditure in post-war local authority dwellings appears to be due to the larger average size of household in these dwellings.

BUILDING OPERATIONS AND DEVELOPMENT

The extensive site trials already carried out by the Station on the use of rail-mounted tower cranes for two- and three-storey building provide a reasonably clear picture of their general value. The saving in manhours and building time which can be expected in any particular case depends, of course, on the quality of the organization and the level of labour productivity which existed before the introduction of the crane. It appears that even on efficiently organized sites, the reduction of both labour expenditure and building time should be about 20 per cent, while on sites with only average productivity and efficiency, the percentage reduction may well be nearly twice as great.

The work has therefore shown that a considerable reduction of building costs can be expected on the majority of sites and even on most well organized ones there should still be some saving. This conclusion is confirmed by the increasing use which contractors are now making of such cranes; there are probably well over 200 in use in this country. In the few cases, say 5 or 10 per cent of the total, where the organization is unusually good and the labour productivity is high the position appears to be more marginal. Site trials are to be carried out under such conditions to obtain a clearer view of likely results in such circumstances.

The earlier trials were made on sites which were reasonably level and whose layout did not present difficulty in using a crane. More recently studies have been made of the particular problems of the more awkward sites. One notable example has been the use of a rail-mounted crane on a site with a cross fall of 1 in 6.

Where, however, the houses do not follow the contours or the site is very restricted, the normal type of rail-mounted crane is inappropriate. Other types are therefore being studied and in addition a crane manufacturer has been asked to develop to the Station's specification the prototype of a tower crane mounted on crawler tracks. This is now being tested.

Good progress has now been made on the study of alternative methods of house construction, an investigation into the part which factory-made components and dry-finished interiors can play in housing, which will involve

the building of about 400 houses. Four forms of construction are included, ranging from " traditional " to factory-finished interiors consisting of room-sized panels of plasterboard on studding. Five local authorities are taking part in the investigation, each building 25 to 30 houses of at least two and in some cases all four types. Work is already complete on one site and the data are being analysed ; on the others, building is under way.

MODULAR CO-ORDINATION

A new investigation in the Station's programme has been to study, in conjunction with the British Standards Institution, modular co-ordination for the building industry. To bring this idea into more familiar language, it is the concept that the complexity of design and construction can be reduced if dimensions can be co-ordinated in simple multiples of some small whole number or numbers.

In this country the main application up to now has been in prefabrication for schools and to some extent for housing. Since it is essential to know where and how to apply modular co-ordination to reduce costs, the programme includes the study, in terms of time, cost and quality, of the problems of designing buildings, of making the components, and of assembling them into the completed structure.

Part of the cost of this work is being covered by a contract with the European Productivity Agency in which the United Kingdom is acting as a Secretariat for a European-wide study of the subject to ensure international co-ordination.

SCOTTISH LABORATORY

The Laboratory has continued to take a close interest in the new methods and materials that are being developed for the building of houses and flats in Scotland. Storied construction is being adopted to an increasing extent in order to conserve building land and this, coupled with the need to reduce costs, has introduced many new technical problems which the Station's experience is helping to solve. For example, by applying the results of research on the strength of brickwork, three- and four-storey dwellings are now being built with thinner load-bearing and cavity walls than were formerly considered necessary, thus permitting a substantial saving in materials and labour.

Various field investigations have been undertaken to supplement researches already in progress at the main Station. The purpose of one was to assess the efficiency of a system of electrical floor and wall panel heating installed in a primary school. Another was a study of the incidence of condensation in the roof spaces of temporary aluminium bungalows and of the efficacy of different remedial measures. A third investigation lay in the field of civil engineering. In the construction of large concrete dams precautions have to be taken to avoid any undue rise of temperature within the mass, which might lead to cracking. The building of a dam for a reservoir in Clackmannan provided an opportunity for the Station to make direct measurements, over a period of 12 months, of the temperature changes throughout a cross-section of the concrete. The early results showed the contractors how far the rate of construction could safely be increased.

COLONIAL LIAISON ON BUILDING RESEARCH

The year saw a marked increase in the work of the Colonial Liaison Section, which has now been joined by two members of the Colonial Office staff. The Colonial Liaison Officer has become a member of the Advisory

Panel on Housing and Town Planning recently set up by the Secretary of State for the Colonies.

The Colonial Liaison Officer has visited Cyprus twice in connexion with reconstruction after the 1953 earthquake. He also served as Technical Consultant at a United Nations Housing and Community Improvement Regional Seminar at New Delhi. An architect on his staff has been seconded to British Guiana for a period of about a year to advise on low-cost housing.

Recent issues of *Colonial Building Notes* have included information on the surface finishing of stabilized earth walls; on the factors determining ceiling heights; on low-cost housing; and on heat absorbing glass. A report on *Housing in British African Territories*, largely prepared by the Colonial Liaison Officer, has been published by the Colonial Office.

INFORMATION SERVICES

The total volume of publications now available is very considerable. Official publications are supplemented by others in the technical press wherever this facilitates contact with particular groups within the building industry. The monthly publication of *Building Science Abstracts* has been brought up to date.

Other publicity efforts include the giving of numerous lectures to professional and other groups; the making of short technical films; the continuation of the system for showing parties of visitors round the Station; and participation in selected exhibitions particularly the Building Exhibition in London in November, 1953. At the Building Exhibition a small cinema was incorporated in the Department's stand and enabled the Station's films to be shown to over 5000 people.

Two short tuition courses were also given during the year—one to a group of building teachers and the other to a group of Colonial architects and engineers.

BUILDING BYELAWS

The rapid development in building materials and techniques over the past 30 years has rendered obsolete the traditional form of byelaw that described the methods that must be adopted. From the research standpoint the byelaws often presented a serious obstacle to the early application of the results of research. The Building Research Board as long ago as 1936 advocated the adoption of a functional treatment and at the suggestion of the Station the recent revisions of both English and Scottish Models have incorporated a functional approach. They represent a stage in progress to the ideal but the achievement of this is still hampered by the difficulty of reconciling certain technical and legal aspects. Evidence on this has been submitted to the Committee appointed by the Secretary of State for Scotland in 1954 to examine building legislation.

CHEMICAL RESEARCH LABORATORY

The Laboratory is organized into six main research groups supported by sections dealing with spectroscopy, micro-analysis, engineering and glass-working. Selected items from the work in progress are described in the following paragraphs.

CORROSION OF METALS GROUP

The need for inexpensive, easily-operable equipment for use in accelerated tests of the corrosion resistance of metals and of the protective value of different types of coating has been experienced by many workers in this

field. Because of its simplicity and compactness the "C.R.L. Beaker-Test Apparatus" has found wide application, particularly in industrial laboratories having only modest resources, and its sphere of usefulness is being extended. Use of the apparatus for the evaluation of protective grease preparations has been approved by the Institute of Petroleum and its consistency in assessing the temporary protection afforded by light oils is being examined. Recent modifications of the apparatus provide for simulation of the attack on metals by marine as well as by industrial atmospheres.

In recent years, workers concerned with the application of protective coatings of paint, lacquer or metal on steel, have noted the widespread incidence of a type of corrosion known as "filiform", which streaks a coating with filament-like lines. The mildest form of this mars the appearance of the finished surface and may lead rapidly to more serious breakdown of the protective coating. The cause of "filiform" corrosion is being investigated and means of preventing its occurrence are being sought. In the course of the work, typical examples of this form of corrosion have been artificially produced by inoculating coated and uncoated steel panels with a variety of salts and subsequently exposing the panels to high-humidity atmospheres.

Because wrought iron boiler tubes are no longer being made, mild steel tubes have been used in recent years in Scotch marine boilers. The life of mild steel tubes in service conditions is, however, considerably less than that of the wrought iron tubes formerly used. In collaboration with the British Shipbuilding Research Association, four model boilers are being used at the Laboratory to investigate this problem and to find means of extending the life of mild steel tubes.

A large proportion of the work of the Corrosion Group entails giving advice and assistance to industrial organizations and to public authorities; this particularly applies to the investigations into the causes and methods of prevention of underground corrosion, where the preservation of buried pipelines is a problem of economic importance to the country as a whole. A typical example of this service concerned a large fruit farm where frequent failures occurred of underground mains conveying spraying solutions. On the recommendation of the Laboratory, cathodic protection was introduced, a measure which arrested the rapid external corrosion of the pipelines, and greatly reduced the former interference with tree spraying at critical periods.

The activity of sulphate-reducing bacteria is instrumental in causing the greater part of corrosion underground in Britain and reference was made in the last report to the discovery of the toxicity of tannic acid towards these organisms. Application of this discovery is now going forward in the form of extensive field tests with the co-operation of the Metropolitan Water Board.

INORGANIC GROUP

One of the items in the programme is the search for some of the less common elements in various wastes or low-grade materials and their extraction from such sources. At present a search is being carried out for selenium. For some years this element has been in short supply while the demand for it has been increasing. As all the country's present supply is imported, any additional source, particularly an internal one, would be helpful and valuable. The most promising sources of selenium found so far have been the wastes arising from the purification of the sulphur dioxide produced by the flash roasting of pyrites. Some of the samples examined have been exceptionally rich, containing up to 80 per cent of the element; on the other hand,

comparable materials from other installations, even where a similar pyrites has been used, have been as low as four per cent. Altogether, these wastes could provide a useful additional source of the element. Processes for recovering the selenium from these materials have been examined; two have been studied in some detail, and a third possible method is at present being investigated.

Germanium is increasingly in demand and its importance to the radio industry alone has necessitated continued search for further sources of supply. In addition to several zinc blendes a number of waste wood products have been examined for presence of the element.

The preparation of certain elements in a high degree of purity is another topic engaging the attention of the Group, and at the request of the Pure Metals Committee research is carried out on the purification of metals not already in the collection of pure metals maintained at the Laboratory. Attempts are at present being made to prepare pure rare earth metals, and the separation of rare earths from one another is being studied as a first step to obtain adequate supplies of the starting materials in a satisfactory degree of purity.

RADIOCHEMICAL GROUP

Considerable interest has been shown by mining houses and similar organizations in a new method for the determination of niobium in low grade materials. The method, a chromatographic one, involves a paper strip separation on a specially designed paper sheet, which permits ten sample solutions to be dealt with simultaneously. The separated niobium is detected by spraying with tannic acid solution and determined by comparison with standard chromatograms.

Using a similar technique, field methods for the determination of a number of trace metals in soils have been designed. The methods are sufficiently simple, speedy and accurate to enable them to be used in geochemical prospecting and in a number of cases they have already been used in the field. Procedures have so far been worked out for the determination of copper, cobalt, nickel, lead, uranium, niobium and tantalum and a number of other metals are under investigation.

A relatively simple separation of the platinum metals, platinum, palladium, iridium and rhodium has also been achieved with the aid of chromatography. Using mixtures of hydrochloric acid with methyl*iso*butyl ketone as solvent, procedures have been designed which permit the separation and estimation of micro quantities of the platinum metals on paper strips or of macro quantities on columns of cellulose.

Metals such as copper, cobalt and nickel are readily adsorbed from aqueous solutions by cation exchange resins but subsequent separation by selective elution with normal aqueous eluting agents is difficult. It has been found possible to obtain quantitative separation of cobalt or copper from nickel by using organic solvents as eluting agents. Simple ketone mixtures with hydrochloric acid have been used in these separations. The behaviour of other metals in such systems indicates that it will be possible to apply this technique to the separation of a number of other mixtures.

A new coincidence liquid scintillation counter has been constructed for the determination of low activity ^{14}C. Use is made of the high solubility of acetylene in toluene at low temperatures. This enables the sample, converted to acetylene, to be dissolved in a small volume of toluene containing diphenyl oxazole as scintillating agent, with a resulting improvement in the ratio of sample to background count.

ORGANIC GROUP

Work on the purification and measurement of the physical properties of organic compounds still continues as a major interest of the Group but during the past year attention has been given to a fresh series of industrially important compounds, viz. phenol and its homologues. A number of these substances have been brought to a highly-purified state, with considerable development of purification technique, and a beginning has been made on the physical measurements.

Collaboration with Physics Division, National Physical Laboratory, has centred chiefly round three topics: precision measurements of heats of combustion, use of the water triple-point cell as a thermometric fixed point and measurements of pressure-volume-temperature interdependence in mixed gases of industrial importance.

Much effort has been applied to encouraging smaller firms to make a greater use of infra-red spectrometry in analysis since spectrometric methods save time and often lead to the closer specification and up-grading of products. Several infra-red spectrometers based on the C.R.L. design have now been constructed in industrial and other laboratories.

The Group has continued to seek new potentially valuable intermediates and products. In the field of isotopically-labelled compounds mention may be made of a new method of obtaining labelled aromatic compounds (toluene, benzene, benzaldehyde and benzoic acid) from labelled methyl*cyclo*hexane. The method has been adopted by the Radiochemical Centre, Amersham, for routine use in meeting commercial requirements for materials of high specific activity.

The provision of standard reference compounds of certified purity has been an integral part of the work of the Group since 1950. That it fulfils a well-defined industrial need is amply confirmed by the increasing demands on this service. During 1953, 355 items were despatched to 38 laboratories chiefly in the United Kingdom and the Commonwealth but some in other parts of the world.

HIGH POLYMERS GROUP

Although of considerable importance in the physical and biological sciences, membranes which exhibit selective behaviour towards molecules and ions are also of practical industrial interest, particularly in connexion with dialytic and similar procedures. The selective properties of poly (vinyl alcohol) membranes have been the subject of investigation for some time but up to the present their use has been restricted to non-aqueous systems. The work has now been extended to include the development of membranes suitable for use with aqueous systems and as a result methoxymethyl nylon films have been made which show considerable promise for use in osmometry and dialysis. One type of film has a comparable rate of solvent transfer to existing membranes, but possesses markedly increased selectivity, while another type exhibits the same order of selectivity as conventional membranes but has a greatly increased rate of solvent transfer.

The investigation of the preparation and properties of the highly specific resins referred to in the last report has continued. In these resins functional groups capable of complex or chelate formation with metallic cations attach themselves to a particular metal towards which they show greatest affinity. For instance, certain resins containing functional groups of the amino-acetic acid type have proved very successful in selectively removing traces of copper from raw water. This result has possible wide industrial

application since it is known that traces of copper as small as one part in ten million can cause corrosion in aluminium vessels and pipelines.

In assessing the probable behaviour of a given polymer it is advantageous to know the number-average and weight-average molecular weight. Excellent facilities are now available at the Laboratory for determining these quantities and the Group has participated in the scheme for the standardization of polymer molecular weights put forward by the International Union of Pure and Applied Chemistry.

MICROBIOLOGY GROUP

The National Collection of Industrial Bacteria (N.C.I.B.) is now well established and is used increasingly by workers and institutions all over the world. Its usefulness has been increased by the publication of a Catalogue (as distinct from a List) of the strains in the Collection. The facilities offered by the N.C.I.B. are of special value to the Commonwealth and it was appropriate that many representatives of Commonwealth Collections should visit the Laboratory during a Conference held in the past year. The status of the Collection has also been recognized by the appointment of one of its staff as Secretary to the Commonwealth organization, the Permanent Committee on Culture Collections of Micro-Organisms.

Although sulphur is now more easily available, the country's dependence on imported brimstone emphasizes the need for examining indigenous sources of supply. A laboratory method employing anaerobic microbiological digestion for producing hydrogen sulphide from raw sewage sludge, and based on normal sewage works practice, has been developed; elemental sulphur is readily obtained by orthodox chemical processes from the gas mixture evolved. At present the hydrogen sulphide is produced at the expense of the economically valuable methane formed during normal anaerobic digestion of sewage sludge, but attempts are being made to enable the two processes to proceed simultaneously.

Fundamental studies on the sulphate-reducing bacteria have shown that cytochrome, a respiratory pigment unexpectedly isolated from these strictly anaerobic organisms, is an important link in the chain of reactions by which sulphate is converted to sulphide. Work has also been started on the mechanism of bacterial attack on the aromatic ring, a problem not of academic interest only, since the efficient degradation of certain industrial aromatic effluents depends on microbiological action. The breakdown of phthalic acid by an organism isolated from filter beds in which effluents are treated has been investigated; pyruvic acid has been identified as an intermediate.

FIRE RESEARCH

In making this review of the work of the Joint Fire Research Organization items of research have been selected which are likely to have important applications in the future, and the following summary should not therefore be taken as giving a balanced and comprehensive picture of the work of the Station.

FIRE STATISTICS

Analyses have been made of the reports of all fires attended by the Fire Brigades during the year and the results of these are being used in the planning of research and as a basis for administrative action by various Government departments.

Special attention has been paid to fires in schools. During 1952 fires occurred in schools at an estimated rate of 130 per 10 000 schools at risk per year. Fortunately, there were few casualties and none of them was fatal. A random one-in-four sample of the reports was examined in detail. In 75 per cent of the incidents in the sample the direct damage was under £10; the total cost of direct damage in the sample was about £135 000, and one fire included in this total is estimated to have cost about £100 000. The causes of the fires were similar to those in private dwellings and no specific cause peculiar to school activities has been observed. An examination of the reports of the fires during 1953 is being made with a view to providing information as to the most satisfactory means of fire protection in relation to the losses incurred by fire.

A study is to be made of the reports of large fires in general since these account for a high proportion of the fire losses. In the textile, dyeing, bleaching and finishing trades, for example, the major losses are associated with fires occurring outside working hours, the main loss being due to damage to textiles rather than to plant and buildings.

FLAMMABILITY OF SHEETED MATERIALS

Flexible sheeted materials offer the greatest hazard from flame spread when they drape vertically. The time for a large fire to develop or the time to escape from burning garments is related to the vertical flame speed, and this may be measured by continuously weighing a burning sample on a torsion balance.

It has been shown that for cellulosic materials in such diverse forms as paper, woven fabrics and wood veneers the rate of propagation of flame is inversely proportional to the weight per unit area; that is to say, in any given material the thinner the sheet, the more rapidly is flame propagated.

It has been shown that the vertical flame speed of a material may be estimated by fixing the sample round a semi-circular frame and observing the distance to which it burns, when ignited at one end, or where appropriate, the time taken to burn round the semi-circle. The apparatus is being considered by a committee of the British Standards Institution as a standard method of testing for flammability.

SMOULDERING FIRES

In the course of an investigation of materials in which smouldering can be started by a small source of ignition, the behaviour of a pile of cork dust up to 3 ft deep was examined. Smouldering initiated by a buried source of ignition took twelve days to reach the surface and no outward signs were readily observable until just before the smouldering zone had spread to the surface. This experiment confirmed the insidiousness of this practical hazard in that deep-seated smouldering may continue without being observed for many days after ignition, as for example when a cigarette end is discarded into sawdust which is being piled. The resulting fire may reach serious proportions when premises are unattended and thought to be safe.

FIRES DUE TO FLUE PIPES

Fires continue to occur as a result of combustible materials being placed near flue pipes. In one type of post-war house the smoke box of a cooker had been placed 2 in. from a plasterboard wall lining, backed by fibre insulating board. This had led to several fires when the stove was burning with the dampers open, due to heat being radiated from the smoke box and conducted by the plasterboard to the fibre insulating board beneath. It

has been shown that the hazard may be removed by fitting a metal plate of appropriate size in front of the plasterboard so that the spacing from the wall is 1 in. The radiant heat received from the flue pipe is dispersed by the metal plate which is cooled by convection.

DUST EXPLOSIONS

Work has continued at the Safety in Mines Research Establishment on problems associated with dust explosions in factories.

There has been a steady accumulation in the data required for the design of explosion relief vents. In particular, a simple hinged-door relief was most effective and appeared to offer little more obstruction than that given by a free opening; the latter of course, is not normally practicable in factory plant.

Basic studies have been made of the propagation of flame in dusts with a view to developing an improved test for measuring the explosion hazard presented by dust laden atmospheres.

PRESTRESSED CONCRETE

It was reported last year that the Building Technology Division, United States National Bureau of Standards had agreed to test in their floor furnace prestressed concrete beams constructed at the Building Research Station in England (cf. p. 28). The results of these tests, together with the results of similar tests on smaller beams carried out at the Fire Research Station, indicate that with beams of this type the fire-resistance increases uniformly with the cross-sectional dimensions of the beam. It is probable that failure in fire of large beams could be delayed by the inclusion of wire mesh reinforcement to prevent the concrete falling away from the cable. Experimental beams are being constructed in various scales to test this hypothesis. The present floor furnace is being enlarged to permit the testing of these larger beams.

VAPORIZING LIQUID EXTINGUISHING AGENTS

The Committee of the Fire Research Board on Vaporizing Liquid Extinguishing Agents has now completed its report, which has been published by Her Majesty's Stationery Office.* The report suggests that none of the agents at present available is completely satisfactory in all respects, but that, pending the development of new compounds, it should still be possible to effect considerable improvements in present practice. Thus, chlorobromomethane (CB), now available commercially, is considerably less toxic than methyl bromide, while in comparison with carbon tetrachloride, it is much more efficient and produces much smaller amounts of toxic products at fires.

The Joint Fire Research Organization has collaborated with the Air Ministry in experiments to help in deciding the extent to which this information can be used in improving the efficiency of first-aid appliances at aircraft crash fires. CB was compared with a dry powder extinguishing agent of commercial origin, and was found to be more effective under the conditions of the test; the fumes produced during the use of CB introduced a certain toxic hazard which has to be taken into consideration as well as the intrinsic efficiency of the medium when deciding where it should be applied.

* Report of a Committee on Vaporizing Liquid Extinguishing Agents. *Fire Research Technical Paper No.* 2. H.M.S.O., 1954. (1*s.* 6*d.*).

EXTINCTION OF FIRES IN LIQUIDS BY WATER SPRAYS

Basic studies of the effectiveness of water sprays in extinguishing fires in kerosine have been mentioned in earlier reports. This work has reached the stage during the present year in which it was possible to compare a variety of sprays on fires in a series of liquids with widely different boiling points. Broadly speaking, extinction was easier with liquids of higher boiling point than with those of lower boiling point. In general, sprays with small drops were more effective against liquids with low boiling points, for instance, benzole or petrol, and coarser sprays were better against those with higher boiling points, such as gas oil and transformer oil.

PROTECTION OF OIL STORAGES

The injection of foam at the base of oil storage tanks for fire extinction has many points in its favour, the more important being that it can be introduced through existing product lines and that the foam layer builds up gradually without breaking the surface layer in contrast to the disturbance which occurs when foam is poured from the top of a tank that is only partially full.

Experimental work using base injected foam in the extinction of oil fires has shown that the expansion ratio of the injected foam should be low (about 3·5), otherwise the foam will pick up petrol to such an extent that the resulting foam layer becomes flammable. It is also important that the foam should not drain rapidly; this may be prevented with some foam compounds by increasing the mechanical work used in producing the foam, and thereby reducing the size of bubble as compared with that required for foams to be applied at the surface.

The amount of foam solution used for this method of extinction is of the same order as that required for top application.

FOOD INVESTIGATION

The Food Investigation Organization comprises a Headquarters in Cambridge and 4 Divisions situated at three main laboratories and three smaller laboratories as follows:—

(i) General Division for Biochemistry and Biophysics at the Low Temperature Research Station, Cambridge.

(ii) Meat and Meat Products Division at the Low Temperature Research Station and at the Smithfield Laboratory.

(iii) Fish and Fish Products Division at the Torry Research Station, Aberdeen, and at the Humber Laboratory, Hull.

(iv) Fruit and Vegetables Division at the Ditton Laboratory, Maidstone, and at the Covent Garden Laboratory.

The Organization is responsible for investigation of problems arising in connexion with the handling, processing, storage and distribution of foodstuffs in general and, in particular, of fish, meat, poultry, eggs, fruit and vegetables. These problems are mainly concerned with defining, maintaining and preserving quality, eliminating wastage and reducing cost. A considerable amount of basic research is carried out at each of the main laboratories.

Selected items from the research programme are described below.

MEAT AND MEAT PRODUCTS

Quality of Fresh Meat

One of the factors which affects the quality of meat is the firmness or softness of the fat. It has already been established that the firmness of the fat of beef cattle increases as fattening proceeds. It has now been found that the same applies to the fat of sheep. One of the reasons why mutton fat is firmer than beef fat is that sheep are generally killed in a fatter condition than are beef cattle.

Frozen Beef

At one time, it was customary to cool sides of beef in chillers for one or more days before cutting into quarters and freezing the meat in special rooms. The development of blast tunnel freezers (through which air at very low temperature is blown at high speeds) has enabled chilling and freezing operations to be carried out in one unit. From the point of view of efficiency and speed of working, this is highly desirable. But it had to be determined whether such treatment would affect the quality of frozen beef, since experiments both on small animals and on the whale have shown that it is inadvisable to freeze muscular tissue (lean meat) before *rigor mortis* occurs. Results obtained in co-operation with scientists of the Commonwealth Scientific and Industrial Research Organization in Australia have shown that, under practical conditions, it is, in fact, not possible to freeze sides of beef before *rigor mortis* has set in. With good quality carcases, there is enough fat on the surface to slow down the rate of cooling below the rate required for freezing meat pre-rigor, while with poor quality beef, the muscles go into rigor so rapidly that freezing pre-rigor cannot take place. While there is, therefore, little danger that the use of blast tunnel freezers will damage beef by freezing it before the occurrence of *rigor mortis*, it has yet to be shown whether such early freezing is really desirable. It may, in fact, be better to hold meat in the chilled condition for some days in order to condition it (i.e. allow it to become more tender) before freezing.

Browning in Dehydrated Meat

When cooked minced meat is dried, and packed in tins with exclusion of air, the usual deteriorative changes such as rancidity of the fat can be prevented. In the dried meat, however, a brown discoloration, and later a stale flavour, occurred. This browning is due to chemical reaction between glucose and amino compounds. It is noteworthy that glucose has been found to be present in fresh meat. During the preliminary cooking of the whole pieces of meat, the glucose passes into the cooking liquid, from which it can later be removed by a fermentation process; the liquid is then added back to the cooked meat after it is minced, and the whole mass is dried. The keeping qualities of the dehydrated meat can thereby be considerably improved and the browning and stale flavour almost entirely prevented.

Detection of Washed Eggs

The economic consequences of washing dirty eggs on the farm, in terms of bacterial rotting during subsequent storage, has prompted many investigations. The position up to the end of 1951 was reviewed in *Food Science Abstracts* (**23**, No. 6, November, 1951). Since it is preferable to store only eggs that are naturally clean, several methods have been proposed for the detection of washed eggs. It is known that washing decreases the amount of potassium chloride on the shell; it has now been found that washing also depletes the surface of the shell of magnesium, and that most

washed eggs can be identified by testing for the presence of this element. The most promising method, however, has proved to be a chloride test, based on the photochemical reduction of silver chloride in ultra-violet light; about 96 per cent of washed or unwashed eggs could be identified correctly by this method.

FISH AND FISH PRODUCTS

A specially designed diesel electric trawler is being built to meet the research needs of the Torry Research Station. When complete, it will greatly facilitate the programme of work on fish and fish products.

Freezing at Sea

Fish is a highly perishable food. If its fresh quality is to be maintained, it must be kept cool at all stages from the time it is caught until it reaches the consumer. On long fishing trips, ice alone is not sufficient to keep fish fresh. The advantages of freezing fish at sea are obvious, but many difficulties are involved in developing economic methods of freezing on board ship. A vertical plate freezer, suitable for use on existing vessels, has been designed at the Torry Research Station and is now to be tried out. A joint experimental venture on freezing at sea on a commercial scale has been agreed upon in principle by the White Fish Authority, the Ministry of Agriculture and Fisheries, and the Humber Trawler Owners' Distant Water Development Committee. In essence, it is planned to install plant to freeze the first part of the catch on an existing Arctic trawler of the conventional type, and to operate the vessel for 12 months. The technical planning and supervision of the installation and of its operation is to be carried out by the Torry Research Station (working with the White Fish Authority). The size of installation depends upon the catching rate, the possible delay before freezing and its effect on the acceptability of the final product, and the total catch desired. The planning of the installation has therefore required study of detailed records of variations in catching rates obtained on survey voyages, and of landings' statistics, as well as much experiment and testing of freezer, product and storage temperature.

Parallel with work on the engineering side, studies have been made of the effects of the procedure used for freezing at sea on the quality of the fish produced. Laboratory experiments have shown that cod frozen at sea, which was first held in ice for not more than 3 days, and subsequently stored at $-29°C$ ($-20°F$), was of acceptable quality. The important fact has thus been established that, after catching, fish can be kept in ice for up to 3 days before freezing. This should allow of a fairly regular supply of fish to the freezer in spite of fluctuations in rate of catch. In further trials, samples of cod which had been frozen after holding in ice for different periods, were thawed, filleted, and in some cases, smoked by commercial firms. When the fish was distributed to retailers through the normal channels, it proved to be very acceptable, either when sold as fresh fish or as raw material for freezing on land or for smoke-curing. Thus, the freezing of fish at sea not only makes it possible to supply the consumer with fresh fish of improved quality but it also enables more of the catch to be utilized by providing fish suitable for subsequent processing by different procedures on land

It is clear that equipment for freezing at sea will not be installed on trawlers unless it is profitable to do so, and one of the objects of the coming trials will be to test this aspect of any possible development.

Quality of Iced Fish

If the consumption of fish is to be increased, a high standard of quality must be maintained. The factors upon which quality depends, and methods of assessing quality, are therefore studied. The usefulness and reliability of sensory assessment of the quality of iced white fish by a taste panel has now been established. In the laboratory, changes in quality can be reliably assessed either by a taste panel, using a numerical scoring system, or by chemical analyses of certain constituents of the fish flesh. Estimates of quality obtained by tasting tests have been shown to be related to certain chemical changes (the production of total volatile bases and trimethylamine) which take place in fish muscle during storage and which ultimately cause spoilage. In catches of cod from widely separated fishing grounds, it was found that, although the rates of spoilage in the different catches varied considerably, there appeared to be a single relationship between the numerical flavour score of the cooked fish, as assessed by the taste panel, and the content of total volatile base in the raw fish flesh.

Fish By-Products

The herring fisheries are seasonal, and at times of heavy catch, quite a large proportion of the total catch may have to be utilized for purposes other than human consumption. The greatly improved utilization of surplus herring is largely due to results of research carried out on behalf of the Herring Industry Board. The conversion of surplus herring to oil for edible purposes and to meal for animal feeding not only achieves full utilization of the catch and prevents waste but has become essential to the survival of the herring fishing industry. Methods of manufacture have now been established on a sound technical basis. To ensure the fullest possible utilization of raw material in times of glut, methods are being devised to preserve stocks of raw material until they can be processed. Certain preservatives can be added, but these must not injure the nutritive value of the processed products, nor must they cause serious processing difficulties. The growth of the herring meal industry has made an important contribution to supplies of animal feeding-stuffs in the United Kingdom. Between 1946 and 1953, production of herring meal increased from a few hundred tons to 18 000 tons ; the latter figure represents the average animal protein content of about 360 000 tons of compound feeding-stuffs.

In contrast to these rapid developments in the herring meal industry, the British white fish meal industry is well established and fairly stable in size, producing over 60,000 tons of white fish meal per annum. The processing techniques have been developing for a considerable time. Chemical engineering studies now in progress, in co-operation with the Association of Fish Meal Manufacturers, should help to keep the industry abreast of all developments in processing methods and machinery.

Biochemistry

Certain constituents of fish muscle affect the palatability of fish flesh, the changes which occur in the flesh during salt-curing, dehydration, and storage, and the growth of certain micro-organisms causing spoilage in fish. Substances which can be extracted from fish (principally cod) muscle are being studied. The important acidic extractive constituents have now been identified ; these include taurine, which had not been detected by an earlier technique. Some 91 per cent of the non-protein nitrogen in codling muscle has now been accounted for. Considerable seasonal variations may occur in some constituents. Qualitative and quantitative differences in the basic extractive substances present in different kinds of fish appear to be partly responsible for the characteristic flavours. During storage of fish in ice

under commercial conditions, the extractive and volatile constituents of the muscle undergo changes, which lead to alterations in flavour. Before the onset of bacterial spoilage, deteriorative changes due to leaching and autolysis occur in stored fish. A new muscle enzyme, anserinase, has been discovered, which is concerned in the metabolism of anserine, an important constituent of muscle.

Bacteriology

It is important to discover the source of bacteria found on food materials. It is generally recognized that the taxonomy of the marine bacteria, and indeed of the non-pathogenic, asporogenous Gram-negative rods, and of certain Gram-positive asporogenous rods, presents peculiar difficulties. A new method of approach is the use of a technique employing antibiotics. By means of this technique, in conjunction with observations of morphological characters and macroscopic colony appearance, the pigmented and non-pigmented *Pseudomonadeae* can be quickly separated from each other and from the *Vibrio* species, and *Achromobacter* species can also be separated from the non-pigmented Gram-positive and Gram-negative *Bacterium* species. This is an important contribution to bacteriology, as well as a discovery which should facilitate work on the problems concerned with bacterial spoilage in fish.

FRUIT AND VEGETABLES

Lenticel Rotting of Apples

One of the outstanding problems in the storage of home-grown apples is to find ways of reducing the amount of lenticel rotting, caused by *Gloeosporium* species, of Cox's Orange Pippin apples held in storage beyond Christmas. This form of rotting (sometimes called " specks ") has long been known as a cause of loss in America, Australia and New Zealand, but it is only in recent years that it appears to have become a serious source of loss in England. The losses due to lenticel rotting suffered by growers in 1953 were considerable; they were higher than in 1952, and were of the same order as those sustained in 1951. Hence, long storage is becoming increasingly unprofitable to the grower. Since this has happened at a time when the more recently planted Cox's Orange Pippin trees are beginning to bear fruit and it is desirable to find ways of prolonging the storage period until March or April to allow efficient marketing of the larger crop, a solution to the problem is urgently required.

Although rotting develops during storage, infection originates in the orchard. Sources of infection, the way in which the fungal spores are spread, and the factors which influence the extent of infection are being investigated. Results so far are as follows: the types of canker and die-back produced on apple trees by *Gloeosporium* species have been identified and can be recognized. Inoculation experiments have shown that twigs of Cox's Orange Pippin trees are infected more rapidly than twigs of Bramley's Seedling trees. Cankers caused by inoculation in May produced viable spores of *Gloeosporium perennans* in June, and continued to produce spores throughout the remainder of the growing season and the following winter. Samples of fruit from badly cankered trees were found to suffer considerably more rotting during storage than fruit from trees without obvious cankers. Apples grown in different orchards, as well as apples of different varieties, show considerable differences in susceptibility to rotting. Spraying trees in the late summer appears to decrease the amount of subsequent rotting. Modifications in storage conditions likely to delay rotting must also be considered. The effect of cultural conditions on the incidence of lenticel rotting and other storage diseases are being investigated in co-operation with the East Malling Research Station.

Scald and other Physiological Diseases of Apples

During the storage of apples and pears, losses are not only caused by infection with micro-organisms but may occur as the result of abnormal changes within the fruit itself. One of the most troublesome of these physiological diseases is scald. Studies on the causes of superficial scald of apples are complicated by the fact that the same variety of apple tends to show different types of skin injury in different seasons. Nevertheless, it is now clear that: exceptionally fine summers (such as those of 1947 and 1949) are much more likely to produce fruit susceptible to scald than are normal English summers; the larger the apple, the greater is the risk of scald; and the earlier the fruit is picked, the greater is the risk of injury developing on the skin during storage. With early-picked apples, the only satisfactory way of preventing scald is to wrap the fruit in oiled paper; with late-picked apples, however, such wrapping often produces skin lesions. The risk of injury is increased if the rate of movement of air inside the store is inadequate.

Some facts of practical importance to fruit growers have emerged from studies of the more academic aspects of the problem, i.e. the rate of production of certain volatile chemical substances, particularly ethylene, by the fruit during storage. Ethylene may accumulate in the atmosphere of the store in two different ways. The more usual way is a gradual increase up to about the 75th day of storage, after which ethylene can be removed by ventilation as rapidly as it is formed; in years when this is the case, the apples remain relatively free from injury. On the other hand, the concentration of ethylene may continue to increase during the whole period of storage; when this occurs, there is a serious incidence of scald. Certain hypotheses to account for this phenomenon are being tested.

Loss of Weight in Stored Fruit

Another problem which causes fruit growers some concern is the loss in weight of stored apples due to evaporation of water. Measurements are being made of the loss of water from apples in commercial stores, and the storage conditions which affect loss of water are also being investigated in a 10-ton store at the Laboratory.

Of the total heat removed by the refrigerating plant during the cooling down period, it has been found that between 20 and 30 per cent can be accounted for by the latent heat of the water which is evaporated from the stored fruit and condenses on the surfaces of the cooler. During the initial cooling period of a 50-ton apple store, the water normally condensing on the coolers amounts to between 750 and 1000 lb. After the store has been cooled to the temperature at which the fruit is to be stored, the heat extracted as latent heat by condensation may still amount to between 12 and 18 per cent of the total, and this may result in excessive loss of weight and, what is even more important, loss of quality and market value of the fruit. Methods of raising the humidity of some commercial stores, and thereby reducing water losses, are being investigated.

Storage and Transport of Soft and Stone Fruits and of Vegetables

Soft and stone fruits and some green vegetables are highly perishable, and consequently extensive wastage may develop in such products between the time they are dispatched by the producer and the time they are used by the consumer, particularly in hot weather. Special attention is therefore given to means of controlling the extent of deterioration, particularly by cooling and by storage in modified atmospheres. A mobile refrigeration unit is proving useful for demonstrating the value of pre-cooling the products immediately after harvest and transporting them from the producing areas

to the large markets. Preliminary trials have shown that pre-cooling combined with treatment with carbon dioxide gas (which can retard the growth of moulds) may be of assistance in marketing soft fruits such as raspberries. With plums, cool storage in an atmosphere with a lower oxygen content than normal might delay ripening and extend the storage life of the fruit. In the late winter and early spring, there are sometimes gluts of Cornish broccoli, and it is important to find ways of making full use of these surplus supplies at a season when green vegetables are scarce in other areas. The mobile refrigeration unit has been used to store broccoli in the producing area. It was found that broccoli, thus stored in Cornwall for up to 3 weeks, could subsequently be transported to London and remain in good condition long enough to permit marketing. Storage at the point of production has proved to be more satisfactory than storage on arrival at the market, since delay in cooling and damage during transport have adverse effects on keeping quality.

Biochemistry

Nitrogen Metabolism of Apples:—About one-third of the total protein of the apple is present in the peel. Since the peel forms only about one-tenth of the total fruit tissue, most of the physiological activity of the whole apple appears to be due to the activity of the peel. Epidermal tissue (peel) respires at least five times as rapidly as cortical tissue, and the respiration of peel continues steadily for relatively long periods, while that of cortical tissue decreases rapidly. The biochemistry of the epidermal tissue thus has an important bearing on the behaviour of apple fruits, and certain differences in composition of the peel and the pulp have been discovered. The peel of young fruits appears to differ from the pulp tissue in containing a greater amount and variety of amino acids; a new amino acid, which has been provisionally identified as methoxyproline, has been found in appreciable quantity in the peel, but not in the pulp, of young Worcester Pearmain apples.

Organic Acids in Apples:—The organic acid content of the pulp of mature apples has been found to consist almost entirely of malic acid, but the peel may contain almost as much quinic acid as malic acid and also considerable quantities of citramalic (1-methyl malic) acid, an acid which has not previously been reported in plant or animal tissue. The proportion of this acid in the peel differs with the variety of apple. Citramalic acid is of interest because it is readily oxidized to acetoacetic acid, which is easily decomposed to yield acetone, one of the volatile substances given off by apples.

Volatile Substances Produced by Apples:—During part of the storage period, Edward VII apples (a variety susceptible to scald) produce more acetone than do Laxton Superb apples (a variety resistant to scald). Greater quantities of volatile alcohols, aldehydes, and esters are produced by Laxton Superb, however, than by Edward VII apples.

GENERAL BIOCHEMISTRY AND BIOPHYSICS

Certain constituents of food materials are responsible for the characteristic flavour, odour, colour, or texture of foods, or for the deterioration which may occur under various conditions of storage or processing. An essential part of food research, therefore, is to determine the chemical nature, and to separate and identify, the important constituents of food materials.

Polyphenols

The phenolic constituents of plants are being investigated. Of these, the leuco-anthocyanins in particular are widely distributed in the plant kingdom,

and have markedly astringent, tannin-like properties. It has been shown that the leuco-anthocyanins make an important contribution to astringency in tea, cacao products, wines, fruits and fruit juices. Synthesis of these substances in the laboratory has confirmed their structure as 3, 4-flavandiols.

Ascorbic Acid

Ascorbic acid occurs naturally in all plants. It is not only an essential constituent of the human diet but it also has uses in food technology. Studies are being made on a semi-technical scale of the economic possibilities of employing ion-exchange processes for the preparation of ascorbic acid and other useful constituents from forage plants. This work entails a study of the ascorbic acid content of such plants, and also of the role of ascorbic acid in plant and animal metabolism and the way in which this substance is formed in plants and animals. The route of synthesis of ascorbic acid from simple sugars has now been discovered and the synthesis effected enzymically *in vitro*. This is an important advance in pure biochemistry. The way in which proteins are built up from amino acids in the cells of plants is also being investigated *in vitro*.

Metabolism of Potatoes and Peas

In general, the rate of respiration of harvested fruits and vegetables determines the time for which these products can be stored in a fresh state. Studies are being made of the constituents of the potato tuber which are concerned in respiratory metabolism during storage under controlled conditions of temperature and gaseous environment, and also of the changes which occur in the metabolism of green peas during ageing and during artificial wilting.

STERILIZATION OF FOODS WITH IONIZING RADIATIONS

When representative samples of meat, fish, dairy products, vegetables, fruits, and processed foods were irradiated, mainly using 2 million electron-volts electrons, it was found that a dose (2×10^{-6} rep) which usually effects sterilization produces changes in flavour, colour, or texture in almost all the products examined. Although these changes may be minimized by a method based on de-aeration and deep freezing before irradiation, it is doubtful whether this method would be commercially applicable. Present available knowledge about the sterilization of foods with ionizing radiations has been embodied in a *Food Investigation Special Report.** A review of the present position has been published in *Food Science Abstracts* (**26,** No. 2, March, 1954).

INSTRUMENTATION

In the course of work on a particular commodity, novel and sensitive instruments are sometimes devised which have a wide application in other fields. An example is the capacitance resistance hygrometer, which was devised at the Torry Research Station for measuring the relative humidity in atmospheres. This instrument gives a direct measurement of relative humidity in terms of electrical quantities, and it can be read at any distance. It can be made in different sizes; even when as small as a needle-point, its sensitivity is unimpaired. It can thus be used to measure humidity in confined spaces, such as the interior of small containers, in granular material such as grain or flour, or in materials such as tobacco,

* HANNAN, R. S. Scientific and Technological Problems involved in Using Ionizing Radiations for the Preservation of Foods. *Food Investigation Special Report No.* 61 (In preparation).

timber, etc. Since relative humidity is related to moisture content, rapid determinations can also be made of the moisture content of these materials. The instrument has applications in air-conditioning in factories or public places where control of the relative humidity of the atmosphere is required. In the laboratory, it has been possible to control the relative humidity to within ¼ per cent by means of this hygrometer.

FOREST PRODUCTS RESEARCH

At the Forest Products Research Laboratory the demand for industrial information and advice remains at a high level, and the finding of time for an adequate pursuit of new knowledge remains difficult. Nevertheless a further small increase can be reported in the amount of work done on research projects, particularly on the applied side. The routine testing of new Colonial timbers is still a major project, but during the year the collaborative work with the Forestry Commission on home-grown timbers from their forests has greatly increased, and is already on the way to equalling that on the exotic timbers. This change of balance reflects the changing timber position arising partly from the freeing of the softwood market, which will challenge the position of some of the tropical timbers utilized in recent years. At the same time, with the increasing maturation of the home-grown crop, much needs to be learnt about its quality, both in regard to efficient utilization and to future afforestation. The project is a long-term one, and owing to the necessarily slow accumulation of information, it will be some time before sound conclusions can be reached.

Another task involving all sections of the Laboratory is the compilation and assembly from interim publications of data on timbers, old and new, which have been dealt with during recent years. Two new handbooks, one on hardwoods and one on softwoods, will shortly replace the *Handbook of Empire Timbers* and *the Handbook of Home-grown Timbers.*

All sections have also played their appropriate parts in the dissemination of the Laboratory's knowledge through written replies and reports, personal visits to industry, and the reception of technical visitors. Close contact with the public, industry, public bodies and government departments has been maintained.

The following notes refer to some interesting aspects of the work of some of the sections during the year:

SEASONING

In the programme of investigations into the kiln-drying of timber, tests have been carried out to find the effect of air speed and relative humidity on the drying rate of the wood. The tests were made in the Laboratory's new pilot kiln, and the timber used was 1-in. beech. The effects of air speed and humidity on drying rate were investigated on the air inlet side of a pile, and a constant-temperature schedule using humidities normally recommended for drying beech was employed. The fan was run to produce speeds of 2¼, 5 and 11½ ft/sec respectively through the 1-in. air spaces between the planks and, to overcome matching difficulties, the samples were re-wetted after each run by a water impregnation treatment. The times taken to dry the wood to 12 per cent moisture content were 7, 5¼ and 4 days respectively, and the drying curves showed that air speed had its greatest effect upon drying rate during the relatively free-drying period when the wood was green, but that from 30 per cent moisture content downwards, when the transfusion

rate through the wood became the main factor in determining drying speeds, the effect of air speed over the wood surfaces on drying rates was small.

The results of these tests and of cognate ones obtained by changing the humidity tend to confirm the view that an increased air speed reduces the film of cooler, more humid air that tends to accumulate over the surface of relatively free-drying material and so in effect reduces the surface humidity. Further tests on other species and also on the drying lag across a wide pile are nearing completion.

An item of interest in the history of the Seasoning Section is the completion of 25 years of the course for kiln operators. Since 1928 the course has been taken by nearly 800 trainees including not only kiln operators but also members of the industry up to executive level. From this course, which is given free, great benefit has accrued both to industry and to the Laboratory, particularly from the continued contact maintained after the trainee has returned to his firm.

WOOD BENDING

Work has been started on a project to investigate the technique of production of large-section laminated bends such as are used in boat building. The actual making of the bends, the setting of the adhesives by conventional and by radio-frequency methods, and the strength of the finished bends are under investigation.

Among other developments of immediate interest to the wood-bending industry are improvements in the Laboratory's process for making plywood corners of small radius, and the development of a method of mass-producing bends containing re-entrant curves.

TIMBER MECHANICS

The results of three investigations of interest to designers of timber structures have been published during the year. The project started in 1952 for the testing of struts had as its main object the provision of data on both high- and low-grade material as short, intermediate and long struts. Over 500 Baltic redwood struts and small clear specimens matched with these struts have been tested and tests have also been made on a high-grade Douglas fir, Sitka spruce and high- and low-grade Scots pine. A report[1] has been published.

The programme of tests to determine the strength of joints made with round wire nails has been completed[2]. This investigation involved a study of the effect of three variables on the strength of the joint, namely, (i) the type of loading, whether single or double shear, (ii) the number of nails used to make the joint, and (iii) the thickness of the members joined. Three sizes of nail in common use were chosen for the tests and two-member and three-member joints were fabricated with each size of nail. All joints were tested in compression parallel to the grain.

Examination of the results of the tests shows that the maximum load carried by the joints is directly proportional to the number of nails used within the range of 1 to 4 nails. The results indicate also that the nails when loaded in double shear give joints about 50 to 75 per cent stronger than when loaded in single shear. The strength of the three-member joints increases with decrease in the thickness of the centre member whilst the strength of the two-member joints increases with increase in thickness of the member receiving the nail point. All joints are extremely stiff initially, three-member joints with 2-in. 12-gauge nails giving a slip of 1/100 in. at half maximum load compared with a slip of $\frac{1}{4}$ in. at maximum load.

Work on the determination of the strength properties of plywood has continued throughout the year. Reports[3], [4] have been published on Part I of the investigation, which has as its object the derivation of fundamental strength data to enable comparisons to be made between different species, and on Part II, in which a study of the effect of geometry and thickness on the strength properties has been made. Samples of gaboon plywoods varying in thickness from $\frac{3}{16}$ to 1 in. have been tested in bending, compression and tension. Solid wood specimens taken from the ends of the billets from which the plywood was made have also been tested by standard methods. From the results of these tests the relationships between the strength of plywood and solid wood have been determined. These relationships when used in conjunction with the test results published in Part I should enable fairly accurate estimates to be made of the strength properties of any plywood construction.

Projects in progress in Timber Mechanics include studies of the effect of temperature on strength ; the effect on strength of kiln drying by superheated steam ; on long-term loading ; and on connector joints.

WOODWORKING

Investigations have been continued on the boring of quarter-sawn and flat-sawn material from various species, the torque and thrust being measured at different spindle- and feed-speeds. The latter conditions control the thickness of the chips removed, and the cutting resistance for a specific wood depends not only on this thickness but also on the efficiency of chip ejection by the bit. With timbers containing resin, there is a tendency for it to act as a binder to the chips, which are not then readily ejected but may form a solid plug in the flutes of the drill. It may also be deposited on the tool clearance faces and cause overheating. It has been found that these troubles can be partly overcome by avoiding conditions under which small-size chips and dust are produced. The suitability of certain types of boring bit for particular classes of timber has also been studied and information obtained on modifications required to the major cutting and clearance angles and the included angle of the wings of the drill. The importance of adequate clearance to the main cutting edges has been noted in these tests, for blunting appears to start at the clearance faces, as shown by the appreciable rise in thrust. As blunting spreads to the actual edges, the torque also increases and the efficiency of cutting deteriorates, thus affecting the accuracy and the quality of the finish. A pilot test was made on the effect of size of bit on the power demand, which was found to be approximately proportional to the square of the radius.

A report on the mechanics of sawing for band- and circular-saws has been published[5]. It contains an analysis of the cutting action of band- and circular-saw teeth, with the relationships established between the dimensions of the wood removed and the conditions of cutting, and includes a hypothesis, based on studies of chip formation, concerning the resistance offered by the wood to the passage of saw teeth. Equations are derived for the energy consumption, maximum allowable feed speeds and other factors in terms of the shape, spacing and relative sharpness of the teeth, cutting speed, and the strength properties of the wood. Information is also given on the influence of the cutting conditions on the rate of blunting of the tooth. The publication is intended to provide data for designing saws for specific requirements and for checking the performance of existing saws. A bulletin on some of the practical aspects of these matters has been published and was referred to in last year's Report (p. 51).

Research in planing has been continued and further knowledge has been gained of the relationship to machine performance of cutting angle, spindle speed, number of knives in cut and feed speed.

COMPOSITE WOOD

Much of the advisory work on plywood and allied products is concerned with defects, such as distortion and surface defects arising in service, the causes of which are often obscure. A systematic study of the effect of those variables in the manufacturing process likely to underlie subsequent distortion has been in hand for some time, but so far the results have been anomalous. The analysis of surface defects has been more successful. On untreated plywood, weathering tests of 59 timbers have enabled a classification to be made of proneness to surface cracking, and similar tests on beech plywood protected by paint, painted plastic coating and impregnated paper facings, give a measure of the efficacy of these coatings in inhibiting the surface splitting.

A cognate problem of great industrial interest is the occurrence, in the surface of articles with a high gloss finish, of blemishes which, minute as they often are, become visible only after polishing. A complete systematic study of such defects has not been possible, but there are certain basic causes of many of them. The two most common defects are small furrows and fine "checks" or splits, which may often be removed by light sanding of the surface, but which may reappear if changes of moisture content of the article occur. The causes of these and similar defects are traced by microscopic examination of the surface veneer and the layers underlying it. Sometimes the primary cause can be found in a defective base on which the veneers are laid—badly peeled or over-sanded material; in other instances the decorative surface veneer itself has been too heavily sanded and is too weak to withstand even the normal movement of the base material, while additional checking may be due to the crazing of a thickly-spread adhesive. A discussion of these defects and their causes has been published[6].

Among the current projects in plywood research which have not yet reached report stage is the work on the production of preserved plywoods, which is being attempted both by treating the component veneers and the finished plywood. The difficulty in the former method is to secure a satisfactory bond when the veneers are made up into plywood; in the latter, to ensure complete penetration of the various selected preservatives. Another project in progress is the investigation of temperature penetration and moisture penetration in plywood, a matter of importance in manufacture.

During the year two reports on service trials have been published[7], [8], as well as a summary of the trials of timbers for plywood manufacture[9], which brings together for 47 species the data on logs, processing, yield and quality.

WOOD PRESERVATION

The standard tests on wood preservatives have now been in progress for about 23 years, and although none of the tests on individual preservatives is yet completed, much information on the performance of all the more important preservatives has been obtained. The results of the tests to date have been included in an interim report[10].

The service trials on railway sleepers begun in 1935 are now nearing completion, the sleepers being gradually taken out of the line during normal track relaying. They have now been replaced at 9 of the 12 original sites, those at 3 sites having been extracted and examined this year. It appears that in fast main lines generally the mechanical degrade is a much more common cause of deterioration than fungal decay.

MYCOLOGY

In the work on timber-rotting fungi, attention has been chiefly given to the physiology of the group of Ascomycete fungi which give rise to "soft rot", which, following its discovery in water-cooling towers, has been found in many other situations[11]. Current work is concerned with the nutrition of these fungi and the mode of their decomposition of wood. Co-operation with the British Electricity Authority on the decay in water towers continues.

Following the inspection of a wide range of craft the bulletin, *Prevention of Decay of Wood in Boats*, has been completed and published[12]. This bulletin is the outcome of a meeting of representatives of the Services, boat builders, naval architects and the fishing interests which was convened to discuss the serious problem of decay in wooden craft.

An inspection of the timbers of *H.M.S. Victory* was carried out. In spite of improved ventilation in her holds, the moisture content of many of the old timbers is still high enough for decay to proceed, and it has been arranged that moisture content determinations shall be made periodically on timbers in different parts of the vessel so that the progress of the drying out can be followed.

In addition to the maintenance of the national collection of wood-destroying fungi and to other routine commitments, work has proceeded on the investigations on dry rot, on sap stain in timber, and on the prevention of deterioration in logs of perishable species.

ENTOMOLOGY

Accurate data are lacking on the comparative susceptibility to *Lyctus* powder-post beetles of air- and kiln-dried hardwoods, as determined by the effect of the method of seasoning on the amount of starch in the sapwood on which the grubs feed. A final answer awaits controlled tests with different timbers of known starch content; meantime, a small-scale investigation has been started with freshly-sawn 1-in. oak boards, of which half were kiln-dried and half left for air seasoning. Considerable depletion of starch took place during kiln drying—probably during the initial warming up of the kiln—which may be compared to the depletion which usually occurs during the slower processes of air seasoning. These preliminary results are supported by numerous observations on starch content before and after kiln seasoning of oak and other hardwoods.

Some damage by *Lyctus* in new hardwood flooring is still being reported. Although it is usually possible from a knowledge of the habits of the insect to indicate the origin of attack and assess the risk of spread of infestation, more definite data based on practical tests are desirable. A series of test panels has therefore been prepared, incorporating kiln-dried oak floor boards laid in accordance with normal practice. In some panels, a number of the blocks was exposed to attack at various intervals before laying, and progress of damage, emergence of beetles and spread of infestation from attacked to sound blocks are being studied. Other panels were exposed to infestation at various stages of preparation, e.g. after embedding of the blocks, after sanding and oiling or after polishing, with the object of determining the degree of protection afforded to finished and semi-finished flooring. The technique will later be used to assess the value of insecticidal dips for application to flooring before laying and also to determine the value of surface application of insecticides for eradicating existing infestation.

Studies on the biology of the common furniture beetle are continuing, particularly on the effect of decay on the attack of the beetle. With both fresh and old heartwood of Scots pine decayed by a brown rot, larvae are

still feeding and tunnelling 3 years after egg-laying. Some confirmation has also been obtained that attack may spread into heartwood in the presence of decay, which renders this insect of greater structural significance than has hitherto been realized.

An analysis has been made of all cases of attack by the house longhorn beetle which have come to the notice of the Laboratory since 1934, and a general account of the distribution of the insect in the United Kingdom, including a discussion of the possibility of spread of infestation in relation to the quality and dimensions of softwood roofing timbers in modern buildings, has been published[18]. Records show that infestation is still largely confined to several districts in Surrey where 300–400 buildings are known to be attacked. Elsewhere, there were instances of damage in only about 30 buildings and in approximately half of these the insect was no longer active.

The long-term biological research on house longhorn and death-watch beetles is continuing.

CHEMISTRY

In addition to a number of *ad hoc* investigations, the work in wood chemistry has included that on its two chief lines of research—the chemistry of wood polysaccharides and the production of hardboards from secondary Colonial timbers. In the former investigation, the isolation of hemicelluloses B and C from beech wood has been accomplished, a polysaccharide containing mannose and glucose units only has been isolated from Sitka spruce, and further work has been done on the saponins of the British Guiana timber morabukea. In the fibreboard project satisfactory progress has been made in increasing the ultimate strength of the boards and in improving their water absorption. During the year successful hardboards have been made from 3 Malayan hardwoods.

PHYSICS

Work has continued during the year on the physical properties of wood, including specific heat, the effect of shear on the frequency of vibration of wooden beams, and various experiments on wood-water relationships.

EXTERNAL RELATIONS

It has been possible to increase considerably the work in co-operation with the Forestry Commission on the quality of timber in relation to site and soil. The consignments of home-grown softwoods converted and examined have been chiefly of Sitka spruce from various localities, but parcels of Norway spruce, Douglas fir, and western red cedar have also been dealt with. Some of the timbers came from the windblown area in Scotland.

Industrial survey work has included visits to a wide range of timber-using firms, and the educational work of the section has been fully maintained. Technical visitors from overseas during the year represented 34 different countries and colonies. General intensive courses were given to four university groups of students and to instructors of the Timber Development Association, and six courses for kiln operators were held. Seven students from Cyprus, India (two), Malaya, Siam, Turkey and Yugoslavia respectively, have carried out long-term courses at the Laboratory.

REFERENCES

(1) SUNLEY, J. G. The Strength of Timber Struts. *Special Report No. 9. (In the press).*

(2) BROCK, G. R. The Strength of Nailed Timber Joints. *Timb. Tech.*, 1954, **62**, 283–286, 333–335.

(3) CURRY, W. T. The Strength Properties of Plywood—Part I. Comparison of 3-Ply Woods of a Standard Thickness. *Bulletin No. 29.* London, 1953 (H.M.S.O.)

(4) CURRY, W. T. The Strength Properties of Plywood—Part II. The Effect of the Geometry of Construction. *Bulletin No. 33.* London, 1954 (H.M.S.O.)

(5) HARRIS, P. Mechanics of Sawing: Band and Circular Saws. *Bulletin No. 30.* London, 1954 (H.M.S.O.)

(6) NEWALL, R. J. Surface Defects in Veneering. *Wood*, 1953, **18**(12), 462–465.

(7) KNIGHT, R. A. G. and NEWALL, R. J. Seven and a Half Years of Durability Tests on Adhesives in Plywood. *Wood*, 1954, **19**(7), 287–290.

(8) KNIGHT, R. A. G., NEWALL, R. J. and SOANE, G. E. Durability of Assembly Glues—Series A. Report on Ply-clad Frames after 7½ Years' Exposure. (*Laboratory Report*).

(9) KNIGHT, R. A. G. Trials of Timbers for Plywood Manufacture. *Wood*, 1954, **19**(2), 76–80.

(10) SMITH, D. N. Field Tests on Wood Preservatives used for Pressure Treatment *Bulletin No. 32.* London, 1954 (H.M.S.O.)

(11) SAVORY, J. G. Breakdown of Timber by Ascomycetes and Fungi Imperfecti. *Ann. appl. Biol.*, 1954, **41**(2), 336–347.

(12) SAVORY, J. G. Prevention of Decay of Wood in Boats. *Bulletin No. 31.* London, 1954 (H.M.S.O.)

(13) WHITE, M. G. The House Longhorn Beetle (Hylotrupes Dajulno) in Great Britain. *Forestry*, 1954, **27**(1), 31–40.

FUEL RESEARCH

During the last few years the programme of work at the Fuel Research Station has been re-adjusted to keep in line with two main trends in the fuel industries of the country; the increased use of petroleum oils is reflected in the amount of work done on flow properties of residual fuel oils; and the ever-growing complexity of modern developments has made it necessary to devote a greater proportion of the total effort to investigations in various fields of fundamental science on which present-day methods of preparation and use of fuels are based.

COMPLETE GASIFICATION

The production of town's gas, industrial fuel gases, and mixtures of carbon monoxide and hydrogen for the synthesis of ammonia and methanol is at present based on the carbonization of coals which give a strong coke as a by-product, and on the subsequent gasification of dump coke with air or steam. The reserves of such coals are limited, and coke is also required by the steel industry and as smokeless fuel, so that it is desirable to develop methods of gasifying non-caking coals, which are more abundant. The methods adopted must be capable of dealing with finely-divided fuel, since many of the coals concerned disintegrate on heating and many have a high proportion of fines when received from the colliery.

Experimental work on the gasification of coal fines with steam by the fluidized-solids technique has therefore been continued, using a small pilot-scale plant and a number of laboratory-scale units. In this method a dense turbulent suspension of fuel particles is maintained by a rising current of steam in a heated reaction chamber. Conversion of peat and of a variety of coals to gas suitable for chemical syntheses has been carried out under these conditions at temperatures of 800 to 900°C, but there were considerable losses of fuel as fine dust entrained in the gas. If this process is to be developed to an industrial scale, methods of utilizing this entrained dust would be necessary. Another method of gasifying fines is to inject them with air or steam into a chamber maintained at a temperature of about 1500°C. The ash of the fuel fuses to liquid slag which flows down to the base of the chamber whence it can be run off. The particles of fuel adhere to the fused slag and are not carried off with the gas. Experimental work has been done during the past year with a cyclone chamber 2 ft in diameter, into which the fuel and air are blown tangentially so that rapid reaction is induced by the intense swirling action of the gases ; up to 500 lb of coal fines have been gasified per hour in this way.

OILS AND CHEMICALS FROM COAL

Where coal is gasified by reaction with steam or steam and oxygen at high temperatures the resulting mixture of carbon monoxide and hydrogen can be converted into liquid fuels, waxes and chemical products by passage over a suitable catalyst, as in the Fischer-Tropsch process, which is of considerable potential importance to the economy of this country. The work in progress at the Station is directed towards reducing costs and introducing modifications to increase its suitability for industrial application.

The catalysts used consist of metallic cobalt or iron with various additions to modify their properties. Part of the work is devoted to the development of cheaper and more active catalysts, with the property of directing the reaction to yield the more economically desirable end products, and to exploring the range of temperature, pressure and gas composition that can usefully be employed with them.

Much heat is liberated during the synthesis reaction and the desired products are only obtained if the temperature is rigidly controlled. An important part of the work, therefore, is concerned with establishing the most suitable type of reaction system to employ in a full scale plant. To try out various systems a pilot plant to treat 2000 cu. ft of gas per hour has been built and, during the past year, has been successfully operated with a reaction vessel containing a "fluidized-bed" of cheap iron catalyst. In this system the gas mixture is forced upwards through a bed of powdered catalyst at such a velocity that the catalyst particles separate and are free to move in a turbulent fashion somewhat resembling a boiling liquid. This condition leads to uniformity of temperature through the catalyst and a high rate of transfer of heat to cooling tubes immersed in the "boiling" bed. The plant was operated for periods up to 21 days' duration and yields of useful products (crude petrol, middle oil, wax, liquified gas, alcohols and other chemical by-products) up to 70 gallons per day were achieved.

Other sections of the work in this field are concerned with the basic chemistry of the process, and include gas adsorption studies on catalyst surfaces, the use of the infra-red spectrometer for studying changes in product composition and the use of radioactive isotopes as tracers in studies of the reaction mechanism.

FLOW PROPERTIES OF RESIDUAL FUEL OILS

Distillation residues from petroleum refining are used mainly as fuel oil for boilers. The flow properties of such oils are generally satisfactory when freshly prepared but on storage physical changes may take place resulting in an increase in the viscosity of the oil which renders it difficult to pump. With some oils this occurs after only two to three weeks, but the problem becomes particularly serious if oil has to be stored for a number of years. When buying fuel oils that will have to be stored it is therefore necessary to be able to predict what the flow properties will be after storage for varying lengths of time. The problem is one which confronts all consumers of such oils but is of particular importance to the Admiralty.

In a study of this problem considerable progress has been made by simulating the viscosity increase that occurs in an oil on storage, through subjecting the oil to a suitable thermal treatment involving shock-chilling. However, the structure found in the oil which gives rise to the increased viscosity on storage does not appear to be of the same type as that produced by shock-chilling, and moreover, a shock-chilling procedure designed for use with one oil may be too severe when applied to another oil. Hence a specification based on this type of test procedure, and applicable to all oils, is liable to exclude many that are actually satisfactory. It is now clear that more fundamental knowledge is required if a completely satisfactory test, applicable to all types of residual fuel oils, is to be evolved. An examination is therefore being made of the types of structures that are built up during natural and artificial ageing.

BOILER AVAILABILITY

The formation of hard deposits on the exterior surfaces of the tubes of boilers fired with pulverized fuel has attracted little attention until recently, when trials at power stations showed that coals of very high chlorine content can cause rapid fouling. It is possible that the extensive exploitation of new seams containing coal of very high chlorine content, and the increasing use of pulverized fuel firing, may cause a serious problem with this type of plant in the future.

One line of attack has been to study a boiler which shows good performance even when fired with coal of very high chlorine content. So far the results suggest that various design features, particularly dispositioning and spacing of the superheater tubes, help to reduce the rate at which deposits form and the effect of the deposits on draught loss.

The constituents of these hard deposits in pulverized fuel-fired boilers are often cemented, or "bonded" by calcium salts, whereas in stoker-fired boilers the deposits are normally bonded by sodium and potassium salts. On the basis of these results, an explanation has been put forward for certain differences in behaviour of stoker-fired and pulverized fuel-fired boilers; one important conclusion from this work is that the formation of deposits in the latter type of boiler may depend not only on the chlorine content of the coal but also on the ratio of sulphur to chlorine.

The radioactive tracer technique has been used to investigate the mechanism of formation of the alkali sulphates responsible for many bonded deposits in boilers.

COMBUSTION CHAMBERS FOR COAL-FIRED GAS TURBINES

Further development work has been carried out on different types of combustion chamber for burning solid fuel in industrial gas turbines. Two of the combustion chambers, the "Straight-through" and the "Vortex",

burn pulverized fuel at temperatures sufficiently low to prevent the ash melting.

The effect of increasing the depth of the vortex chamber and the turbulence of the air stream which carries the coal into the chamber has been examined. Both these changes resulted in an increase in thermal efficiency, which is now about 95 per cent, but unfortunately this improvement was accompanied by an increased tendency for dust to be deposited on the refractory walls of the chamber. As a result of this a new central section of the unit is being built in which the fuel nozzles are situated around the periphery of the chamber instead of in the top.

Combustion chambers of the straight-through type, fitted with a burner of Fuel Research Station design, are being used by some of the firms working under contract with the Ministry of Fuel and Power on gas turbines fired with solid fuels. Work at the Station has been mainly concerned with modifications to overcome the tendency for small amounts of dust to be deposited on the refractory wall in the primary combustion zone. To supplement the full-scale combustion experiments, small-scale models have been constructed of transparent plastic to show the flow pattern of the gases within the chamber and to indicate changes in flow pattern resulting from changes in design or operating conditions. The construction of an experimental straight-through combustion chamber to be operated at pressures up to four atmospheres is in progress. This chamber will be used to obtain data on the influence of pressure upon combustion and overall performance. It is designed to burn about 1250 lb of coal per hour when supplied with 25 lb of air per second, preheated to 350°C.

A third type, the 'Cyclone' combustion chamber, is being developed by the British Coal Utilisation Research Association under a contract with the Department, as part of the programme of the Fuel Research Board. The chamber burns fuel below $\frac{1}{8}$ in. in size and operates at a high temperature which enables most of the ash to be fused and removed as liquid slag. The principal difficulty remaining to be overcome is a tendency for solidified slag to build up at points in the combustion system where the temperature is not sufficiently high. This may occur at the outlet of the combustion chamber where the diluting air mixes with the hot products of combustion and much of the work carried out on the chamber during the year has been devoted to overcoming this difficulty.

An industrial unit designed to operate on this slagging principle is being developed by a firm under contract with the Ministry of Fuel and Power.

Development work is proceeding on methods of cleaning the hot gas from the combustion chamber, so that, in the open cycle unit, the fouling of the gas turbine blades owing to erosion and corrosion and to deposition of ash is reduced to tolerable proportions.

SECTIONAL CENTRAL HEATING BOILERS

Experiments on a sectional heating boiler (rating 380 000 B.t.u. per hour) showed that under conditions that often occur in practice when burning coke, considerable amounts of fuel are wasted through combustible gases being present in the flue gas. Boilers of this type are usually operated by firing heavy charges of fuel at comparatively long intervals and it was found that the proportion of combustible gases was higher while the fresh charge was 'burning through'. After this stage, the heat loss depended on the burning rate, being highest when the burning rate was lowest.

It was found that the heat loss during the 'burning through' period could be reduced by firing the fuel as four small charges at 5 minute intervals instead of a single heavy charge, and that the loss at low loads could be

reduced by increasing the size of the opening in the fire-door, thus increasing the quantity of secondary air. The use of large coke (4 in. to 3 in.) instead of the smaller coke normally used (2 in. to 1 in.) also reduced the proportion of combustible gas.

COMBUSTION OF LOW-GRADE FUELS

In tests on various types of grates to determine their effect on the performance of a sectional heating boiler when burning coke breeze and other low-grade fuels some interesting observations were made on the effect of the size of the openings in the grate on the distributon of air through the fuel bed.

When burning small fuels, grates with small openings are generally used, partly to avoid loss of fuel through the grate but also to ensure an even distribution of air through the fuel bed. It is generally assumed that the effectiveness of this type of grate is due to the high resistance of the grate which compensates for variations in the resistance of the fuel bed itself.

During experiments in which air was passed through one of these grates, first bare and then covered with varying depths of fuel, it was found that the resistance of the grate itself was small, but the resistance of the fuel bed increased rapidly up to 1½ in. from the grate, after which it increased slowly and uniformly. From this it appears that good air distribution with this type of grate is not due directly to the resistance of the small openings but to the fact that air moves through the first 1½ in. of the fuel bed in small channels at high velocity. This observation may be of value in attempts to design a grate without using small openings which tend to become choked with dust and fine fuel.

DOMESTIC HEATING

The work on domestic heating is ultimately directed towards economy in the use of solid fuels in the home. It has two main objectives and involves both the testing of new designs of domestic heating appliances, and detailed studies of those factors which contribute to efficiency of production of heat. The one is aimed at the continuous maintenance of established standards of performance, the other at a long-term improvement in methods and appliances.

The facilities of the Calorimeter Building are being fully utilized in the study of the heat distribution from various types of domestic heating appliance, notably open fires and openable stoves, under various conditions. The practicability of establishing 'room heating efficiencies' for the main types of heating equipment is being studied. The measurement of the amount of smoke emission is also being investigated for various types of appliance, when burning different coals. A new and improved form of instrument for recording and measuring domestic smoke has been developed.

ATMOSPHERIC POLLUTION

During recent years, and particularly since the dense fog which covered London and some other parts of the country for several days in December, 1952, the problem of air pollution has received increased attention. The work of the Station on this subject has increased greatly since the war and at the present time the investigation of atmospheric pollution in various parts of the country receives the active co-operation of about 200 local authorities and other organizations who maintain about 1500 instruments for the regular measurement of deposited matter, smoke and sulphur dioxide. The results obtained from these instruments are valuable not only for the

nation-wide investigations but also for assisting local authorities and others in maintaining or improving the purity of the air in the areas covered by the measurements.

As the study of air pollution has developed new and specialized methods are required for more detailed investigations. At present work is in hand on the development of instruments for the continuous recording of the concentration of sulphur dioxide and of the loss of daylight due to smoke. Attention is also being given to the study of some relatively rare pollutants and of the substances emitted from the exhausts of motor vehicles.

Surveys of the distribution of sulphur dioxide in the vicinity of certain electricity generating stations are being continued and two additional surveys have been started in co-operation with medical research organizations who are studying possible relationships between air pollution and health.

Work is also being continued on the Fulham-Simon-Carves ammonia process for the removal of sulphur compounds from flue gas and it has been shown that the process must be worked in two stages if efficiency is to be maintained without excessive loss of ammonia.

GEOLOGICAL SURVEY AND MUSEUM OF PRACTICAL GEOLOGY

The Geological Survey of Great Britain is concerned with the investigation of the geology of the whole country and the presentation of results in the form of (i) maps at various scales, (ii) explanatory memoirs and research papers, (iii) economic reports and (iv) mineral, rock and fossil collections for exhibition and for study in the Museum of Practical Geology. Legislation enables the Survey to study all mine-workings, boreholes for minerals and for water, and the records pertinent to these activities. A geological service is also provided at the request of the Government of Northern Ireland.

The need for concentrated work on problems connected with coalfield development, mineral and water resources and hydro-electric schemes inevitably leads to the acquisition of new geological data and the critical investigation of new methods of research.

FIELD WORK

As in former years, the field staff has been engaged principally upon primary and revision six-inch mapping, with the concomitant duty of preparing maps for publication and furnishing descriptive accounts of the rock sequence and structure.

The general aim of primary six-inch survey is to carry towards completion the detailed geological examination of the country as a whole; during 1953, 295 sq. miles were surveyed which compares with approximately 200 sq. miles in each of the preceding three years. Priority in choice of ground is governed to a large extent by economic considerations. In South West England the needs of agriculture and dairy farming provide a strong reason for carrying the survey eastwards from the Bristol and Somerset Coalfield into the Bath (265) and Frome (281) sheets. In the south-east of England the incidence of agriculture, of the sand and gravel industry and of water supply problems makes the production of geological maps necessary; thus survey of the Canterbury Sheet (289) has continued. Attention has been given also to the Kent Coalfield. In addition the fenland east and north of Cambridge has been under survey. In the east and south Midlands the Jurassic ironstones upon which the country so largely depends for the raw material of its iron and steel industry, have been the dominant factor in

guiding the progress of survey in the Bourne Sheet (143) now completed, and in the Banbury Sheet (201) which has just been started. Work on the Chapel en le Frith Sheet (99) is related to lead and fluorspar mining and limestone quarrying in Derbyshire. In the Chester Sheet (109) the Cheshire salt field is being taken into account. On the other hand, the primary six-inch survey of the Church Stretton Sheet (166) is dictated by the need for progress in fundamental scientific investigation of the problems associated with a sequence of strata ranging from Pre-Cambrian to Carboniferous in age, with igneous rocks of various types, with structural problems of some complexity and with interesting late-Glacial features.

North of Avonmouth, on the Bristol Channel, the National Coal Board has drilled five boreholes on the basis of a report by the Survey in order to find the thickness and distribution of certain coals known to occur in the area. A basin of Coal Measures has been proved, having a length from north to south of at least four miles and a maximum width of a little over a mile. This field is completely concealed by Triassic and alluvial deposits.

Investigation of the country between Bradford and Skipton has yielded important scientific results regarding the Millstone Grit Series of the Carboniferous. The thickness of the Series in this district is about 4500 ft, and the marine fossil content, here as in adjacent ground to the west, is such as to make the Pennine uplands between Yorkshire and Lancashire an ideal type area for the Millstone Grit in Britain.

Primary survey in the Scottish Highlands has continued on ground astride the Great Glen in the Loch Eil Sheet (62); north-west of the Glen, various igneous and metamorphic belts were mapped and to the south-east, the classical fluvio-glacial terraces and "Parallel Roads" of Glen Roy and Glen Gloy gave opportunity for further study.

In connexion with the North of Scotland Hydro-Electric Board schemes, special surveys were undertaken to assist the two new projects at Glass-Morie and Glen Tilt. Further tunnel logs and reports were provided concerning the five projects of this Board mentioned in last year's Report (p. 64).

Nearly two-thirds of the field geologists have been doing revision survey in the coalfields and adjacent areas. Their work involves the examination and recording of borehole and shaft sections and the provision of advisory service in geological matters for the National Coal Board. The area of revision survey completed during the year 1953 was 341 sq. miles, including 40 sq. miles in Northern Ireland.

The resurvey of the area of the Pontypridd Sheet (248) in the South Wales Coalfield, was completed and further revision work was done in the anthracite and steam coal areas to the west and in the more bituminous coal district of the Newport Sheet (249) to the south-east. Revision survey in the Clitheroe Sheet (68) was completed. Progress was made with the Chesterfield Sheet (112); in this part of the Derbyshire Coalfield there is extensive opencast working and mining activity. The outcrops of the coals have been mapped on the six-inch scale, mostly for the first time. West of the coalfield metalliferous veins associated with the Matlock limestone have been the scene of recent prospecting with a view to the renewal of lead and zinc mining. In north-east England, the Durham Coalfield has been the subject of resurvey. Revision of the Bewcastle Sheet (12) in Northumberland has continued including a detailed study of its 6000 ft of Lower Carboniferous strata. Many areas in the Scottish Lowlands have been under revision, all related directly or indirectly to the coalfields but strata of Old Red Sandstone

age as well as Carboniferous have been examined. As a result of advice given by the Geological Survey, the National Coal Board has proved by boring a small but hitherto unknown coalfield in Clackmannanshire.

Revision of the area of the Ballycastle Sheet (8) on the north-east coast of Ireland has continued and the finding of a new small field, a few miles east of the main coalfield, was announced during the year. Revision mapping has begun in the Belfast Sheet (36), the various geological problems of this ground being a fruitful source of enquiry.

PALAEONTOLOGY

During 1953, nearly 24 000 fossils were added to the collections. Of these 2420 were presentations from 51 donors. Over 10 500 specimens were lent to specialist workers for study.

Coal Measures fossils have been examined from boreholes or workings in most of the coalfields in Great Britain and Northern Ireland, and special attention to the microfauna has led to increased knowledge of the thickness and distribution of marine horizons. Detailed study, in collaboration with the field staff, of the results of deep boring by the National Coal Board in the twenty miles of concealed ground between the North Staffordshire and Cannock Chase coalfields has made it possible to recognize the chief index horizons in these measures, thus providing a sound basis for correlation of the Coal Measures sequence between the exposed fields. The intervening area is covered by New Red Sandstone.

PETROGRAPHY

Petrographical investigations have continued to reflect the wide variety of work undertaken by the Survey. Accounts have been prepared of English rocks collected during current field-survey and from boreholes drilled for economic minerals including coal and potash. Scottish and Northern Ireland rocks have been examined from surface exposures, from boreholes or from tunnels driven for reservoir or hydro-electric schemes. Joint work with the Road Research Laboratory has shown the amount of correlation between the petrography and mechanical testing of quartz-dolerite, extensively used as metal on British roads.

X-RAY ANALYSIS

The X-ray work has been concerned with mineralogical and petrological problems arising from current field-survey, from economic enquiries and from long-term mineralogical and petrological research. The work has necessitated the examination of comparable material from the mineral collections and has thereby added considerably to the information available on certain selected minerals. The library of registered photographs has been increased by 274 films and now totals 923.

CHEMISTRY

Minerals submitted for examination included some containing uranium, rare earths and other elements such as niobium, zirconium and vanadium. A new chemical method has been devised for the determination of ferrous iron.

Vanadium in bituminous material, germanium in ores, and various rare metals in coal ash are amongst the elements now being determined quantitatively by spectrographic analysis.

GEOPHYSICS

Gravity surveying was continued in the English Midlands in an area which includes the coalfields of Coalbrookdale, North Staffordshire, South Staffordshire, Warwickshire, Leicestershire, South Derbyshire and Nottinghamshire. In the district surveyed during the year, a broad, elliptical area showing high gravity values was encountered south-east of Lincoln where Lower Carboniferous and earlier rocks have been proved by deep boring. Furthermore several local and irregular gravity variations were charted in the Stamford area. Detailed gravity surveys were undertaken near Stockport to investigate the courses of faults beneath drift-covered ground. A portable six-channel seismic equipment was used in surveying the junction between the Ashdown Sand and the Purbeck Beds at depths of a few hundred feet in an area near Mountfield, Sussex. The velocities of seismic waves in the Ashdown Sand were found to be 7000 ft/sec. and in the Purbeck Beds 10 000 ft/sec. Electrical resistivity surveys were also made in this area.

GEOLOGICAL SURVEY PROGRAMME OF BORING

Two types of investigation by boring are undertaken; the first to ascertain by deep boreholes the nature and distribution of the rocks lying some distance below the surface and the second to amplify and extend the findings of mapping and to add to its value and accuracy.

The Cambridge Borehole, undertaken jointly with the Woodwardian Professor of Geology, to prove the character of the Palaeozoic rocks underlying that area was stopped at a depth of 860 ft. At 771 ft, it passed downwards from Carboniferous Limestone into a conglomerate and then into red beds. These last are tentatively regarded as Old Red Sandstone.

The field survey of the Stockport Sheet (98) did not give enough information to produce a map in adequate detail, owing to the thick covering of drift. A series of ten boreholes, about 300 ft in average depth, was put in hand to provide the necessary data, and the work is nearing completion. In nearly all cases the cover of drift was 50 ft or more. The underlying beds have been successfully identified as belonging to the various subdivisions of the Triassic, and the purpose of the investigation has been fulfilled, namely, to produce a more satisfactory geological map. In this programme there has been close and mutually profitable co-operation with the geophysical department, gravity surveys having been carried out both before and after the boring operations.

To assist current mapping on both sides of the Scottish border a borehole is being drilled at Archerbeck, near Canonbie in Dumfriesshire, through the Lower Carboniferous succession.

UNDERGROUND WATER

The survey of the water resources of the Triassic Sandstone area of the English Midlands was continued. In the Birmingham district it was found that water was being pumped at an average rate of two to three million gallons a day in excess of the natural replenishment, whereas in the Lichfield district a surplus was proved although the reserves are small. The general question of artificial replenishment of aquifers is being studied.

RADIOACTIVE ORES

Researches directed towards the discovery of new sources of raw materials for atomic energy installations have continued. The growing interest in commercial atomic power has given a further impetus to prospecting in many parts of the world and a steady stream of specimens from supposed

new discoveries of uranium and thorium ores has been submitted to the Survey laboratories by prospectors, mining houses, and Government organizations, mostly from Commonwealth and Colonial territories. Approximately 2800 minerals, concentrates, and rocks were examined for radioactivity during the year and more than 500 other enquiries on radioactive ores have been handled.

Recent field studies in South-West England have revealed some hitherto unknown occurrences of uranium mineralization; but the total resources so far discovered in Britain are too small to support the high cost of a treatment plant. Attention continues to be given to exploration for new deposits within the British territories overseas; and during the year visits to inspect discoveries were made to Northern and Southern Rhodesia, Nyasaland, Tanganyika, Bechuanaland, Swaziland and elsewhere. The information derived from these tours has in a number of instances encouraged the mining houses to launch more costly programmes of exploration.

To assist exploration overseas, attention has been given (in collaboration with the Atomic Energy Research Establishment—A.E.R.E.) to the improvement of car-mounted Geiger counter and scintillometer equipment. Using this self-recording "Cargo" instrument mounted in a Land Rover vehicle, a radiometric survey traversing 8000 miles of bush track and open veldt country in Bechuanaland and Swaziland has been carried out by a G.S.M.-A.E.R.E. field party. Several regions were found which merit further investigation. This type of equipment has since been acquired by various official geological surveys and commercial mining interests; it is expected to prove a more satisfactory prospecting tool than similar aeroplane-mounted radiometric instruments which experience has shown are only of value under special geological and topographical conditions.

The importance of chemical adsorption in the geochemistry of sedimentary rocks has been emphasized by work on the uranium content of various phosphatic and carbonaceous deposits. In Nyasaland, for example, the remarkably high content of 0·73 per cent U_3O_8 was found; while such remote occurrences may not be of economic potentiality, they indicate types of deposit which merit further exploration. A high uranium content (0·08 per cent in the ash) has also been found in a thin coal seam encountered in the Warwickshire Coalfield; and similar uraniferous coals have been recognized from localities overseas. Typically these radioactive coals are thin, and they usually form the topmost seam of a sequence overlain unconformably by red beds, acid volcanic ashes or other strata from which uranium may be leached by downward percolating waters. It is believed that the coal adsorbs the uranium (and probably other metals such as germanium) from these waters either as a result of an ion-exchange mechanism or in the form of organo-metallic compounds. The uranium content in some foreign coals has been found to be high enough for the coal ash to form uranium ore.

Recent study has shown that fossil bones adsorb uranium from percolating waters, their radioactivity, taking geological variants into account, being roughly proportional to their age. By this technique it has been possible to contribute to the demonstration that the remains of Piltdown man are of post-Pleistocene age and hence of no geological significance.

MUSEUM OF PRACTICAL GEOLOGY (THE GEOLOGICAL MUSEUM)

In 1953 there were 355 592 visitors to the public galleries of the Museum, again a record. Attendance at the public lectures and demonstrations was 5936, an increase of 503.

Systematic revision of many of the permanent exhibits in each gallery to incorporate the results of recent research, was begun in 1953. Special exhibits in the Main Hall were also prepared, and some of these after display were sent on loan to museums.

Selections from extensive suites of lead and zinc ores acquired during the year from important producing mines in Australia, Canada, Mexico, the United States and Yugoslavia are being incorporated into a revised exhibit of lead and zinc ores of the world and the remainder will be available in the Study Collections.

The varied nature of the enquiries dealt with is illustrated by the following examples:—the identification of gemstones; the provenance of pebbles found in tobacco leaf; possible British sources of shale suitable for light-weight concrete aggregate after expansion by heat; European sources of stone for laboratory furnishings; the names and sources of many kinds of marble and building stone from Roman buildings at Colchester.

LIBRARY

The Library had 5498 visitors and 101 postal enquiries; more than 2820 books and 149 geological maps were added during 1953. In addition to the geological maps listed in Appendix VII as published by the Ordnance Survey Office, 77 quarter sheets on the scale of six inches to one mile were deposited in the Library for public reference. Of these 27 showed the results of original survey and 50, those of revision survey.

INFORMATION

During the year, answers were supplied to 3903 enquiries from Government departments, National Boards, Public Authorities, industry and agriculture, research and educational workers, and private individuals. Of these 1261 were problems referred to the field staff and the remainder were classified as follows:—water supply 1143, mineralogical and general 699, palaeontological 570, petrographical 174, geophysical 43. Enquiries dealing with radioactive ores have already been mentioned.

HYDRAULICS RESEARCH

Satisfactory progress has been made with the construction of the first stage of the Main Hall of the new Hydraulics Research Station at Wallingford, and it is hoped that experimental work will be started in the Hall in January 1955. Research has proceeded in the wave basins, flumes and smaller laboratories, which have been in use since 1952. As in previous years, assistance has been given to the Port of London Authority in the work on the Thames Estuary which the Authority is carrying out at the Royal Victoria Docks, London. The research which has been conducted extra-departmentally by Brigadier R. A. Bagnold, O.B.E., F.R.S., at the Imperial College of Science and Technology on the carriage of solid particles by flowing water has been completed.

TIDAL STUDIES

Work has been completed on the first major problem to be investigated in the large model of the Thames Estuary; this was carried out by the Port of London Authority in consultation with the Station. This problem concerned the heavy siltation which normally takes place in the Tidal Basin at Tilbury. After reproducing the complex three-dimensional flow pattern in and around the Basin as it had been found to exist in nature, it was

shown that certain training works would greatly reduce the inflow of silt-laden water to the Basin and thus reduce the dredging required to keep the Basin open to shipping. Recommendations for remedial works based on these experiments were therefore submitted to the Port of London Authority.

Research in the Thames Model (the scales of which are 1/600 : 1/120), and in the river, is now being concentrated on the formidable problem of siltation in the reaches immediately down-stream of the Royal Docks. The immediate object of this work is to collect further data in order to form a comprehensive working hypothesis to account for the behaviour of the whole estuarine system.

In the Pilot Model of the Thames, the scales of which are 1/3000 : 1/120, work carried out on the behaviour of storm surges in the estuary has been completed for the Departmental Committee on Coastal Flooding. The experiments demonstrated that the reduction of high water levels by spill over the embankments and by breaches in the embankments on the 1st February, 1953 was relatively small. If no flooding had taken place, high water levels in London would have been about 4 in. higher than those actually recorded. Experiments were also carried out on the behaviour of a higher surge, and on the effect of spill over the embankments on the high water levels of this higher surge. In a search for methods of reducing or even eliminating the flood risk in London from future surges, experiments were carried out on the effect of a surge-reducing barrage situated in Long Reach. These showed that a barrage of this type would be effective in preventing excessive high water levels in London if operated in conjunction with an efficient surge-forecasting service. Further experiments on the behaviour of a barrage are being planned.

Work carried out on a small pilot model of the Severn Estuary—the scales of which are 1/8500 : 1/200—has facilitated the design of a large model for the investigation of the effect of the proposed Severn Barrage on the estuary. The pilot model includes that portion of the estuary which lies between Barry and Gloucester—the same area that was reproduced in Professor Gibson's model constructed in the late nineteen-twenties.

Recent research into certain aspects of the reclamation of tidal lands, particularly of those around the Wash, was based on an examination of previous surveys and charts. The collation and analysis of these charts demonstrated the complexity of problems of this type and it was felt that it would be wise to make a detailed investigation of the general principles involved in the formation of tidal lands before proceeding to experimental work on the Wash itself. In consequence, a programme of field research on this subject was drawn up and observations have been made in a section of the estuary of the River Wyre, which is small enough for information to be collected in considerable detail within a reasonable time, but large enough and typical enough for the results to have some general significance. Among other things, the laying down and removal of mud flats has been studied by marking sites with a creamed suspension of silica.

WAVE STUDIES

Research into the effect of sea walls on beaches has been in progress in a wave tank 54 ft × 10 ft × 3 ft. A sand beach is allowed to form a stable profile under the influence of waves and tides. A vertical sea wall is then inserted on the upper beach and its effect on erosion and accretion is observed. The most recent experiments have shown that there is a critical level for the sand lying against the sea wall. If the sand is above this level,

the beach tends to build up ; if the sand is below it, the beach erodes. The accretion that takes place if the level is high is relatively slow, but the erosion that takes place if the level is low is rapid. The critical level is near the level of high water.

A mobile-bed model of Southwold Harbour, Suffolk, to scales of 1/50 : 1/33⅓, has been constructed in Wave Basin 2, to examine various means of reducing wave action in the harbour and the effect of these works and of proposed repairs and alterations to the harbour arms on littoral drift and siltation. Longshore tidal currents are reproduced in addition to waves and the tidal rise and fall. Good progress has been made towards the solution of this problem and, in addition, it has been found that the three characteristics of the waves (height, period and direction of approach) have distinct effects on the topography of the model, and that it is possible by observing changes in the topography to predict what modifications are required to prevent the change. Thus, the position of the plungeline bar is mainly a function of the wave-height ; the steepness of the exposed beach is mainly a function of the wave period, if the height is kept constant ; and the gain or loss by the North beach in relation to the South beach is mainly a function of the direction of wave approach.

An investigation being undertaken for one of the overseas Commonwealth countries is that of Lyttleton Harbour in New Zealand, mentioned last year. Two models have been built in Wave Basin 1 for this study. The models have been proved ; that is to say, it has been shown that the behaviour of the existing harbour and inlet is satisfactorily reproduced in the models. Designs for the first of the new extensions to the existing harbour, proposed by the Lyttleton Harbour Board, have now been tested. It has been demonstrated that the first of these proposals would not provide satisfactory protection to shipping, as the waves and long-period oscillations would be about twice the height of those in the present harbour. The experiments also indicated that large quantities of silt would have to be dredged annually to keep the proposed harbour open. Tests of other proposals for extending the existing harbour are in progress.

RIVER STUDIES

A basic study is being carried out in a concrete flume or channel 350 ft long, 12 ft wide and 2 ft 6 in. deep to determine the equilibrium sections and slopes of straight channels carrying various charges of water, flowing through erodible material. In addition it is planned to determine the basic relationships between these quantities and the channel dimensions by varying the proportion of bed and suspended load.

A rigid-bed model to the scales of 1/200 : 1/50 has been constructed to investigate a flood relief scheme proposed for the River Severn in the neighbourhood of Shrewsbury. The initial proving tests have been completed and indicate that the model reproduces accurately the behaviour of this portion of the River Severn both in flood and under low flow conditions.

Another model study made in connexion with the River Severn was of a proposed barrage which the Severn River Board planned to construct just north of Gloucester. A 1/48 natural-scale model of the proposed barrage was tested in the 5-ft flume and indicated that the afflux at bank-full discharge was well within the River Board's allowable maximum. It also showed that no especial bed protection would be required downstream at the barrage, and that separation would not occur at the pier or side-wall boundaries.

A theoretical study, supplemented by a small model, has been completed for the Department of Health for Scotland, whose problem concerned the disposal of storm water to the River Leven by way of the Bighty Burn Culvert. A complete analysis of flow conditions in all parts of the Culvert enabled various modifications of the original design to be recommended, and a model of the stilling basin indicated the best method of delivering the storm water to the river at a nearly uniform non-scouring velocity.

INTELLIGENCE AND INFORMATION DIVISION

Productivity has been a central feature of the Division's work during the past year. This was due to the extensive participation in the Conditional Aid programme, especially on the research side, to discussions concerning U.K. participation in the programme of the European Productivity Agency, and to an interdepartmental review of productivity matters. The result has been to clarify the Division's role in the overall national productivity effort: this includes the effective communication to industry of information on new techniques and methods, research into underlying productivity problems in the human factors and economics fields, and survey and development work in the field of industrial engineering techniques.

The marked emphasis on research which is now apparent in the Division's work is particularly noteworthy for its relevance to the Department's own operations and activities. Projects are in progress on the utilization by industry of university graduates, the comprehensibility of technical reports, the flow of scientific and technical information, the economics of specific innovations, and the human and social problems arising from technological changes. These investigations are expected to lead to deeper understanding of how to accelerate the contribution of science and technology to social and economic wellbeing.

An important factor in enabling the Division to perform adequately its liaison function on scientific and technical matters is the excellent co-operation it has received from national bodies in many fields. Valuable exchanges of viewpoint have taken place with national organizations in the productivity field, and the Division has joined with several professional institutions in organizing meetings and seminars. Seminars on materials handling and work study, the latter on the occasion of a visit to the U.K. of a group of European experts in industrial engineering, were held in conjunction with the Institution of Mechanical Engineers.

RAW MATERIALS AND OTHER TECHNICAL SURVEYS

Although the raw materials supply position has greatly eased in the last twelve months, the importance of conservation and the best utilization of such materials still remains. The future supply of raw materials must also be assured and more attention has therefore been given to the longer term prospects. The Division's surveys on pyrites cinders, selenium and germanium reported last year have stimulated action both in industry and elsewhere. The erection of a plant for treating the cinders is being actively considered; and on the basis of further work by the Chemical Research Laboratory it is hoped that a significant addition to the country's supply of selenium will be possible. In the case of germanium, the Department has set up a research study group to investigate ways and means of increasing the proportion of germanium recoverable from coal, which is undoubtedly the best indigenous source: considerable progress has already been made in assembling the basic information.

Some other technical surveys are indicated below.

Mineral Ore Dressing, Beneficiation & Extractive Metallurgy

On a longer-term basis, facilities available in the United Kingdom for research in these subjects have been reviewed and, at the request of the late Ministry of Materials, suggestions have been made for increasing them.

Geochemical Prospecting

The Department's interest in geochemical prospecting, first indicated by sponsorship of the visit of a British expert from Imperial College to the U.S.A. in 1952, has developed further during the past year. In September/October, 1953, a course was held at Imperial College at which about 60 geologists from the United Kingdom and other parts of the Commonwealth were given a grounding in geochemical prospecting methods, the Division sponsoring the visit of a U.S. expert to take part in the course. Following the course, and a symposium in which interested organizations participated, a small committee drew up proposals for a co-ordinated programme of research and development in geochemical prospecting to be carried out at Imperial College. These were submitted to the Colonial Office and the Special Grants Committee of the Department who agreed to finance the programme on a 60/40 basis for a period of 3 years. Imperial College has also commenced to extend the laboratories for geophysics and geochemistry: this will provide within the next year a useful addition to research facilities in the interests of industrial and colonial development.

Size Reduction

Work has been continued on a bibliography on size reduction (crushing and grinding) for industrial purposes, under the guidance of a committee of the Institution of Chemical Engineers, on which members of the Division are represented.

Industrial Microbiology

Contact has been maintained with developments in this field, and in particular with progress in the field of algal culture. The Division is collaborating in the U.K. section of a Commonwealth survey of industrial microbiology which was initiated following the British Commonwealth Scientific Conference in Australia in 1952.

INDUSTRIAL OPERATIONS UNIT

During the year this advisory service, set up with the help of Conditional Aid funds, has undertaken its first projects. In all cases these have been carried out through the appropriate research or trade association so as to ensure that the problems investigated are of widespread interest in the industries concerned, and to provide a focal point for effective consideration of the results and if possible, for continuation of the work. Experience indicates that the unit can best serve industry in the following ways:—

(i) "demonstration" projects to pioneer new fields of industrial application and indicate the practical value of particular industrial engineering techniques;

(ii) surveys and studies to evaluate new industrial engineering techniques and to explore their field of application;

(iii) generally acting as a channel for research information on best practice in the industrial engineering field.

To date it has not been possible to do more than explore the above forms of action by carrying out individual projects at the request of industry.

A "demonstration" project using industrial engineering techniques to examine the operating methods of the hardware department of a large retail store has been carried out for the Retail Distributors' Association Incorporated. A project on the balancing of labour in mechanized foundries has been done in association with the Operational Research Unit of the British Cast Iron Research Association. A third project, undertaken for the Furniture Development Council, consisted of a materials handling survey in the furniture industry.

Assistance has been given to various bodies setting up or operating training courses in the industrial engineering fields, for example, several technical colleges and the Wool (and Allied) Textile Employers' Council.

HUMAN FACTORS IN INDUSTRY

The Division's main task in this field has been to provide technical and secretarial servicing for the two human factors committees which advise the Department and the Medical Research Council. These Committees have now allocated most of the Conditional Aid funds placed at their disposal for a 3 year research programme, and have begun to build up a long-term research programme. Details of the current research programmes in the human relations field have been published in the First Report of the Committee on Human Relations in Industry (H.M.S.O., 1954); a broad outline of the programme of the Individual Efficiency Committee was given in the Department's Report for 1952–53 (p. 72). It may be noted that under the sponsorship of these committees 35 projects have been approved which will engage about 70 research workers for periods up to three years; work on the majority of these projects has now commenced.

In the new and growing human factors research field, the Division's liaison function, namely of helping contact between research groups and between research and industry, is doubly important. A good deal of active liaison work has therefore been undertaken during the year. The greatest importance is attached to exposing suggestions for research to the viewpoint of those directly concerned with human factors problems in industry; meetings have therefore been held at which managers and trade unionists have discussed particular projects or areas of research. The Division has co-operated closely with outside bodies in organizing a number of informal conferences between research workers, notably on "Empirical Research in Industry" and "Interviewing and the Social Sciences". One of these conferences pointed out the need for a clearing-house for semi-published material. Following consultation with the editors of scientific journals in psychology and the social sciences, the Technical Information and Documents Unit (T.I.D.U.) is providing this service.

ECONOMICS

The economics section has continued to give advice and assistance from time to time on economic problems arising out of the work of stations and research associations.

Information on the scale and distribution of research expenditure and manpower in the United Kingdom is needed if research effort, technical information services and the training of research workers in the universities are to reflect the relative needs of the various industries. Existing information, notably that of the 1948 Census of Production, needs to be supplemented. A set of questions on which information is needed has been worked out and tested on a sample of firms.

In order to obtain a better assessment of the economic case for research on food, the Food Investigation Board asked for a study of the published statistics of the country's expenditure on research into food processing and handling compared with expenditure on research into food and agriculture. This showed that some £700 000 was spent on research into food in the United Kingdom, while Government supported institutions spent some £3 700 000 on research into agriculture and fisheries, compared with a total expenditure on food by consumers of £2500 million.

The Division administers a programme of research carried out at the research associations, the Department's research establishments and elsewhere; this consists at present of 14 projects financed wholly on an allocation of £65 000 from Conditional Aid. Productivity studies are being made in the cotton, wool, rayon, lace, rubber, steel welding, building and footwear industries. Another group of projects focussed on technical innovation includes case studies of successful innovations, an examination of the flow of technical and scientific information to the iron and steel industry, and a study of the needs of small firms in Scotland in respect of their ability and willingness to innovate.

Under this programme, also, research workers within the Division are studying the effect on an industry of the work of its research association.

The report of the Manchester Joint Research Council, referred to in last year's Annual Report, has now been published(*) and has received favourable notice in the Press.

TECHNICAL INFORMATION SERVICES

The technical information functions of the Division are discharged principally through two units, the Library and Records Bureau, and the Technical Information and Documents Unit.

The first named has mainly internal functions: the Library is a focal point in library service within the Department's own research establishments; the Records Bureau is a central depository for all research reports received from the establishments, other Government departments and the grant-aided research associations, and is concerned with making known the reports received.

The information services in the United Kingdom were reviewed in 1949 by the Panel on Technical Information Services of the Committee on Industrial Productivity. The recommendations of this Panel in so far as they relate to the Department have since been implemented. Subsequent to this report T.I.D.U. was transferred from the Board of Trade to the Department, and this section is now the main point of contact between the Headquarters of D.S.I.R., and industrial and other organizations, on technical information questions. It is primarily concerned with carrying out work which appears essential, but which is not covered by any of the specialized technical information services.

Two of the current activities of T.I.D.U. illustrate its work. One is the co-operative Russian translation scheme which is operating on an experimental basis. The scheme provides for the supply of the translations of many of the papers listed in "The Translated Contents List of Russian Periodicals" on the basis that the translating costs are shared by those requiring the translations.

The other venture is the issue to industrial organizations of a series of brief digests covering recent practical developments described in the technical press. This experiment is directed towards assisting industrial productivity

* *Industry and Science*, Manchester University Press, 1954.

and is financed under the Conditional Aid programme. The digest material is presented in a form which is acceptable to responsible, but not necessarily highly technical, personnel in industry and particularly in industrial units not yet in close touch with sources of new technical information.

REGIONAL ACTIVITIES

The Liaison Officer for Wales, who took up office in 1952, has made good progress in establishing close relations with many sections of Welsh industry and with technical education and training activities. In 1954, for the first time, the Command Paper on Wales and Monmouthshire contained information about the research work going on in Wales under the aegis of the Department.

A feature of the work of the Scottish branch office, which has continued its established activities, was the part played in arranging a very successful exhibition on "Research in Industry" in the Kelvingrove Museum, Glasgow, concurrently with the Scottish Council's "Scottish Industries Exhibition" in September 1954.

In regional activities in England useful advisory work has been done, particularly on materials conservation. In collaboration with the National Industrial Salvage and Recovery Council, the Division has taken part in Salvage Conferences at London, Tynemouth, Bristol, Birmingham and Manchester; its advice has been sought on uses for more than 50 waste materials.

OVERSEAS SCIENTIFIC ACTIVITIES

The 1952-53 Report described the general pattern of overseas scientific activities, and within this framework the Department has continued to play its full part in international scientific co-operation, in particular through the representation of U.K. interests at the Organization for European Economic Co-operation (O.E.E.C.) and UNESCO, and on such bodies as the European Organization for Nuclear Research and the International Federation of Documentation.

An important feature of the Department's external life is its relations with Commonwealth and foreign scientific organizations and individual scientists and technologists. With the return to more normal conditions of organized scientific work abroad, the Department's relations in this respect are developing increasingly and many valuable contacts have been renewed or initiated. There is also a welcome tendency for foreign scientists to turn to the Department for advice on the organization of research, as well as on individual scientific and technical problems.

Organization for European Economic Co-operation

The Division has taken an active part in the creation of the European Productivity Agency within O.E.E.C. and in its initial programme of scientific and technical work. The head of the Division is Chairman of the Productivity and Applied Research Committee which is the governing body of the Agency. Attempts have been made to ensure that the Agency's programme is in balance with the overall needs for increased productivity in the O.E.E.C. member countries and the Division has provided representatives for discussions on productivity and applied research, technical information services, methods engineering, human factors and systems of remuneration. The Department has so far participated in four E.P.A. projects.

Colombo Plan—Technical Co-operation Scheme

The Technical Co-operation Scheme is a subsidiary but nonetheless important part of the Colombo Plan. Its purpose is to assist with modern techniques in the economic development of Asian member countries. The Department has provided scientific and technical advice to the Foreign Office and the Commonwealth Relations Office in order to assist the Technical Co-operation (South and South-East Asia) Standing Committee in providing equipment and services to meet the most urgent needs of those countries entitled to benefit from the scheme and has promised such continuing assistance as may be necessary to complete the work.

United States Technical Assistance

The Division has administered the funds made available under the U.S. Technical Assistance Programme for the purchase of technical equipment and publications. The work is now virtually complete, since no allocation of dollars for technical assistance is being made to the United Kingdom from the 1954-55 budget of the U.S. Foreign Operations Administration. In all, equipment and publications to an approximate total value of $1 400 000 have been obtained for the Department's research establishments and for a number of research associations. In addition dollars were provided for more than twenty visits to the U.S.A.

MECHANICAL ENGINEERING RESEARCH

During the year the staff of the Mechanical Engineering Research Laboratory has been increased by 25 per cent. This has meant that more effort could be devoted to work already on the research programme and that new items could be started. Temporarily the laboratories are overorowded, but the situation will be eased when the Hydraulic Machinery laboratory comes into full use ; at the end of the year it was nearly completed. Laboratories for work on Heat Transfer and on Mechanisms and Metrology were started late in 1954.

DIVISIONS A AND B—MECHANICS AND MATERIALS

The object of the work in these two divisions is the determination by analytical or experimental methods of the loads and stresses occurring in engineering components in service and the way materials behave when subjected to these stresses. With this knowledge, more efficient use can be made of existing and new engineering materials.

The stresses may be single or complex ; they may result from steady loads, repeated loads or shock loads ; and they may occur at room temperatures or at high or low temperature. All these aspects are being studied, but the emphasis is on repeated loading—i.e. fatigue—and on materials for use at high temperatures.

Fatigue

A high proportion of failures in service is caused by repeated loading. The fatigue behaviour of certain high- and medium-strength aluminium alloys have been compared for the benefit of the aircraft industry. Pin joints of the same size with tongues of either alloy have been found to have almost identical fatigue strength. This agrees with work by other investigators which suggests that in the presence of changes of section or other stress-raisers the fatigue strength of all but the softest aluminium alloys is independent of the alloy or its condition. Fretting corrosion between the pin and tongue

has been found to be the main cause of the very low fatigue strength of such fork and tongue joints; some success has already been achieved in alleviating this.

The fatigue strength of certain materials subjected to relatively high stresses for fatigue loading cycles between 10 and 10 000 is being investigated. It has been shown that fatigue strain rather than fatigue stress is the critical factor; the work is important in such cases as a bridge over which heavy loads pass at infrequent intervals, an aircraft which occasionally flies into a severe gust, or an expendable weapon with a known short life.

In an extension of the work which led to the adoption of the Unified Screw Thread, the fatigue strength of heavily-truncated threads has been determined. It has been shown that severe truncation, reducing the depth of engagement to one-fifth the full depth, may actually increase the fatigue strength of a bolt and nut.

The initiation and propagation of fatigue cracks is being studied. It has been found that in mild steel, cracks start and spread under either maximum shear or maximum tensile stress. In one aluminium alloy so far studied the cracks begin only under maximum principal stresses; this result is contrary to what would have been expected from a cursory examination of failures in heads of fatigue specimens where it appears that shear stress is the important factor.

High-temperature Materials

Creep—the continuous deformation of metals under steady loads—is becoming more and more important as alloys are subjected to higher temperatures in turbines. Work on creep under simple tension is continuing at the National Physical Laboratory, but work on more complex stress systems is now in progress at East Kilbride. An investigation has been made of the properties of alternative materials for use as gas-turbine discs. They have been subjected to cycles of loading and temperature corresponding to those occurring at the rim of the disc under working conditions. New equipment is now available for studying the behaviour of alloys and steels suitable for high-temperature operation under the complex stresses met with in practice. Further light has been thrown on the basic relations between creep, recovery, and relaxation, and on their dependence on time and temperature, for a magnesium alloy, an aluminium alloy and a carbon steel.

Creep is also important in light alloys which are now frequently used for structural members and which may show creep at ordinary atmospheric temperatures. Rigs in which portal frames and continuous beams can be so loaded as to cause all the more probable types of failure are being used to study the behaviour of light alloy structures. The creep deflection of light-alloy struts is also being analysed.

Special investigations

Work for industrial firms and for other Government departments has included examination of watch balance-shafts, small steel balls, wire-rope fastenings, and plastic structural joint materials at −50°C. A wide variety of parts which have failed in service have also been examined, including a 15-inch diameter crankshaft, a coal-cutter swivel-pin, large fan blades, 12-inch diameter light-alloy pistons, and racing-car parts.

Help has been given in formulating new British Standards for dental materials. A setting test for dental amalgams has been devised and the performance of dental instruments has been measured.

Gas Cylinders

The Laboratory carries out tests to help the Home Office in its responsibilities regarding safe handling of cylinders containing compressed industrial gases. During the year butane cylinders made in America, France, Holland, and Germany have been tested. Two welded cylinders, each of which burst and caused an accident, have been examined. New and old seamless light-alloy cylinders have been burst to determine the effects of service conditions. Advice has also been given on special projects such as road-tankers for propane and for carbon dioxide, aluminium drums for carbon disulphide, and a new design of welded container for propane.

DIVISION C—FLUID MECHANICS

The Fluid Mechanics Division is applying modern knowledge of fluid dynamics, especially that gained in aerodynamics research, to mechanical engineering problems. One of the main objectives is to improve the efficiency of water-turbines, pumps and other hydraulic machinery. Work has continued in temporary accommodation pending completion of the new Hydraulic Machinery laboratory.

Flow Measurement

The efficiency of hydraulic machinery is usually checked by full-scale tests after it has been installed. The rate of water flow is one of the measurements that have to be made, and it is both difficult and expensive to do this accurately because very large flows are involved. There is now a general tendency to replace these full-scale trials by model-tests of a kind which will be undertaken in the Hydraulic Machinery laboratory.

A quick and accurate method for calibrating flow-measuring instruments is essential but tests of a volumetric method showed that it was not sufficiently accurate. A direct weighing method will be used instead in which the water is discharged into a measuring tank supported by a beam on two hydraulic jacks, and the pressure in the jacks will be weighed automatically to an accuracy of 1 part in 1000. Piping up to 18 inches in diameter will be installed upstream of the measuring tank so that venturimeters, orifice plates and other instruments can be inserted for calibration.

Venturimeters are particularly suitable instruments for measuring flow because of their low energy loss. It is known that the readings of a venturimeter vary over a period of years, probably because of changes in the roughness of the meter surfaces. The effects of surface roughness in the meter and in the piping upstream of it have been analysed(1); a theory relating these effects to the meter coefficient gives good agreement with measurements on a "Herschel" type of meter. Further tests are to be made to see whether venturimeters can be used to measure flow to an accuracy of 0·1 per cent without frequent re-calibration.

The position of pressure tappings on a venturimeter are important and are specified in Codes of Practice. Tests on a specially-designed meter have shown that the shape of these tappings will also affect the readings.

High-pressure Oil Systems

The use of oil systems in machine-tools, textile machinery and other mechanical equipment is increasing. They may be used for transmitting power or movement, and are sensitive, easy to control, and compact; they are particularly useful for servo-mechanisms.

Pumps and control valves are essential components of hydraulic systems. The operation of a spool-type piston-valve is being studied to find out what forces are necessary to operate the valve as the speed and pressure are

increased, and how the forces on the valve vary with the flow pattern through the ports. The valve is encased in a "Perspex" block; dyes are injected into the oil stream and the flow of the fluid photographed with a high-speed cine-camera. The loads on the valve are measured electrically.

Self-acting valves on a high-speed, positive-displacement pump are also being tested. The flow through the valve is being studied and the forces on it are being measured to see how the speed of the pump is limited by the design of the valves. It is hoped to test these valves at speeds up to 6000 rev/min and at pressures up to 2 tons/sq.in.

These investigations will enable piston-valves and self-acting valves to be designed on sound principles for operation at higher speeds and higher loads than are used at present.

DIVISION D—LUBRICATION AND WEAR

The study of the fundamental causes of friction and wear between rubbing surfaces and of techniques for their reduction in machinery has continued.

Wear

Fretting corrosion is a particular kind of wear which occurs between closely fitting surfaces which undergo slight relative movement due to vibration. Earlier work had shown that the amount of damage depended on the total number of oscillations, on the load and on the atmospheric humidity[2]. Electrical contact resistance measurements made during the fretting of hard steel specimens showed that after a short time the surfaces became separated by ferric oxide, a material of high electrical resistivity. Thus, in its later stages, fretting corrosion may be described as abrasive wear in which the abrasive material is produced by the wear process. Under the electron-microscope, the initial damage appears to consist of furrows produced in the surface by hard particles.

The electron-microscope has also been used to examine new and used lubricating oils for Diesel engines. The unused oils containing "heavy-duty" additives were found to be true solutions and not suspensions of solid particles as had been suggested by some other workers.

Launching Greases

Ships are usually launched on bearing surfaces of hard grease covering the sliding and standing ways. Considerable variations in the friction between such surfaces have been observed but it has not been found possible to correlate these variations with climatic and other changes of environment. Laboratory experiments on one proprietary grease have shown that the length of time the surfaces have been in contact has a marked effect on the force along the surface needed to start the ship moving, but has little effect on the force necessary to maintain the motion. Changes of weight of the ship affect both of these forces but changes of atmospheric humidity or temperature have a less marked effect. The laboratory results are now being linked with measurements taken during launchings to provide data for the design of launching triggers and drags.

Hydrodynamic Bearings

Important factors in the design of bearings for high-speed machinery and especially for gas-turbines are the rate of flow of lubricant through the bearing and the way in which heat is dissipated from the bearing. The flow through a high-speed bearing has been examined by making the outer bearing shell of transparent material and introducing a fluorescent dye, excited by ultra-violet light, into the oil. The tests have shown that special care must

be taken in designing the passages by which oil is introduced into the bearing. To investigate the dissipation of heat from a bearing, fifty thermocouples have been embedded in a bearing shell. These are automatically connected in turn to a recording potentiometer.

Rail-Tyre Adhesion

The British Transport Commission is financing an investigation of the causes of varying adhesion between wheels and rails. In the laboratory a wheel and a rail are each represented by a roller driven by a d.c. motor which can also act as a generator so that driving and braking conditions can be simulated. Slip between wheel and rail is measured and recorded electrically. The machine is enclosed in an air-conditioned chamber so that the effect of different weather conditions can be examined. To check the results from the machine the correlation between weather and adhesion is being studied on a local railway.

DIVISION E—MECHANISMS AND METROLOGY

Basic components of mechanisms, such as gears, ball-bearings and universal joints, are studied to improve their operation and to reduce noise. Accurate measurement of these components is necessary and this requires temperature- and humidity-controlled surroundings. These facilities will be provided in the new Mechanisms and Metrology laboratory.

Accuracy of Gears

Errors in the dimensions of a small gear are often measured by meshing the gear with a master gear of known accuracy. The gears are kept in mesh by the pressure of a spring; as they are rolled together the variation in the distance between their centres gives a measure of the composite errors. This method does not give a true picture of the errors because the spring keeps both flanks of the gear-teeth in contact, whereas, when gears run normally, only single flanks touch.

To improve the accuracy of small spur and helical gears, a new instrument using a master rack in place of the master gear has been designed. It will record the "true" composite errors and a prototype is being built in the Central Workshop. The instrument will help to improve the accuracy of fine-pitch gears, such as are used in radar and fire-control equipment.

Small Precision Ball-Bearings

Modern instruments such as gyroscopes require small ball-bearings to run at very high speeds with the minimum frictional torque. Work is being carried out for the Admiralty to find out how frictional torque is related to the dimensional accuracy of the bearing.

A prototype apparatus for testing precision ball-bearings has run satisfactorily at speeds up to 50 000 rev/min in a series of tests on 5 mm ball-bearings of the angular contact type to find out how the torque varies with speed. The results indicate that the axial load has a greater effect on frictional torque than the radial load. A second machine, which is being developed for vibration measurements, will operate at higher speeds.

Pitting in Gear Teeth

The surfaces of gear-teeth tend to become pitted after the gears have run for some time. If the pits are allowed to develop they can lead to fracture of the teeth and may cause complete mechanical breakdown. Little basic information is available on this phenomenon and fundamental work on the

mechanism of pitting in curved elastic surfaces subjected to cyclic loading has continued. Steel spheres have been tested in a machine designed to produce pitting under controlled conditions of loading. Steel spheres in a relatively soft condition showed plastic deformation in the form of "brinelling" but no cracking took place. In a further series of tests on hard steel specimens failure occurred by cracking in the contact zone at the surface. The cracks appeared to start from the outside and work into the material; further tests are being carried out to see whether the failure of surfaces under fluctuating compressive loads always occurs in this manner.

Measuring Techniques

Mechanical and electrical measuring techniques have been applied to various industrial problems such as the errors in alignment of the saddle motion of large gear-hobbing machines. An example of domestic interest is the use of optical and pneumatic methods in the measurement of the facet angles and overall width of razor blades at various stages of manufacture.

DIVISION F—PLASTICITY

The manufacture of almost all metal articles depends on plastic deformation of the material. The production processes involved fall into two main groups: formation processes such as hot and cold rolling, forging, pressing and deep drawing, wire drawing, and extrusion; and cutting processes such as turning, milling, shaping, drilling, and grinding. Commercial practice in these fields has developed by trial and error with little appreciation of the basic principles involved. The Division is obtaining a fuller understanding of the fundamental mechanism of plastic flow, that is of flow beyond the elastic limit. The work should make possible a more efficient use of materials, a more exact and economical design of machinery, and a saving in power.

Deformation Textures

When metals are rolled, drawn, extruded or worked in any way, they develop directional properties peculiar to the process involved which may affect the quality of the product. Such properties depend on the rotations of the individual "grains" of which the metal is composed. The problem has been considered for face-centred cubic metals (such as aluminium, copper, nickel and brass) and a theory based on the Bishop-Hill theory of crystal distortion has been formulated[8]. It accounts for the textures observed when these metals are rolled and for the difference between brass and copper.

Materials under High Hydrostatic Pressure

In formation processes such as extrusion and rolling, deformation occurs under high hydrostatic pressures. The properties and behaviour of materials under such high pressures are being studied to gain a better understanding of the processes and to provide information on the range of validity of the assumption, made in the theory of plasticity, that hydrostatic pressure has no effect on the yielding of materials. Pressures up to 70 tons per square inch (10 000 atmospheres) have been achieved and measured by a small electrical resistance gauge specially developed for the purpose. Preliminary tests show that the ductility of materials is much increased under high pressures; materials such as bismuth and "Perspex", which are brittle at atmospheric pressure, show large deformations in tension at high pressures.

Forging and Extrusion

A study of the basic principles governing the plastic deformation of metals in press- and drop-forging has been confined to model tests. The conditions necessary to ensure similarity of model and full-scale results have been

investigated and the results have shown the importance of maintaining equal strain rates in both series of tests. The factors governing the resistance of a material to deformation are being further studied. Electronic equipment has been developed to determine the force required to produce a given shape by compression between parallel platens.

An attempt is being made to establish the fundamental principles governing the behaviour of metals in cold extrusion. Accurate data have now been obtained on the loads, displacements, and general behaviour of lead, aluminium, copper, and steel during extrusion. A technique has been developed for measuring temperatures occurring at different points of the extruded metal during the process. This enables the build-up of temperature to be measured for the first time.

Metal-Cutting

Most theories of the cutting process assume that the chip is formed in such a way that the amount of work done is a minimum. A theoretical investigation supported by experimental results has shown that this minimum work principle might not be valid. As a basis for a more exact theory the deformation of grids inscribed on the specimens and cut with tools of varying rake angles, has been examined. Results show that the rake angle had an appreciable effect on the coefficient of friction and that the effect of chip friction on the deformation mode differed considerably from that predicted by current theories.

To establish the mechanism of tool wear, an attempt has been made to correlate the effect of rake angle on chip friction with changes in temperature on the tool face. A theoretical technique developed in the Division for estimating temperature distribution is being used.

DIVISION G—HEAT TRANSFER AND THERMODYNAMIC TABLES

The objectives of this Division are to increase the efficiency of heat transfer equipment, including boilers, condensers, heat exchangers and many types of chemical engineering plant. It is also preparing tables of thermodynamic properties of working fluids used in engineering, correlating and co-ordinating data from various sources. The work on heat transfer requires substantial supplies of steam, electricity, gas, and cooling water which are not available in the temporary laboratories at present being used by the Division.

Pending completion of the new Heat Transfer laboratory at East Kilbride, experimental work is being supplemented by extra-mural researches at universities and technical colleges.

Condensation of Steam

More accurate design data for heat transfer equipment in general would probably save between 5 and 15 per cent of the metal now used in their construction. Even greater savings (from 20 to 40 per cent) would accrue in making steam condensers if the steam could be made to condense as drops rather than as a film. Work on this problem has been undertaken at Queen Mary College, University of London. In the first place the unusually high rates of heat transfer with "dropwise" condensation were demonstrated and the performance of condenser tubes and condenser plates under these conditions was compared. Substances which would "promote" dropwise condensation were then prepared and tested, the requirement being for a promoter which gave prolonged dropwise condensation and caused no trouble in other parts of the system. One compound has been tested for over 3500 hours without the promoting surface breaking down. The final stage in the work is to make check tests in an actual power-station condenser and design and manufacture of equipment for this stage is in hand.

Another investigation on steam condensation is in hand at the College of Technology, Birmingham, where heat transfer from condensing steam containing air is being studied. The presence of quite small amounts of air reduces the heat transfer considerably. Although this is not important in plant which is run continuously, since steps are taken to remove the air, plant which is run intermittently is bound to have air in the steam for much of the time.

Thermodynamic Measurements

The collection and correlation of viscosity and thermal conductivity data has shown that accurate values over wide ranges of density and temperature are still very scarce. This is particularly true of substances with simple molecules. Information about these would enable existing theory to be checked and help in its extension. Work is therefore being undertaken, again at Queen Mary College, on measuring the viscosity of liquefied gases; the first is argon.

To provide data about thermal conductivity, equipment is being designed to measure it for a number of substances which are important to industry. Measurements will be taken up to and beyond the critical pressure from room temperature upwards. Particular attention will be paid to the conditions under which appreciable convection occurs.

Work on the properties of mixtures of gases is also being undertaken. So many mixtures are of practical importance that direct measurement for each one is impossible. Theoretical generalizations have therefore been formulated and these are being tested with experimental data obtained in the University of Manchester, in the Imperial College of Science and Technology, University of London, and at the National Physical Laboratory.

REFERENCES

(1) HUTTON, S. P. The prediction of Venturi-meter coefficients and their variation with roughness and age. *Proc. Instn Civ. Engrs*, Part 3, 1954, 3, 216–241.

(2) WRIGHT, K. H. R. An investigation of fretting corrosion. *Proc. Instn Mech. Engrs*, 1952–53, **1B**, 556–574.

(3) BISHOP, J. F. W. A theory of the tensile and compressive textures of face-centred cubic metals. *J. Mech. Phys. Solids* (*In the press*).

NATIONAL PHYSICAL LABORATORY

A new research division has been established by the combination of the Electronics Section and the Control Mechanisms Section of the Metrology Division. Its work will include the automatic control of experimental, industrial and administrative operations and the development of techniques and equipment for data processing and computation. Some members of the new Control Mechanisms and Electronics Division will form part of a Working Party which will investigate the possibilities of applying electronic and other high-speed mathematical equipment to the problems of large-scale clerical work.

The Laboratory was honoured on 29th June by an official visit from H.M. The King of Sweden. Although the visit lasted only one hour, it was possible to show the work on high voltage, ship and propeller design, pure iron and Johansson slip gauges.

The detailed planning of the new laboratory for the Ship Division at East Bedfont has been worked out in association with the Ministry of Works, and it is hoped to place a contract for this work before the end of 1954. According to the time schedule proposed, the new establishment

should be completed by 1958. It will include a tank 1300 ft long, a propeller water tunnel suitable for testing propellers of 2 ft diameter and a steering pond for models about 8 ft in length, as well as some additional laboratory space and the necessary shops and offices to operate the laboratory.

AERODYNAMICS DIVISION

The greater part of the work of the Division consists of fundamental theoretical and experimental research planned to give basic information for use in the design of safer and faster aircraft. Particular attention has been given to the problems of flight at high speeds, the investigation of air flow over sweptback wings at incidence and the study of boundary layer phenomena.

The facilities for research on high-speed problems have been increased by the erection of two new wind tunnels in which tests on models and partial models of aircraft and missiles will be carried out at speeds up to nearly twice that of sound. One of these tunnels is nearing completion and will be used mainly for studying problems of unsteady flow such as occur in flutter; the other should be completed before the end of 1954 and will be devoted to steady flow investigations.

In the existing tunnels the work done includes detailed studies of the effect of viscosity in high-speed flow, particularly on the flow pattern which arises when a shock-wave interacts with the boundary layer formed on the surface of a body placed in the airstream. Measurements of the aerodynamic forces on oscillating models have been made to provide information for use in flutter calculations and to check methods of estimation.

Considerable effort has been put into the development of techniques and instruments for use in high-speed wind tunnels. The new apparatus that has been built includes strain gauge balances and an interferometer for measuring the density of air. By means of this instrument the density changes and hence the pressure distribution round an aerofoil can be determined.

Much theoretical and experimental work has been done on three-dimensional boundary-layer flow at low speeds. In particular, the flow over sweptback wings at incidence is being investigated in a water tunnel. Methods of visualizing the flow pattern caused by the presence of the model have been developed and much useful information has been obtained.

Tests have been made in the Compressed Air Tunnel on models of prototype aircraft under full-scale conditions, particularly of maximum lift. Calculations are proceeding on wing loading and stability of modern plan forms and wind tunnel experiments have been carried out to check the theories.

Considerable work has been done on the proposed Runcorn-Widnes suspension bridge and the influence of the nearby railway bridge on its stability has been examined. The work showed that the position originally proposed for the new bridge would be unsatisfactory because of the large buffeting oscillations set up by the wake of the railway bridge. As a result of the tests, the site of the suspension bridge has been moved nearer the railway bridge and modifications have been made in the design to increase the stiffness of the bridge. Fundamental data have also been obtained on sections of cranes and lattice work masts to find the wind forces on the high structures now being erected.

Investigations of airflow over ships have led to modifications to increase the comfort on navigating bridges and to improvements in the design of funnels to lessen the nuisance caused by the descent of effluent smoke on the decks. A particular case examined was the Royal Yacht *Britannia*.

CONTROL MECHANISMS AND ELECTRONICS DIVISION

The electronic simulator set up in the Control Mechanisms Section of the Division has been used to study several complex industrial control problems. These have been concerned with electrical machines, hydraulic servos, aircraft stability, chemical process control and economic systems. Experience has shown that sufficient linear units are available for the most complex problems likely to be met in practice. Some non-linear units are already in use and others are being developed. A number of electronic multipliers are being fitted. The use of the simulator largely eliminates the need for desk computations on simple problems and makes the solution of complex ones practicable. The basic assembly, power supply and inter-connexion system have recently been considerably enlarged.

Work is continuing on the development of equipment for the reduction of data obtained in large-scale trials and experiments. The work is at present directed towards a specific object, but much of it is of general application and the equipment is being designed wherever possible in the form of versatile units which can be connected together for particular purposes.

Units now being developed include a general purpose film reader, a calibrating and digitizing unit, an automatic graph-plotter, a small special-purpose computer and a transcribing unit in which letters and numbers are recorded on magnetic tape. The equipment has been designed for operation with automatic typewriters and card-punches. Much of the work is being carried out, under the technical control of the Laboratory, by firms operating under Ministry of Supply development contracts.

The Electronics Section of the Division has concentrated on high-speed electronic digital computers; it has maintained the ACE Pilot Model in working order and has made improvements to it. One such improvement has been the addition of a magnetic drum store, for storing 32 000 binary digits, which was added early in the year; this has since been replaced by one storing 128 000 digits, and one of twice this capacity is now in an advanced stage of construction.

Much effort has also been expended in the design of the final ACE which it is intended shall be about five times faster than the present Pilot Model.

ELECTRICITY DIVISION

The work on standards, electrotechnics and high voltage has continued and progress has been made with re-equipment. Test work has shown some tendency to decline in amount, while the complexity of individual tests has increased.

In the High Voltage Laboratory the main event of the year has been the installation of the 3·2 million volt surge generator referred to last year, which has involved much heavy civil engineering work. This unit has now been put into service, and should be of great value for the testing of "super-voltage" transformers and cables for industry and for the extension of the Division's own research programme to higher voltages.

The rectifiers required for the provision of 1 million volts d.c. have been erected, and preliminary tests will soon be made. The fact that a d.c. transmission system is now operating in Sweden indicates that this facility is likely to be needed.

A specification has been drawn up for a new power-frequency transformer to replace the existing units. The installation of this apparatus will complete the major re-equipment of the High Voltage Laboratory.

Work has continued on aspects of gas discharge phenomena, which are of interest both theoretically and for the practical design of switches, etc. Breakdown characteristics of electro-negative gases are being investigated with different electrode arrangements and with the gas used in conjunction with solid insulation. This work is partly directed to explaining the somewhat anomalously high electric strength of these gases. The equipment for recording very low light intensities of very short duration has reached a point where it can be used to assist in this work, by a study of the light emitted by corona during a short high-voltage surge.

The investigation for the British Electrical and Allied Industries Research Association on the breakdown of combinations of solid and liquid dielectrics has made good progress. With some arrangements a degree of generalization on breakdown by puncture seems possible and this should be of direct help to transformer and switchgear designers. Work has also been done on high-voltage cables, and this should form a sound basis for a satisfactory specification of performance.

In the field of fundamental standards, the maintenance of which is one of the most important functions of the Laboratory, the mutual inductor that forms the basis of the determination of the ohm has been re-measured. It was found to have altered considerably in dimensions, and, on taking this into account, the recent absolute determinations of the ohm were found to agree with the unit as maintained by standard resistance coils within about one part in a million, a very satisfactory result. Progress is being made with the construction of the new standard, which uses fused silica in place of marble; the latter material is known to be somewhat unstable dimensionally. Silica is a considerably more difficult material to work, but the construction and preliminary machining of the primary bobbin have been completed.

The Standard Frequency Service has continued to operate satisfactorily on a 24 hours per day basis throughout the year. The monitoring apparatus has been made automatic and is giving good results. A paper on this aspect of the service has been prepared[1].

A special sprung foundation, weighing some six tons, has been prepared for the apparatus designed to produce a frequency standard based on the properties of the caesium atom, and the main vacuum chamber has been installed. If successful this work should provide a standard of frequency having a theoretical reproducibility of parts in ten thousand million, and independent of irregularities known to exist in the rotation of the earth. There are already indications that such a standard might not be merely of academic interest.

In the Electrotechnics Section steps have been taken to enable the testing of instruments to be done at constant temperature. Much attention has also been given to the generation and measurement of power at frequencies in the audio range; such frequencies are of increasing importance for aeroplane electric supply systems, high-speed motors, induction heating, etc. A double-channel electronic generator giving 700 watts per channel, with great stability, is now in operation, and saves much time in the calibration of certain instruments. Apparatus involving the use of the new resistance alloys containing aluminium has been constructed and has proved very satisfactory.

LIGHT DIVISION

One important factor in the problem of the unnatural appearance of coloured objects when illuminated with fluorescent light is the extent to which the energy distribution of an acceptable illuminant, such as daylight, can be

distorted before the colour-rendering becomes "objectionable" or "unnatural". An extensive study of the observer's visual tolerance in this respect is in progress in the Division. Using a special spectroscopic apparatus a source of light has been obtained whose spectral energy distribution can be gradually distorted by the progressive removal of the light in one or more spectral bands. The point at which observers find the colour-rendering impaired when viewing various test patterns (colour pictures, etc.) is being determined. The object is to enable the limits to be specified within which the spectral energy distribution of the closely-related spectral luminance distribution of fluorescent light sources must lie if their colour-rendering is to be satisfactory.

Work has begun on the measurement of the photometric properties of flash tubes, which include the total light in the flash in relation to the electrical energy consumed in the tube, the variation of the light intensity during the flash, the spatial distribution of the light and the approximate spectral composition. In some of these tubes the effective duration of the flash is little more than a millionth of a second; they are widely used in photography and adequate methods of measurement need to be developed for the specification of their characteristics.

One important result of the development of diffraction gratings made by the Merton-NPL process is that the use of infra-red spectroscopy in chemical analysis and process control, hitherto seriously limited by high cost of instruments, is likely to be greatly stimulated. In three prototype spectrometers constructed in the Division it has been shown that the performance of the expensive prism spectrometers hitherto available to chemists can be exceeded at a fraction of the cost by means of a simple grating spectrometer. Two of these instruments are being given a prolonged trial in Ministry of Supply establishments and the third has provided the basic design for commercial production.

Merton-NPL gratings ten inches in length are now being made for use in linear measurement in machine tools. These gratings are really scales of very high accuracy but unlike conventional scales they require a special method of reading them. Such a method, using the moiré fringes of two superposed gratings, has been developed and enables linear intervals as small as 10^{-4} in. to be converted into electrical pulses capable of working electronic counters. These developments are being used by an important industrial firm as the basis for an extensive programme aiming at the automatic control of machine tools.

Many materials can be indentified, or their purity specified, by their optical density, and the calibration of the commercial refractometers used to measure this property necessitates a knowledge of the refractive indices of selected samples to a high order of accuracy. This, in turn, entails a very precise control of the temperature at which the measurements are made. For this work a temperature-controlled room has been built and is undergoing its first trials.

Ultrasonic methods have been developed for the machining of hard materials and in Light Division they are being applied to glass. In windows for wind tunnels used in aerodynamical research accurately cut slots 20×4 mm are often required in glass plates as thick as 50 mm. The production of these slots by conventional milling techniques would be an extremely difficult task, but they are being cut ultrasonically in thirty minutes.

The work on transparent electrically conducting windows has been rounded off by a detailed investigation of the electrical, optical and structural properties of the bismuth oxide-gold films. It is now possible in the laboratory

to produce films of this type with an optical transmission of 80 per cent and a resistance of less than 4 ohms between opposite edges of a square. The problem of applying this work to the full scale production of aircraft windows is now under study elsewhere.

MATHEMATICS DIVISION

The bulk of the work done in the Division has once again been carried out on the ACE Pilot Model. The level of serviceability has been kept remarkably high and over the full year 80 per cent good time has been achieved. Moreover this figure has been maintained despite the addition of extra storage facilities on magnetic drums.

The most marked feature during the year has been the very large increase in work done for aircraft firms. This continues to be mainly calculations of critical flutter speeds and stress analysis computations. In addition a large amount of work has again been done for the Ministry of Supply and as in previous years facilities have been provided for some members of the Royal Aircraft Establishment to programme for, and solve problems on, the machine; in particular the analysis of a large amount of data from flight trials of the Comet was carried out in this way.

This year, for the first time, the Division had programmes ready for the computation of new Tax Tables though in the event, of course, they were not used.

The amount of up-to-date machinery in the Punched Card Section has been augmented with a corresponding increase in the effort devoted to random walk problems in nuclear physics. In collaboration with the Atomic Energy Research Establishment a punched card method has been established for the analysis of spectrum lines as a method by which the energies and types of electron levels in an atom can be established. Data collected by the British Boot, Shoe and Allied Trades Research Association during a survey of women's feet are being analysed with a view to improving the available range of fittings.

The installation of the large, servo-connected, differential analyser has been completed and it has been used on problems arising in varying fields of physics and engineering. The mechanical differential analyser, after many years of useful service, has been transferred to the College of Aeronautics.

With the larger outside problems now being done on the ACE or punched card machines, the Desk Machine Section has been able to devote its energies to smaller but more complicated problems arising mainly from the research work of other Divisions. Various mathematical tables have been computed both in collaboration with the Royal Society Mathematical Tables Committee and for use within the Laboratory.

Research has been devoted to the general improvement of numerical techniques and on allied work in numerical analysis. In particular results have been obtained in the asymptotic solution of differential equations which should be of great value in computing various well-known functions, for example, Legendre functions of large order. In addition the numerical applications of Chebyshev polynomials have been investigated in some detail.

METALLURGY DIVISION

An extension of the Metallurgy Division laboratories designed to accommodate the Ceramics, the X-ray and the new Radioactive Tracer Sections was formally opened by Sir Lawrence Bragg on 6th April, 1954. The extension consists of a two-storey building of a total floor area of about 11 700 sq. ft.

The Ceramics Section is mainly concerned with the development and production of refractory ware for use under exacting conditions, especially those involving very high temperatures. For the Radioactive Tracer Section the plan underlying its design and equipment has been to provide facilities for carrying out on metals of all but the highest activity most of the operations normally carried out on metals in a research laboratory. The X-ray laboratory consists of a single large room divided by means of easily removable partitions into a number of cubicles, each of which is intended to contain a single piece of equipment. The laboratory is well equipped with apparatus for standard X-ray techniques and many specialized equipments, such as X-ray sets adapted for Geiger-Muller counter work and high precision measurements of diffraction line intensities, a fine focus set, an electron microscope, a soft X-ray spectrograph and a recording microphotometer are also available.

From 31st May-2nd June a Symposium on *Creep and Fracture of Metals at High Temperatures* was held. Nearly 150 people attended, of whom 33 were from overseas. The object of the Symposium was to review progress in the theoretical aspects of the subject. Twenty-two papers were presented, and fully and informally discussed. The Proceedings will be published in a single volume by H.M. Stationery Office.

Work for the British Electrical and Allied Industries Research Association on the high temperature properties of steels for new electricity generating stations has progressed considerably during the year, and the tests have reached a stage at which some estimates of the performance of the steels are possible. It has become clear that it is practicable for steam temperatures to be appreciably higher than are contemplated at present; important improvements of the thermal efficiency of generating stations thus appear to be possible, but much development work is necessary before these improvements can be realized. As part of this work, an investigation of the properties of welds in these steels has been planned. Very interesting results have been obtained in the improvement of the high temperature strength of steels containing 6 to 8 per cent of chromium. It seems likely that these steels will prove capable of bearing useful loads at temperatures well above 600°C and be able to replace the more expensive austenitic steels in certain components of generating equipment.

A technique for preparing replicas of high resolution and contrast for the electron microscope has been successfully applied to the examination of the fine structures of heat-treated alloy steels. The first examination of a series of metallic alloys with the soft X-ray spectrograph has been commenced during the year. This equipment enables the condition of the electrons within the metallic atoms to be examined directly, and it has proved possible to demonstrate changes in the electronic structure of magnesium produced by alloying it with aluminium, and also to make observations on the electronic structure of the aluminium atoms dissolved in magnesium. The observations have been made on specimens cut from massive samples of the alloy such as might be used in engineering practice, so that if the power and scope of the experimental method can be sufficiently developed, a new and more penetrating method of examining metallic materials will have been made available.

The first stage of a comprehensive examination of the mechanical properties of single crystals of pure iron over a wide range of temperature has been completed. The work was done in connexion with studies of the embrittlement of iron at low temperatures, which is the essential cause of the occasional

failure of large welded mild steel structures. The change from a tough to a brittle condition has been followed in detail, and the way has been opened for a systematic study of the stresses that cause cleavage in iron and steel.

Preliminary experiments on the processes taking place during the fatigue of metals have been commenced. These have led to the initial conclusion that there is an atomic mobility in metal under alternating stresses that is not present in the unstressed material at the same temperature. More detailed experiments are planned.

Systematic work on the effect of impurities on the properties of polycrystalline iron has also continued, as well as work on the constitution and properties of titanium alloys and of uranium alloys.

Much work is in progress in conjunction with British Iron and Steel Research Association committees on the establishment of standard analytical methods for the determination of new additives to steels, and of elements present at very low concentration. A highly accurate analytical technique has been developed for the determination of total titanium in titanium metals and alloys, and the method is being applied to other elements.

METROLOGY DIVISION

Recommendations have been made by an international advisory committee, on which the Laboratory is represented, expressing the need for a new definition of the metre and a strong preference for basing this on the natural standard of the wavelength of light rather than on the length of a certain metal bar as at present. Various sources of monochromatic light suitable for purposes of defining the metre and of measuring length in terms of light waves are being investigated to provide data which will enable the best choice of an ultimate standard to be made. Improved knowledge of another natural constant, the speed of light, is of fundamental importance in theoretical and applied physics. A new determination of the velocity of very short radio waves by means of an interferometer has led to the value 299 793·0 km/s (186 283·1 miles per second). This agrees closely with the value determined for light by means of the geodimeter—an instrument developed in Sweden primarily for measuring geodetic bases by timing the passage of a pulse of light.

Two impersonal methods of measuring line standards of length more precisely than by present visual methods are being developed, and it is hoped to apply both to the direct determination of line standards of length in terms of wave-lengths of light. In one, an analysis of measurements on photomicrographs of the defining lines has shown that it may be possible to make a photographic comparator of accuracy better than 0·000 05 mm (2 millionths of an inch). In the other, the image of a line is made to oscillate across a slit in front of a photoelectric cell and the variation in cell current is transformed electronically into an indication of the line position sensitive to about 0·000 02 mm.

To improve the basis of pressure measurement a new primary standard of pressure, of range 900 mm Hg measured either from zero or from ambient pressure, has been brought to the final stages of development. It employs a precise photoelectric "optical probe" to measure the positions of the mercury surfaces from above. This may have applications to positional measurements on reflecting surfaces which are mechanically inaccessible.

Notes on "Balances, weights, and precise laboratory weighing"[2], and on the "Scientific aspects of volumetric glassware"[3] have been published in the NPL series of *Notes on Applied Science*. It is expected that publication of notes on the "Measurement of pressure with the mercury barometer"

will precede the implementation by the Laboratory on 1st January, 1955 of new internationally agreed barometer units and conventions. These were originated in the Division and will remove much existing confusion associated with mercury barometry. Strong support has been given to the British Standards Institution and through it, to the International Organization for Standardization (ISO) on this and other matters of wide and basic concern.

A new protective coating, consisting of a tin-nickel alloy, has been tested and found highly satisfactory as a finish for analytical weights. It is being adopted commercially in the place of gold plating.

A Symposium on *Engineering Dimensional Metrology,* organized in collaboration with the Mechanical Engineering Research Laboratory, was held at Teddington in October, 1953. Authors from America, Canada and Europe contributed forty papers of which nine were by members of the staff of the Division. The Proceedings are to be published by H.M. Stationery Office.

The data required for the investigation into the accuracy of measurement of large dimensions attained in industry, and the measuring techniques used, have largely been completed. The results are being analysed with a view to publishing shortly a final report which will serve as a basis for the British proposals for extending the ISO tables of work tolerances.

Two high-precision instruments for the measurement of internal diameter have been constructed. The first, covering the range 0·1 to 3 in., has been in regular service and has proved most valuable; the second, which covers the range 1·5 to 6 in., is undergoing final performance tests. A pneumatic comparator with a measuring head designed to cover the range 2 to 6 in. is proving a valuable complementary instrument; it provides the same accuracy of measurement, viz. $\pm 0{\cdot}000\ 01$ in., and is rapid in use, being self-locating in the bore under measurement. It can be employed for measuring very long bores, and since the sensitivity may readily be reduced, is likely to prove useful in armament inspection and research. Preliminary work on a two-stage pneumatic comparator of very high sensitivity intended for very accurate measurement of external dimensions has given encouraging results.

The new gauge interferometer constructed in the Division has been in continual use for measuring the highest grade slip gauges. It enables routine measurements of slip gauges up to 1 in. long to be made to an accuracy within ± 1 millionth of an inch, with little loss of accuracy for the longer lengths up to 4 in. A large-field flatness interferometer designed and made in co-operation with the Light Division has also proved to be a valuable instrument for testing end-standards, platens of measuring machines and toolmakers' flats.

PHYSICS DIVISION

Work on combustion calorimetry has been actively continued and details were presented to the Calorimetry Conference at Schenectady, U.S.A., in September, 1954. The heat of combustion of pellets of benzoic acid, submitted by a British firm of manufacturers, has been precisely determined; this material will be available for use as a working standard in combustion calorimetry.

Work on the International Temperature Scale has been mainly devoted to platinum resistance thermometry. At present, the resistance thermometer is used to define the scale between the boiling point of oxygen (−182·97°C) and the freezing point of antimony (630·5°C). At temperatures below the oxygen point, slight variations in purity of platinum are more likely to

cause variations in the scales defined by different thermometers than is the case at higher temperatures. To investigate this point thermometers made of platinum from different sources have been designed and constructed for use down to the boiling point of hydrogen (−252·9°C).

The various national laboratories have now been charged by a Committee of the Bureau International des Poids et Mesures with the duty of investigating the best design of thermometer for extending the scale of the resistance thermometer up to the freezing point of gold (1063°C). Special thermometers for this work have already been constructed at the Laboratory.

Work on noise suppression has continued for industry and government departments, and the techniques employed in noise measurement have been further improved. An item of particular interest was a very successful application of the principles of the acoustic filter with oil instead of air as the fluid medium. In a hydraulic power drive system, noise was caused by the transmission of pressure fluctuations from the pump, in a separate building, through the oil in the pipe line. A two-stage acoustic filter, installed in the pump room, almost completely suppressed the noise, the fundamental being reduced by about 40 dB and the harmonics to a level well below the background and no longer measurable.

A detailed investigation of the variation of the sound absorption in air with humidity has been carried out in the reverberation chamber. Measurements have been made covering the humidity range 4 to 80 per cent R.H. at 20°C, for frequencies from 1000 to 12 500 c/s.

During the last few years the Laboratory has been carrying out a redetermination of the "equal-loudness curves" for pure tones. These curves are virtually the basis of the study of noise measurement and many other aspects of hearing, but previous determinations have shown large discrepancies. The investigation, which has been carried out on a very comprehensive scale, is now practically complete.

An extensive study is being made of the calibration, in absolute terms, of pressure balances such as are used in high-pressure measurement. The balances maintained at the Laboratory are being compared with those adopted at the Van der Waals Laboratory in Amsterdam and other laboratories where accurate measurements of high pressures have been established.

The pressure-volume-temperature relations of various mixtures of gases of importance to the chemical and mechanical engineer are being studied, with the co-operation of the Chemical Research Laboratory. At present, mixtures of carbon dioxide with certain hydrocarbons are being measured.

In ultrasonic flaw detection it is generally fairly easy, though laborious, to find the flaws that are present but it is often difficult to assess their seriousness especially if the surface of the specimen is rough or uneven. Improvements have been made, on the one hand, to reduce the labour and increase the speed of search by providing a beam steered in direction (like a searchlight) from a fixed and prepared site; on the other hand, where normal search methods are used on rough surfaces, it is now possible to determine whether the flaws indicated are genuinely large or small. The steerable beam device can be operated electrically to permit the results of testing several beam positions to be displayed simultaneously without moving the probe. Further alteration of the beam angle at the same site can be effected mechanically. In this way, a detailed search can be made from a few prepared sites.

Development of ultrasonic delay-lines continues, and improved crystal backings have been applied to them at high frequencies. A proprietary American cobalt-iron alloy wire can be used successfully for longitudinal wave delay lines and has a much lower temperature coefficient than nickel; for torsional waves, excellent ferrite generators have been made up to 1 Mc/s.

Improved methods of measuring elasticity with tiny specimens a few millimetres long and a millimetre in diameter have been found and a large number of binary and ternary titanium alloys have been tested.

Some success has been achieved with high intensity ultrasonic generators using ferrites both in the 10 to 15 Kc/s and in the 100 to 150 Kc/s ranges, the former at about 100 watts being used for ultrasonic cutting and the latter at about 300 watts being used for irradiation; they are also intended for a possible metallurgical investigation of the solidification process.

Intercomparisons of measurements of radioactive isotopes by different laboratories have shown that agreement within a few per cent is attainable by the appropriate methods, and arrangements have been made whereby standard samples of ^{131}I and ^{32}P are available from the Laboratory to users in this country and abroad at specified times, for the calibration of equipment and other purposes. Attention is being given to the design, operation and production of simple equipment for the long term maintenance of standards. A comparison of British and United States national radium standards at the National Bureau of Standards, Washington, has confirmed the comparison made at the Laboratory two years ago; the standards, which have been in use since 1934, are in very close agreement.

Development of three types of fatigue testing machine continues. The prototype 10-ton machine has completed 660 million cycles satisfactorily and the 1500-lb machine 350 million cycles. Several potential users are interested in these machines, and it is hoped that a commercial model of the smaller machine will be available shortly.

The prototype multiple unit machine is at present in use for a statistical investigation of the fatigue strength of some hundreds of samples of 1·7 mm diameter screws. This machine also is likely soon to be available commercially.

Work on photoelasticity and stress analysis has included an investigation of stresses in deeply notched pieces, and the development of means for the practical computation of local instability in stringer-sheet combinations. An investigation, in which five different forms of stud fastening were compared, has now been completed for the British Shipbuilding Research Association

SHIP DIVISION

As noted last year there has been a drop in demand by shipbuilders and others for routine investigations on resistance and propulsion and a larger proportion of this work is for small craft such as tugs and trawlers.

Research work has continued on the ship-model comparison, and in association with the British Shipbuilding Research Association a paper has been published giving results to date[4]. Perhaps the most interesting feature of these results is that the performance of modern flush welded, smooth painted ships indicates a surface friction resistance considerably below that calculated by the normal Froude method, and even below the value given by the Schoenherr method. The results also confirm the conclusion which was arrived at some time ago, namely, that the difference in performance between an all-riveted hull and a flush welded hull (both being smooth painted) is of the order of 15 per cent. The results also show the great care that is necessary to obtain satisfactory ship trial results, and therefore

the desirability of concentrating attention on more extensive trials of a limited number of ships. New emphasis has been placed on the importance of roughness of the hull surface on the performance.

The study of the friction resistance of long smooth surfaces has continued and the question of form effect on friction resistance has been brought into prominence. The results of this research have been published[5] and they are having an important bearing on the whole question of the extrapolation of the ship model results to the full-scale.

During the past year, in response to a demand from yacht designers and also from the Yacht Research Council, a novel type of dynamometer has been developed to enable sailing yachts to be tested in an attitude which corresponds closely to the sailing condition. Advice and assistance is being given to the Council in carrying out full-scale trials on a 5½ metre yacht for comparison with the results of the model tests.

A successful prototype torsionmeter has now been developed in collaboration with the Physics Division and highly satisfactory results have been obtained on two ship trials. The instrument is readily adaptable over a wide range of shaft diameter, and gives at least as high a degree of accuracy as can be obtained with any commercially-available type of torsionmeter.

Research is continuing on the wavemaking resistance of ships, and attention is being concentrated on a study of the effect of tank boundary interference. It is a matter of some complexity, which is being studied both from the theoretical and the experimental angle, and it will be some time before results are obtained. The matter is of importance in relation to the present efforts which are being made both in this country and abroad to assess in more detail the various elements which contribute to the resistance of a ship. In connexion with wave work also, experiments have been carried out on wavemaking equipment and valuable results, which are important in relation to the design of wavemaker for the No. 3 Tank project, have been obtained. At certain critical frequencies a very large standing wave system has been built up across the tank, and this completely swamps the normal fore and aft wave system. This phenomenon has been of some considerable interest outside the Laboratory.

TEST HOUSE

The continued policy of maintaining close contact with industry has resulted in a pronounced improvement in the accuracy and quality of certain types of instruments and apparatus. This service is now employed by an increasing number of firms.

Further installations of up-to-date equipment have taken place and, as a result, it has been possible to take over further items of routine test work from divisions.

Arrangements are being made to undertake a type of test new to the Laboratory—that of testing 'Trilene' inhalers for the Ministry of Health.

REFERENCES

(1) STEEL, J. McA. *The Standard Frequency Monitor at the National Physical Laboratory* (accepted for reading and publication by the Institution of Electrical Engineers).

(2) Notes on Applied Science, No. 7. *Balances, Weights and Precise Laboratory Weighing.* N.P.L. London, 1954 (H.M. Stationery Office) Price 2*s.* 0*d.*

(3) Notes on Applied Science, No. 6. *Volumetric Glassware—Scientific Aspects of Design and Accuracy.* N.P.L. London, 1954 (H.M. Stationery Office) Price 1*s.* 6*d.*

(4) ALLAN, J. F., and CANHAM, H. J. S. *Ship Trial Performance and Model Prediction.* (Read to the Institution of Naval Architects, 9th April, 1954).

(5) HUGHES, G. *Friction and Form Resistance in Turbulent Flow, and a Proposed Formulation for use in Model and Ship Correlation.* (Read to the Institution of Naval Architects, 9th April, 1954).

PEST INFESTATION RESEARCH

In the main, the principal lines of research have continued unchanged from the previous year; certain investigations have been completed, however, notably the work on the infestation of slaughterhouses by blowflies, and the study of the interaction of wheat protein with the fumigant methyl bromide. One new line of work that has been started is a study of the practical control of the Cacao moth in a London warehouse.

BIOCHEMISTRY

The new Biochemistry block was completed during the year and formally opened by Sir Ben Lockspeiser, in November, 1953. This has made an important difference to the work of the section by providing additional space and excellent facilities.

Considerable progress has been achieved during the year in the basic physiological research which underlies the study of the mechanism of insecticidal action. However, none of the work has reached a stage in which progress can be reported in other than the most technical terms, and accordingly this will not be attempted. Current investigations include: the study of acetylcholine and cholinesterase in insects; the effect of insecticides on the phosphorus metabolism in insects; and the preparation of radioactive allethrin and its metabolic fate in insects, with special reference to synergism mechanisms.

BIOLOGY

Ecology of the Khapra beetle (Trogoderma granarium)

This insect can only multiply rapidly at a high temperature, and is therefore found principally in tropical countries, where it causes an immense amount of damage to cereals and to certain other stored foodstuffs, notably groundnuts in Nigeria. In Britain it is a serious pest in maltings, being able, unlike most other insects, to develop rapidly in the very dry conditions prevailing in the malt stores.

The larvae are very difficult to control, partly because they are unusually resistant to insecticides, but mainly because of their ability to remain hidden, often for very long periods, in inaccessible cracks in the fabric of the building. It has been shown in the laboratory that two types of larvae exist, one having a very much longer growing period than the other.

The short-lived larvae spend most of their time feeding in the malt, only pausing at intervals for brief moulting periods. During the feeding periods the oxygen consumption of these short-lived larvae is very high and only drops when the larvae are moulting.

The long-lived larvae, on the other hand, have an increased number of moults, and undergo many prolonged "resting periods" during which they remain hidden in the cracks. The oxygen consumption of such resting

larvae is exceptionally low, their life processes being slowed down so much that they live on their fat reserves, gradually decreasing in size. Eventually they leave the cracks to feed once more, after which they may pupate or start another resting period.

Beetles developing from long-lived larvae give rise to both long- and short-lived offspring. The proportion of long-lived larvae increases in crowded breeding conditions such as would be found in a heavy infestation.

Experiments are in progress to ascertain what conditions, if any, will induce hidden larvae to come out into the open, when they would be accessible to chemical control measures.

Overwintering of Storage Pests

The ability of imported insect pests of stored foodstuffs to overwinter in Britain has an important influence on their significance as pests in this country.

Accordingly a large number of different species of insects have been exposed to winter conditions in a variety of unheated structures, continuous temperature records being kept in each situation.

Fifteen species, out of a number tested in a meteorological screen, survived the unusually cold winter of 1950–51. It is of interest that the survivors included, in addition to certain species found out of doors in Britain, a few insects normally found only in heated premises, such as the Mill moth (*Ephestia kühniella*) and two Dermestid beetles (*Anthrenus vorax* and *Trogoderma granarium*).

It is possible that the reason why such insects thrive only in heated buildings is not that they cannot survive the British winter, but that the summer temperatures in unheated situations are too low to permit the completion of the life cycle with sufficient rapidity.

FOOD STORAGE

Hermetic Storage of Grain

The work reported briefly last year on hermetic storage of damp grain aroused considerable interest and stimulated requests for further information.

In a laboratory scale experiment at 20°C with wheat of 19 per cent moisture content the intergranular concentration of carbon dioxide rose progressively and germination fell until after about 26 weeks' storage there was no appreciable change in carbon dioxide concentration and germination was zero. During the same time the milling and baking properties (determined by the Research Association of British Flour Millers) changed gradually, although the grain was not regarded as damaged until after 26 weeks. By 52 weeks the sour-sweet smell that developed could not be removed by airing and the flour no longer produced an acceptable loaf. The temperature of the experiment (20°C) was however considerably higher than that likely to be met in practice in this country, and similar experiments on the current crop, with grain of slightly higher moisture content, are being conducted at 15°C.

The large scale experiment begun in August, 1953, is still in progress and final results are not yet available. Combine-harvested wheat containing over 20 per cent moisture was fed without further cleaning into 10-ton silo bins, which were filled almost to capacity and then sealed. After the first few weeks the temperature at the centre of the bins fell progressively and after 3½ months was about equal to the average outside temperature.

Possibly owing to the high temperature and moisture content the carbon dioxide concentration rose more rapidly than expected and the oxygen concentration fell almost to zero in a few weeks. The rapid production of

carbon dioxide made it necessary to relieve the internal pressure by letting air out at intervals during the first few weeks, thus gradually removing atmospheric nitrogen. The carbon dioxide reached a concentration of over 90 per cent within 15 days of sealing, and after rising to 95 per cent there was no further change or increase in pressure.

INSECTICIDES

Control of Bean Weevils

Bean weevils of the family Bruchidae damage immense quantities of leguminous crops throughout the world. The British canning industry could absorb some 40 000 tons of East African beans annually if these could be shipped to the United Kingdom free from infestation, which is not at present the case.

Investigations in the Laboratory, recently completed, have shown that the admixture with each 200 lb of beans of 6 oz of a diatomite powder containing 0·05 per cent of gamma-benzene hexachloride will ensure freedom from infestation if the insecticide is applied at a sufficiently early stage after harvesting.

This treatment remains within the limit of 1 part per million gamma-BHC acceptable to the authorities and to the importers and processors in the United Kingdom.

Control of Ants in Hospitals

Continued experiments have shown that even heavy infestations by Pharaoh's ant, *Monomorium pharaonis*, in hospitals can be controlled by systematic application of chlordane. In each of five infested hospitals visited and in all other cases reported the seat of infestation was in the underground ducting carrying the steam and hot water pipes. It has been found, however, that treatments should always begin at the periphery of an infestation and work towards the centre, because ants tend to move away from the treated areas and establish sub-colonies in previously uninfested places.

Recent experiments at a hospital where the ducts are small and inaccessible showed that, except in a few narrow side-tunnels, which needed separate treatment, complete control was achieved by using a portable electrical machine to blow a heavy mist of insecticide along the ducts.

FUMIGANTS

Effect of Fumigation with Methyl Bromide upon the Malting and Brewing Quality of Beer

Methyl bromide has been used in this country for large scale fumigation of barley intended for animal feeding stuffs but before using it on barley for malting it was considered that tests were necessary to determine its possible effect on malting and brewing quality. Some tests have now been carried out in collaboration with the Brewing Industry Research Foundation. Two varieties of barley were tested at two moisture contents and two levels of dosage. After airing the samples were malted and germination tests, analyses of the malts and brewing tests were carried out. The germination of all the treated samples was affected, particularly those with the higher moisture content and larger dose. Satisfactory beers were brewed from all samples. In tasting tests adverse comments were made on one of the beers from barleys treated at the high level and while there was no definite conclusion that the effect was due to fumigation, the use of methyl bromide on malting barley cannot yet be recommended unreservedly.

COLONIAL LIAISON

The link between the Laboratory and the Colonies has been greatly strengthened during 1953–54 largely through the activities of the Colonial Liaison Officer. There is no doubt that there is work of the highest importance to be done in relation to the conservation of food in the Colonies, whether it be for famine reserves or the improvement in the quality of export crops.

Twelve reports, based on overseas visits, have been prepared and distributed. Six of these dealt with food storage in the territories of Kenya, Uganda, Tanganyika, Zanzibar, Gambia and Sierra Leone. The remainder covered investigations on:—

Bruchid beetles or "fly" in beans;

Fumigation using chlorinated hydrocarbons;

Assessment of degrees of infestation in Colonial territories;

Quality of Gambian groundnuts with special reference to insect infestation;

Present condition of Nigerian groundnuts;

Comparison of quality of "new" and "old" crop Nigerian groundnuts.

Storage schemes and disinfestation measures specially suited for local conditions have been devised and sent to the territories concerned. Many of the enquiries received have concerned the use of fumigants, the merits of different types of grain drying machinery and moisture determination meters, the uses of various forms of storage buildings, and the use of different contact insecticides.

RADIO RESEARCH

Construction of permanent laboratories for the Radio Research Organization has commenced on the present site of the Radio Research Station at Slough where temporary wooden buildings have been in use for many years. With these greatly improved facilities it will be possible to accommodate those sections of the work now located at the National Physical Laboratory and to extend the research programme.

Ionospheric observatories and atmospheric noise measuring stations are maintained at a number of places overseas; these are operated either by the staff of the Organization or through the co-operation of other authorities.

The work of the Organization is mainly concerned with wave-propagation; that is, with what happens to the radio-frequency energy leaving the transmitter and how its passage to the receiving aerial affects the characteristics of the signal applied to the receiver terminals. The wave-propagation investigations are of considerable importance in the planning and operation of radio and television services, and to the operating as well as to the manufacturing side of industry.

In addition to these investigations, research is in progress into semiconductors and other materials used in making radio components and the development of radio-frequency power and field-strength measuring techniques continues.

LOW FREQUENCY PROPAGATION

This work is concerned with the phase of the ground wave at frequencies of the order of 100 kc/s, in particular how it varies with distance over paths of mixed geological structure. The case of transmission across a coast-line is of special interest because position-fixing systems depending on the comparison of the phases of signals from two or more low frequency transmitters are widely used for marine purposes. Extensive phase measurements have been made overland and off the south coast of England along various paths radiating from a transmitter near Lewes (frequency 127·5 kc/s). The results agree generally with theoretical expectations in showing that the rate of change with distance of the phase-lag, relative to free-space transmission, of the ground-wave crossing the coast-line from the land, reverses from positive to negative sign at the coast and then slowly returns to the small positive value appropriate to transmission over the sea. That is, the local phase speed which over the land is rather less than that of light, exceeds the latter value for a short distance on the seaward side of the coast line and then, as the distance from the coast increases seawards, it slowly relapses to a value very slightly below the speed of light. Fluctuations are superposed on this phase-lag/distance characteristic. Also, within half a wavelength of the coast-line there is, on the land, a pronounced phase change similar to that already observed overland at an abrupt geological boundary; this aberration cannot be accounted for on simple theoretical grounds. Clearly conditions very near the coast are complicated and it is not at present known how far the observations can be applied to coast-lines in general.

THE IONOSPHERE AND HIGH FREQUENCY PROPAGATION

The main objective of the ionospheric research programme is the collection of observational material describing the temporal and geographical variations in the properties of the ionosphere, and the interpretation of these data for application to practical communication problems, particularly in the high frequency band (3-30 Mc/s). A related and more specialized line of investigation is in the field of high frequency direction finding, where the directional errors imposed by the ionosphere are studied.

On the communications side, an important item is the preparation of world-wide forecasts of transmission conditions, which are issued at monthly intervals for periods six months ahead. They are based on the routine measurements made by the world network of ionospheric observatories. One of the sources of error in the forecasts is that they aim to cover transmission conditions between *any* two points on the earth's surface. A more restricted set of forecasts applicable to circuits terminating in the British Isles has been prepared and the accuracy of these is being studied in relation to the general forecasts. The equipment at Slough for examining long-range back-scatter from the earth's surface has been used extensively; particular attention is being paid to the accuracy of measurement of maximum usable frequency made with this apparatus. Another line of research is the measurement of the angle of elevation of the component rays arriving from long distance transmitters. Many techniques were used to study the changes occurring in the ionosphere during the solar eclipse of 30th June, 1954, but it is too early to comment on the results.

A paper on high-frequency direction finding prepared for the International Radio Consultative Committee and since published[1] discusses the improvement in accuracy likely to accrue from the use of pulsed transmissions for emergency use at sea and in the air. With this type of modulation wave-interference errors, due to the simultaneous reception of rays coming from

the transmitter by way of different ionospheric routes, are reduced by time-discrimination. For continuous wave signals time-averaging of the bearings may be used and the possibilities of this method have been studied by exploring the time-scale of the rapid bearing fluctuations. If the surfaces of constant ionization density were spherical and concentric with the earth then all ionospheric rays would lie in the great-circle plane between the transmitter and receiver. The primary cause of the bearing deviations of the individual ionospheric rays is the distortion or wrinkling of these surfaces and experiments have continued to improve the description in statistical terms of the imperfections and how they vary with time.

VERY-HIGH AND ULTRA-HIGH FREQUENCY PROPAGATION

The two decades of radio frequencies from 30 Mc/s to 3 Gc/s are of growing practical importance for sound and vision broadcasting, low-power mobile services, navigational aids and other purposes. The coverage areas of these systems and the incidence of interference between distant stations operating on the same frequency involve propagation considerations which deserve close attention. At Slough, recordings are made of the field strength of the various B.B.C. television stations. This work has been proceeding for some years and has enabled a statistical appreciation to be obtained of the temporal variations in fairly long-distance metre-wave transmissions due to changing meteorological conditions in the lower atmosphere. The statistics giving the proportion of time that any chosen field strength is exceeded in various circumstances, together with similar material obtained by the B.B.C. and G.P.O., have been accepted by the International Radio Consultative Committee for general use in appropriate geographical regions. Experimental experience has been gained of the variation of field strength with distance at 100 and 600 Mc/s over various types of country[2]. At the higher frequency the data show that the median field strength is considerably lower than the value calculated on a smooth-earth basis. Taking these results and other measurements into account ground-wave propagation curves have been prepared for 50-800 Mc/s which will be useful over average terrain[3]. It is hoped to extend the experimental observations to 900 Mc/s and to obtain further experience within the band already covered.

ATMOSPHERIC NOISE

At frequencies less than 20 or 30 Mc/s the noise level due to atmospherics imposes a minimum field strength below which the signals received from a transmitter will not provide a useful signal. Consequently the measurement of noise levels throughout the world is a necessary complement to the study of propagation conditions at these frequencies. While the noise survey in the high frequency band continues at reception points in various parts of the world, preparations are in hand to extend observations to lower frequencies. For this purpose a number of equipments covering the frequency band 15-500 kc/s have been made commercially to a specified design; the first has been installed in this country and the remaining sets will be used overseas.

If the measurements of noise characteristics were of an entirely objective character they would provide a more comprehensive basis for estimating the effect of the noise on any chosen radio service, whatever its method of operation. The difficulty is to decide on the parameters of the noise to which attention should be mainly directed. This problem is under active consideration and experimental work is in hand in the low frequency band.

Assistance continues to be given to the Meteorological Office in the improvement of methods and apparatus for the location of thunderstorms, making use of the radio frequency energy radiated from lightning flashes.

SEMICONDUCTOR RESEARCH

During the past few years there has been an increasing application of highly purified germanium in diodes and triodes (transistors). These components may be of the point-contact type in which one or more of the electrodes is a sharp metal point bearing on the surface of a block of germanium having nominally uniform composition. Junction-type components use mono-crystalline material, into small regions of which minute quantities of impurity are introduced so endowing these regions with either an excess or deficit of conduction electrons. Germanium treated in these ways is referred to as *n*-type or *p*-type respectively. The properties of the junction components are determined by phenomena occurring near the *p*/*n* boundaries both within the material and on its surfaces, the metal electrodes themselves playing no fundamental part in the mode of operation.

The work at the Station is directed to understanding the physical processes occurring in point-contact and junction components and how these are related to their electrical behaviour. Measurements have been made of the voltage/current/temperature characteristics of both types of diode and of junction transistors; some progress has been made in using the results to identify the fundamental physical features involved. It has for example been shown that the point-contact diode probably incorporates a crude *p*-*n* junction introduced during construction when the contact is "formed" by the passage of high-density current impulses, and that this junction determines most of the properties of the diode. The noise-spectra of the diodes when passing current in the reverse direction provide complementary information about the physical processes. Spectra have been measured over a very wide range of frequencies (8 decades) and compared with those obtained at various currents from a small untreated mono-crystalline rod having non-rectifying contacts. Such comparisons are useful in establishing those aspects of noise-generation which are a property of the material itself and are not associated with the rectification process.

It is hoped that these investigations will lead to a better understanding of the inherent reasons for the noisiness and restricted high-frequency performance which at present limit the use of these components.

POWER AND FIELD STRENGTH MEASUREMENT

Equipment has been developed and calibrated for measuring power at a level of about 1 mW on frequencies in the region of 3 and 10 Gc/s (wavelengths 10 and 3 cm). As the United Kingdom sub-standard, it is available for calibrating continuous wave equipment submitted by industrial or other organizations and will be compared with the sub-standards of other countries. An instrument for measuring the noise-power from gas-discharge sources is being developed for use at about 10 Gc/s.

Field strength meters operating in the high frequency band have been calibrated for industry and measurements have been made for government departments. An interesting practical application was the measurement for an industrial firm of the local interference level from a radio-heating plant intended for export, to discover whether it conformed to the regulations of the importing country.

RESEARCH WORK AT THE UNIVERSITIES

The investigations outlined below are being carried out at universities, under contract from the Department, as part of the programme recommended by the Radio Research Board.

Very Low Frequency Ionospheric Research—Cavendish Laboratory, Cambridge

The work falls under two headings. The routine measurement of the amplitude and phase of the downcoming waves from the Rugby transmitter (16 kc/s) distant 90 km from Cambridge: and, using the same transmitter, the study of the variation of these same quantities together with the polarization of the downcoming waves, at distances ranging from 90 to 600 km.

High Frequency Ionospheric Research—University College of Swansea

Two lines of investigation are in progress: an examination of the propagation of disturbances in the F2 layer of the ionosphere by comparing the vertical incidence records obtained from pulsed sounding transmitters at Slough, Inverness, Swansea and Bangor: the correlation of vertical incidence absorption measurements at Swansea and Slough; and the relation between these measurements and the field strength at Swansea of signals from distant continuous wave transmitters.

Transmission Characteristics of Surface Waves—University College, London

This work was prompted by the possibility of using single conductors as efficient transmission lines at centimetre and millimetre wavelengths. The properties of dielectric-coated wires[4], corrugated metal rods and helical guides have been examined practically and theoretically. Dielectric-coated metal sheet and dielectric rods are also being studied.

Dispersive Artificial Dielectrics—Imperial College, London

An assembly of conducting elements arranged regularly can be constructed so as to behave as a dielectric and has possible applications in the design of beamed aerial systems at centimetre wavelengths. Structures receiving special attention are those likely to yield high dispersion so that a small change in frequency of the incident radiation produces an appreciable angular deviation of the emergent beam. A major part of the work so far carried out has been the design and construction of a spectrometer for use at 24 Gc/s (1·25 cm wavelength).

Ferromagnetic and Ferroelectric Materials—Imperial College, London

This work is designed to improve understanding of the relation between the composition and lattice structure of materials and their magnetic and dielectric properties. Various ranges of ferrites have been prepared and X-ray structural studies made. Measurements have been made of the saturation magnetization over a wide range of temperature and of the ferromagnetic resonance behaviour at centimetre wavelengths. The variation in permeability and permittivity over the frequency range 50 c/s to 24 Gc/s will be studied as a guide to possible uses for the materials.

The work on dielectric materials includes the preparation of high-density sintered ceramic specimens of various mixed oxides and the measurement of their dielectric properties.

REFERENCES

(1) SMITH, S. B., and HOPKINS, H. G. H.F. Direction Finding: Comparison of C.W. and Pulsed Transmissions. *Wireless Engineer*, 1954, **31**, 11.

(2) SAXTON, J. A., and HARDEN, B. N. Ground-Wave Field-Strength Surveys at 100 and 600 Mc/s *Proc. I.E.E.*, Part III, 1954, **101**, 215.

(3) SAXTON, J. A. Basic Ground-Wave Propagation Characteristics in the Frequency Band 50–800 Mc/s *Proc. I.E.E.*, Part III, 1954, **101**, 211.

(4) BARLOW, H. M., and KARBOWIAK, A. E. An Investigation of the Characteristics of Cylindrical Surface Waves *Proc. I.E.E.*, Part III, 1953, **100**, 321.

ROAD RESEARCH

The volume of traffic on the roads is growing and engineers are finding it necessary to strengthen and widen many of the existing roads. In spite of improved road surfaces accidents continue to increase and skidding accidents in particular remain high. These facts give a new urgency to the work of the Road Research Laboratory both in the fields of safety and traffic and of road materials and methods of construction.

SAFETY AND TRAFFIC

Toughened Glass

The windscreens of most vehicles in current production in Great Britain are made of toughened glass. This material has the merit that when shattered it breaks into small rounded fragments that do not easily cut flesh: its drawback is that when struck by a flying stone it may suddenly become a mosaic, which is difficult to see through. In glasses at present produced this mosaic has about 40 particles per square inch. In an attempt to produce windscreens more easy to see through when accidentally damaged in this way, manufacturers have produced experimental glasses which have a much lower number of particles per square inch when damaged. These glasses have been tested by driving round a series of irregularly spaced obstacles on an airstrip, the windscreen being deliberately shattered by being struck a sharp blow on entering the test run at speed: where the particle count was 25 or less the run could be made safely at 60 mile/h. In view of this finding the British Standards Committee on Safety Glass is recommending an alteration of the British Standard to require a particle count of not more than 20 per square inch.

Protective Helmets

Motorcyclists belonging to the Metropolitan Police have been issued with protective helmets following a demonstration by the Laboratory of their value in cushioning a blow. Studies of hospital records have shown that 60 per cent of head injuries are due to blows on the front of the head and that blows on the crown are rare. Helmets therefore need maximum protection at the front with peaks pliable enough to bend and protect the eyes from a frontal blow. Preliminary laboratory investigations suggest that although the padding next to the head may be soft the bulk of the protection should be provided by a layer of firm material of about the compressibility of cork. The outer shell should be tough and not brittle and should be smooth enough to slide easily over a road surface.

Yellow Headlight Beams

Many motorists who have driven in France consider that the yellow headlight beams required there make for easier and safer driving at night by virtue of their colour alone. French regulations, however, require the use of meeting beams having a more sharply defined upper limit and lower glare intensities above the horizontal than are used in Great Britain. The Laboratory has carried out experiments on a track using several observers: the recognition distances of various grey test objects were determined, comparisons being made between white and yellow light (*a*) of the same intensity (*b*) from bulbs having the same wattage. The differences in recognition distance observed were so small that they may have been due to chance variations.

Dazzle

The Laboratory's work on dazzle has now been summarized[1]. The general conclusion is that a great improvement in seeing conditions at night could be attained by improved setting of vehicle headlamps. Several designs of headlamp beam will give a high standard of visibility if the lamps are correctly aimed and maintained but the best results will only be obtained when everyone is using the same design of beam.

Pedestrian Crossings

Observations have been made at intervals at selected pedestrian crossings in the suburbs of London. These show that there has been a steady increase over the years both in the proportion of pedestrians using the crossings and in the proportion of motorists giving way to pedestrians at the crossings. An increase in these proportions was recorded at night after the introduction of flashing beacons.

In experiments in which a group of observers were required to estimate the last possible moment at which it was safe to cross the road in front of traffic approaching at known speeds it was found that the time allowed was sometimes dangerously short for very fast or very small vehicles.

Skidding and Braking

In the past, measurements of the resistance of a wet road surface to skidding at speeds up to 30 mile/h. have normally been made by means of one of the Laboratory's special motorcycle and sidecar machines. Improved apparatus for measuring slipperiness has now been built into a car so that tests can be made at higher speeds and with greater safety.

The skid-resisting properties of airport runway surfaces when wet have been studied, at speeds up to 110 miles per hour, by means of a small "braking-force" trailer towed by a car: this information, the first to be obtained on wet surfaces at high speeds, was required owing to the increased landing speeds of aircraft, but is also of importance in connexion with the increasing speed of modern road traffic. The results showed that skidding resistance continued to decrease as speed increased but at a decreasing rate. At 30 miles per hour the friction coefficients ranged from 0·4 to 0·7 whilst at 100 miles per hour they ranged from 0·1 to 0·5.

Motorcycle Brakes

Brake tests have been carried out using the Laboratory's roller machine on motorcycles chosen at random on three trunk roads out of London: 80 per cent of machines had adequate rear wheel braking but on many the front wheel brakes could usefully have been better. An analysis of the answers to a questionnaire suggested that some solo motorcyclists rarely use their front brake even for an emergency stop and that many lack the considerable amount of skill and judgment required to obtain the maximum deceleration safely possible using both brakes but without losing control of the machine.

Traffic

A method has been developed for calculating the optimum settings for fixed-time traffic signals for various conditions of traffic: the results obtained also apply to vehicle actuated signals running to "maximum" during periods of peak traffic.

MATERIALS AND METHODS OF CONSTRUCTION

Soils

The increased interest in stabilized soil as an economical form of road base has led to the development, with the Laboratory's help, of special machines for spreading the cement and for mixing it into the soil. Several such machines are now in production in this country and one firm has developed a train of machines which carry out all the operations required by the process in a single pass. In view of the importance of this process a member of the Laboratory staff visited the U.S.A. to study American methods of soil stabilization and to find out how far American methods and machines would be applicable to British and Colonial conditions. A summary of his impressions has now been published[2].

The organic matter in certain sandy soils contains a constituent which prevents the setting of cement and a rapid method for recognizing it is being developed so that such soils may be avoided in the construction of road foundations by the soil-cement process. Attempts are also being made to isolate and identify this constituent and to link the chemical properties of soils of different pedological profiles with their suitability for stabilization with Portland cement. As this matter is also of importance in the construction of military roads certain of these investigations are being undertaken at the request of the Ministry of Supply.

The higher the state of compaction that can be achieved in a soil the greater is its bearing power. For a specified traffic load a thinner and cheaper road structure may thus be laid with safety where a high state of compaction can be developed and maintained in the sub-soil. This is of great importance in the construction of roads and airfields and since 1946 a comprehensive study has been made of the compaction of different types of soils produced by a wide range of machines in common use. The results of the first series of these investigations were published in 1950[3] and information on the compaction given by the later machines has been embodied in a further publication[4] which also deals with the selection of the moisture content for compacting soil, with states of compaction required in road embankments and subgrades and the specifications and control of soil compaction. The present tendency is towards the development of heavier machines and of machines of special types: to further this work the Laboratory now has a large covered shed having head room of 15 ft with hard standings and pits each 80 ft × 15 ft × 3 ft deep for the soils under test; such weather protection is necessary for experimental work to maintain the soils at a controlled moisture content.

Aggregates

Increasing knowledge of the properties required in roadmaking aggregates and in particular of their grading has led to a demand for single-sized aggregates graded within close limits. Of these aggregates, gravel is both wide-spread and cheap. A survey has been made of present-day production of single-sized gravels and samples have been subjected to a wide range of tests. The results of this work formed the basis of the new British Standard for single-sized gravel aggregates and are described with other relevant information in a recent publication[5]. In this work the Laboratory has been greatly helped by the Ballast, Sand and Allied Trades Association.

Concrete

For more than 20 years the Laboratory has been publishing data concerned with the life and performance of concrete roads. Besides the periodic examinations of existing roads this has involved the construction of several

experimental concrete roads and their subsequent study. The stresses likely to be developed by traffic and by temperature changes have been calculated and observed. Recommendations based on this information are now put forward for the design of concrete roads on representative soils for different traffic conditions[6].

Bituminous Materials

As part of an extensive investigation into the mechanical properties of dense bituminous mixtures used for the surfacing of roads a study has been made of the rheological properties of a wide range of fine mineral powders when mixed with bituminous liquids. The results have now been published[7]; they have a bearing on the products of many industries since the work is concerned with fundamental aspects of the flow properties of two-phase systems of the solid-in-liquid type.

As part of the research undertaken by the Laboratory in co-operation with the British Road Tar Association two investigations have been undertaken bearing on the use of tar in coated macadam surfacings. These are experiments to improve the quality of commercial tars for use with this type of surfacing, as well as studies to find the causes of the variable and sometimes disappointing results given by these surfacing materials as currently laid. An important requirement in a road tar for use in these surfacings is high durability and resistance to attack by atmospheric oxygen: this matter has been studied for some years and a summary of the results obtained has now been published[8].

Cases occasionally occur of defects developing in coated macadam surfacings owing to the stripping of the binder from the stone. Apparatus has now been developed for testing mixtures thought to be susceptible to this type of failure: in the test, samples of the surfacing material prepared in the laboratory are subjected to the rolling action of a loaded rubber-tyred wheel while immersed in water. Results with the machine show good agreement with practice, materials known to show stripping on the road failing relatively soon on the machine.

For some years the Laboratory has recommended surface dressing the soil foundation of a new road immediately it is exposed: this provides protection from the weather while waiting for the road to be laid. The practice is growing and recommendations have now been published[9], which describe types of soil formation and base suitable for treatment and the particular treatments to be given.

More than half the roads in Great Britain are kept in good condition by periodic surface dressing with tar or bitumen and chippings. In order that the process may be carried out with success in inclement weather, "surface active" wetting agents have been developed which when coated on the chippings make the binder stick to the stone even during rain. Agents have now been developed which are claimed to work in the same way when mixed with the binder: these are now undergoing trial.

Snow Fences

Several county authorities have now set up lengths of snow fence of the kind recommended by the Laboratory. These fences are erected in hilly districts at right angles to the direction of the prevailing snow bearing winds and are designed to encourage the formation of large drifts to leeward. When erected some 40–60 ft to the windward side of a road they collect the snow between fence and road and keep the latter free from drifts.

Snow and Ice

Recommendations have recently been published[10] dealing with the use of salt either alone or with abrasive materials in removing snow and ice from roads: a table gives the amounts of salt required for the various conditions of snow and ice to be met with.

SCOTTISH LABORATORY

The building of roads over peat provides some of the most difficult problems for the engineer in Scotland. The Scottish Branch is collecting information on existing roads over peat and a short length of experimental road on peat has been constructed in the Shetlands in collaboration with the County Surveyor. It is also working with the Scottish Department of Agriculture and the Forestry Commission on the best ways of using sea sands, river gravels, morainic deposits and other local materials to build "development" roads at minimum cost.

COLONIAL ROAD PROBLEMS

The Colonial Research Council has recommended an allocation of £50 000 from the Colonial Development and Welfare Fund, to be spent on research on colonial road problems during the next two years.

During the year under review the Colonial Liaison Officer visited British Honduras, British Guiana, Jamaica, Trinidad and other islands in the West Indies to study road making problems.

INDEX OF PUBLICATIONS

The work of the Laboratory has been described in many publications ranging from official reports issued by H.M. Stationery Office to papers contributed by members of the staff to learned societies and to the technical press. A list and index of all such publications issued between January 1933 and June 1953 has now been published[11].

REFERENCES

(1) HARRIS, A. J. Vehicle headlighting: visibility and glare. *Department of Scientific and Industrial Research, Road Research Technical Paper No.* 32. London, 1954 (H.M. Stationery Office).

(2) CLARE, K. E. The use of stabilized soil for road construction in the U.S.A. *Department of Scientific and Industrial Research, Road Research Technical Paper No.* 29. London, 1954 (H.M. Stationery Office).

(3) WILLIAMS, F. H. P., and D. J. MACLEAN. The compaction of soil. A study of the performance of plant. *Department of Scientific and Industrial Research, Road Research Technical Paper No.* 17. London, 1950 (H.M. Stationery Office).

(4) LEWIS, W. A. Further studies in the compaction of soil and the performance of plant. *Department of Scientific and Industrial Research, Road Research Technical Paper No.* 33. London, 1954 (H.M. Stationery Office).

(5) SHERGOLD, F. A. A study of single-sized gravel aggregates for roadmaking. *Department of Scientific and Industrial Research. Road Research Technical Paper No.* 30. London, 1954 (H.M. Stationery Office).

(6) ROAD RESEARCH LABORATORY. The design thickness of concrete roads. *Department of Scientific and Industrial Research, Road Note* No. 19. (In the Press.)

(7) RIGDEN, P. J. The rheology of non-aqueous suspensions. *Department of Scientific and Industrial Research, Road Research Technical Paper* No. 28. London, 1954 (H.M. Stationery Office).

(8) LEE, A. R., and DICKINSON, E. J. The durability of road tar (with special reference to its use in tarmacadam wearing surfaces). *Department of Scientific and Industrial Research, Road Research Technical Paper* No. 31. London, 1954 (H.M. Stationery Office).

(9) ROAD RESEARCH LABORATORY. Protection of subgrades and granular bases by surface dressing. *Department of Scientific and Industrial Research, Road Note* No. 17. London, 1953 (H.M. Stationery Office).

(10) ROAD RESEARCH LABORATORY. Salt treatment of snow and ice on roads. *Department of Scientific and Industrial Research, Road Note* No. 18. London, 1953 (H.M. Stationery Office).

(11) ROAD RESEARCH LABORATORY. Index of publications of the Road Research Laboratory, January 1933–June 1953 (revised). London, 1954 (H.M. Stationery Office).

WATER POLLUTION RESEARCH

This year has seen the completion of the new Water Pollution Research Laboratory at Stevenage, and removal into the new premises began on 1st October 1954. For the first time since its establishment in 1927 all the sections of the Laboratory will be brought together in one place and as a result the problems of direction and organization will be greatly simplified. The removal to Stevenage will include those sections of the Laboratory which have been working since 1938 at Birmingham and since 1947 at Coventry in accommodation provided by the Birmingham Tame and Rea District Drainage Board and the Corporation of Coventry. The relations between the Laboratory and their hosts have been good examples of co-operation of benefit to both parties. At Birmingham, for example, the results of the Laboratory's work on alternating double filtration have been used to reduce very considerably the cost of extensions to the Drainage Board's treatment works. Much of the work at Coventry has been concerned with the effect of spent gas liquor on the treatment of sewage, a question of interest to local authorities in many parts of the country. The Joint Research Committee of the Gas Council and the University of Leeds have been closely associated with this work; the laboratory at Coventry is to be taken over by the Committee, who will continue the experiments.

As in previous years the Laboratory has been engaged in fundamental work on processes of sewage treatment, in investigations on methods for the treatment and disposal of industrial waste waters, and on the effects of pollution in rivers and estuaries. In addition a small section has now been established to develop equipment for facilitating the work of the other sections; apparatus so far designed has included two types of automatic sampler, and a turbidimeter.

REMOVAL OF RADIO-ISOTOPES FROM WATER

The increasing use of radio-isotopes in industry, medicine, and research has brought with it the need for vigilance in protecting water supplies from radioactive contamination. At the request of the Ministry of Housing and Local Government the Laboratory investigated the extent to which certain radio-isotopes would be removed from water by processes normally used at water-treatment plants. The removal of radio-iodine was discussed in the last report (p. 113); later work has been largely concerned with radio-strontium[1] as this is one of the most dangerous of the possible contaminants of water supplies. Treatment with coagulants in the quantities normally used at a water works did not remove more than 5 per cent of the activity due to strontium. The proportion removed could be increased by increasing

the concentration of coagulant and raising the pH value but very large amounts in strongly alkaline solution were required to have any useful effect. Up to 80 per cent of the radio-strontium could be removed by softening the water with lime, but greater removal was effected by softening by the base-exchange process. In laboratory experiments 97 to 99 per cent was removed in this way. When water containing radio-strontium was softened in a small domestic water softener under the conditions recommended by the makers, the maximum activity of the softened water was 3·3 per cent of its initial activity. As with radio-iodine almost complete removal of radio-strontium was effected when water containing it was first applied to a slow sand filter, but the efficiency of removal fell off rapidly and after 14 days continued use the filter had no effect on the activity of the water.

At the request of the Ministry of Supply the possibility was investigated of using the activated-sludge process to remove radioactive substances from effluents[2]. Several different isotopes and mixtures of isotopes were added to separate samples of sewage containing an appropriate proportion of activated sludge; after the mixtures had been aerated for a time the sludge was removed by centrifuging and the residual activity in the supernatant liquid was determined. Although when plutonium was added about 96 per cent could be removed by aeration for 24 hours, results with other radio-isotopes were much less satisfactory; the amount removed was affected by the concentration of other ions present and the optimum pH value was different for different isotopes. It was concluded that in general the activated-sludge process was not likely to be as reliable or efficient as chemical methods of treatment.

TREATMENT OF SEWAGE

Work on the biological filtration of sewage has confirmed that the periodicity of dosing is an important factor in determining the efficiency of a filter. In large-scale plant at Minworth, Birmingham, previous work had shown that the efficiency of pairs of filters operated by the process of alternating double filtration improved when the rate of rotation of the 4-armed distributors was slowed down from the usual rate of 1 revolution in 1 to 5 min to 1 revolution in 30 min. The rate of rotation has since been further reduced to 1 revolution in 55 min; this appeared to be slower than the optimum, for a deterioration occurred in the quality of the effluent as measured by the biochemical oxygen demand. Experiments with semi-scale filters both at Minworth and at Coventry have shown that the same kind of result is obtained when the period of dosing is controlled on filters operating as single filters, both at standard rates of application and at high rates.

Before the effect of periodicity of dosing can be explained more information is required about the distribution of liquid inside the filter and some experiments with this object in view have been begun.

INDUSTRIAL WASTE WATERS

It was mentioned in the previous report (p. 114) that percolating filters treating sewage were not only able to become acclimatized to the presence of cyanide but were also able to destroy the cyanide. It has now been found that the presence of sewage is not necessary and that percolating filters are able to break down cyanides when these are supplied as solutions of potassium, zinc, or cadmium cyanides in concentrations up to 160 parts HCN per million[3]. Destruction of cuprocyanide and nickelocyanide was less complete and very little of the cyanide in ferrocyanide was removed by this method. The experiments so far have all been made with small-scale filters, but as it appears that the process might be of value for treating certain types

of dilute waste waters containing cyanide, for example washing waters from electroplating, it is proposed with the help of an industrial firm to extend the experiments to a larger scale.

It seems likely that this biological process might be able to adjust itself to considerable fluctuations in the concentration of cyanide. Thus it was found that an experimental filter that had been acclimatized to cyanides still retained its ability to destroy these compounds after addition of cyanide to the filter feed had been interrupted for periods of up to 5 weeks. The nature of the organisms responsible for the destruction of cyanide is being investigated.

During the past few years there have been many reports of pollution of water courses by effluents from silage and the Laboratory was asked by the Ministry of Agriculture and Fisheries to obtain information on the volume and composition of these liquids. Experiments on ensilage under controlled conditions are being made by the National Institute for Research in Dairying, and an arrangement was made for the collection and examination by the Laboratory of samples from experimental silos at the Institute. The liquid from concrete tower silos was found to be about 135 times as polluting as crude domestic sewage and the total effluent from 1 ton of silage was equivalent to 7500 gal. of sewage; effluent from a pit silo was much weaker but it was probably considerably diluted with surface water[4]. The main flow of effluent is produced over a relatively short period and biological treatment would therefore be difficult and costly. Suggestions for avoiding pollution are that the crop to be ensiled might be allowed to wilt for a few hours after cutting, and that the silage might be protected from rain. The volume of effluent would then be very much reduced, possibly to nothing.

EFFECTS OF POLLUTION ON FISH IN RIVERS

In collaboration with the staff of the Ministry of Agriculture and Fisheries and of the Freshwater Biological Association an investigation is in progress on the effect on the River Colne, near Watford, of the discharge of effluent from a modern sewage treatment works of substantial size, and an attempt is being made to correlate the distribution of fish in the effluent channel with the chemical characteristics of the water. So far no such correlation has been found. To help in the interpretation of the field observations the Laboratory is determining the toxicity of some substances likely to be present in sewage effluents—one of these substances is ammonia. Evidence suggests that the ammonium ion is only slightly toxic to fish but that un-ionized ammonia is much more dangerous. Since the latter increases with increasing pH value close control is necessary in toxicity tests. Results of experiments at a given pH value showed that in a toxic concentration of undissociated ammonia the period of survival of rainbow trout increased with increasing content of dissolved oxygen. This work again emphasizes the importance of maintaining the content of dissolved oxygen in a river as high as possible, as a small reduction may greatly increase the effect of any toxic substances present, even though there is still plenty of oxygen for the respiration of the fish.

SURVEY OF THE THAMES ESTUARY

Work done in the early stages of the survey of the Thames Estuary made it clear that production of hydrogen sulphide and its resultant nuisances occurred only in places where dissolved oxygen was absent or was present in only very small concentrations. The work is therefore now mainly concerned with investigations of the factors affecting the oxygen balance in the estuary. From statistical examination of records of the condition of the

estuary over many years it appears that, except in the most seaward reaches, the variations in the concentration of oxygen are due to changes in flow of fresh water into the upper end of the estuary. The effect of seasonal changes in temperature is generally small except in a stretch of about 10 miles each side of London Bridge; near London Bridge a rise in temperature of 1°C is accompanied by a fall of about 2 per cent saturation in the content of dissolved oxygen. An attempt is being made to determine the effect on the temperature of the estuary of the various known sources of heat, of which by far the most important is cooling water discharged from electricity generating stations; the amount of heat discharged from this source is increasing and it is hoped to obtain enough information to be able to predict the effect on the estuary of possible discharges from new power stations. A knowledge of the rate of oxidation of polluting matter is of importance if the effect of the discharge of an effluent at a certain point in the estuary is to be fully understood; the course of the uptake of oxygen by typical effluents is therefore being examined by means of respirometers. Two factors which affect the content of oxygen in the estuary and about which very little is known are photosynthesis and the rate of absorption of oxygen from the air through the surface under different conditions. To measure absorption from the air an apparatus has been devised consisting of a plastic tent which is allowed to float freely on the surface of the water; a known volume of air is enclosed and its composition is determined at the beginning and end of the experiment. Little work has so far been done on photosynthesis but there is some indication that it may account for some unusually high concentrations of dissolved oxygen observed in the period April to June in the reaches 35 miles and more below London Bridge.

References

(1) Downing, A. L., Wheatland, A. B., and Eden, G. E. Observations on the removal of radio-isotopes during the treatment of domestic water supplies. II. Radio strontium. *J. Instn Wat. Engrs*, 1953, **7**, 555.

(2) Eden, G. E., Elkins, G. H. J., and Truesdale, G. A. Removal of radioactive substances from water by biological treatment processes. *Atomics*, 1954, **5**, 133.

(3) Pettet, A. E. J., and Mills, E. V. Biological treatment of cyanides, with and without sewage. *J. appl. Chem.*, 1954 (*In the Press*).

(4) Jones, E. E., and Murdoch, J. C. Polluting character of silage effluents. *Wat. Sanit. Engr*, 1954, **5**, 54.

RESEARCH ASSOCIATIONS

(and other Grant-aided Organizations)

In this section some account is given of the work of the co-operative research organizations in receipt of grant from the Department. These include 37 Research Associations, four co-operative industrial research organizations which have not yet reached the status of a Research Association and two other organizations carrying out work of special importance to industry.

The material for the individual reports has been supplied by the organizations themselves and consequently there are variations in style and completeness. In the interests of brevity, the reports are selective and no attempt has been made to cover the full programmes of work in hand, although in most instances, more space has been devoted to the larger Associations than to the smaller ones.

NEW RESEARCH ASSOCIATIONS

During the period covered by this report, grants are being made or have been offered to two new research organizations.

The British Steel Castings Research Association

Research on steel castings has been undertaken for a number of years by the British Iron and Steel Research Association, but the steel founding section of the industry considered that it would be advantageous for the work to be carried out by a separate organization. The British Steel Castings Research Association was therefore formed and was offered the terms of grant recorded on page 210.

A Research Association for the Chalk Lime Industry

A Research Association which will serve the chalk lime industry has been formed.

NEW TERMS OF GRANT

The following Research Associations were offered new terms of grant during the year:

The British Cast Iron Research Association.

The British Coke Research Association.

The Research Association of British Flour-Millers.

The British Hat and Allied Feltmakers Research Association.

The Hosiery and Allied Trades Research Association.

The Lace Research Association.

The British Launderers' Research Association.

The Research Association of British Rubber Manufacturers.

The British Shipbuilding Research Association.

The British Welding Research Association.

Particulars of the new terms will be found on later pages at the end of each individual report.

CAPITAL GRANTS

No fresh offers of special grants for capital purposes have been made during the year.

BRITISH BAKING INDUSTRIES RESEARCH ASSOCIATION

During the past year further expansion in the Association's work has continued. Partly this is the natural outcome of planning in previous years and the building up of suitable equipment and facilities. Equally important, however, has been the closer definition of research problems resulting from the large number of written enquiries received at the Research Station, now exceeding 1500 per annum, and from the number of visits that have been paid to member firms—nearly 300 bakeries have been visited. At first sight, many of the problems raised appear to be concerned with day to day production. Quite often, however, the same basic problem is encountered at various bakeries, showing the need for further research work. This point is emphasized because it is believed that this form of liaison with members is of great importance to the industry and because it is the Association's view that only by means such as these can the research staff learn of the difficulties, both long-term and short-term, confronting the industry. Thus, it is most encouraging to record that collaboration with members, some with their own laboratory facilities, has again increased.

Relaxation of controls on the supply of various ingredients and raw materials has made available a greater variety of products and in many instances this has led to the need for up-to-date information on these materials. The progressive reduction in the use of substitutes or alternatives has, therefore, in no way reduced the amount of basic research work required but has in fact increased it.

NATURAL OILS IN FLOUR AND BREAD

Last year it was reported (p. 117) that there were indications of the existence of a complex material in flour oil which has a fundamental influence on the action of crumb softening agents including fat. During the year various methods have been developed of studying this new substance so that its nature and properties may be exactly assessed. In connexion with this work a special piece of apparatus has been devised for carrying out counter current distribution experiments and it has been described in the scientific press. (*Chem. and Ind.* 1954, 450–452).

MECHANISM OF CRUMB SOFTENING ACTION

Work on the mechanism of crumb softening continues and a comprehensive paper dealing with the whole problem has been published in the *Journal of the Science of Food and Agriculture*, 1954, **5**, 8–26. The effect of glycerinated fat products of varying composition on selected properties of bread, sponges and Madeira cakes was described together with suggested specifications of purity for such fatty products. Since bread and cakes form such a large part of the nation's diet the specification of the purity of such additions is regarded as of the highest importance.

FLOUR AND DOUGH TESTING

The monthly survey of flours received from selected centres throughout the British Isles continues and the panel of cereal chemists referred to in the previous report has been further strengthened by a representative of the Research Association of British Flour Millers. Measurements of the effect on bread doughs of flour and bread improvers have been made on a number of different instruments. Changes in the techniques of using some of

the standard types of flour testing instruments are being investigated as a further result of this work. The practical application aimed at is the more accurate assessment of the behaviour of different flours and treatments in the commercial bakery, thereby producing better bread.

BREAD INGREDIENTS AND MANUFACTURE

Of the large number of chemicals examined to compare their effectiveness as inhibitors of rope in bread, acetic and propionic acids were found to be the most efficient. The sodium and calcium salts of these acids were also found effective. These results have been embodied in the submissions made to the Preservatives Sub-Committee of the Food Standards Committee of the Ministry of Food. Pending any amendment to the Preservatives Regulations, acetic acid of 12 per cent strength used at the rate of 1 pint per sack of 280 lb of flour remains the simplest rope preventive.

In collaboration with the Low Temperature Research Station, Cambridge, a paper has been published in the *Journal of the Science of Food and Agriculture*, 1954, **5**, 292–304, on the survival of rope spores (*B. subtilis*) in bread during baking and information is also included on the internal temperature conditions of a wide range of baked goods.

Work on the refrigeration of bread dough continues, as before helped by the loan of a specially designed refrigerator by a member firm. The major problem is to prevent the characteristic open texture in the centre of a tin loaf that normally results from retarding dough development by freezing. A formula and method have, however, been developed by which bread of reasonable commercial standard can be obtained after retarding the dough for periods up to 18 hours. Members had already been advised on a method of retarding fermented buns for periods up to 48 hours.

Studies are being made into the electric power consumed in the mixing of doughs and batters. The amount of power consumed can also be used as a measure of dough and batter consistency. A special type of instrument for this work has been obtained from the U.S.A.

Collaboration with the Ministry of Food, the Medical Research Council and the Research Association of British Flour Millers continues in tests designed to ascertain the effect of certain flour and bread improvers on the health of the consumer. A considerable amount of work has been done on the use of unbleached and untreated flours with particular reference to the effects of overmixing and of aeration with atmospheric and pure oxygen. In collaboration with a member a simple process involving relatively low capital expenditure for using unbleached and untreated flour in the production of bread of good colour and texture has been developed and patented. In view of the public interest in these matters, this work has taken priority over all the other activities of the Association.

The relationship between the efficiency of the dough divider and the weight of the baked bread has been referred to in earlier reports. This work has now been extended to an examination of the finished bread at the point of sale. Preliminary indications suggest that atmospheric conditions after baking have a greater effect than previously imagined.

The effect of additions of oat flour in breadmaking and flour confectionery have been investigated. In bread and small goods, additions of 10 per cent of oat flour had little effect on the volume of the products but produced a noticeable and pleasing flavour.

EMULSIONS AND EMULSIFYING AGENTS IN CAKES, BISCUITS AND OTHER PRODUCTS

Studies on the physical properties of synthetic whipping creams continue and it has been found that the hardness of the fat used is a most important factor; as a progressively softer fat is used there is a decrease in whipping volume and an increase in the volume of liquid draining from the cream. A considerable amount of work has also been done recently on methods of pasteurizing synthetic cream and the effect of pasteurization on cream quality. Data have been obtained on the rate of cooling such creams after pasteurization by various methods, including refrigeration.

CAKE AND FLOUR CONFECTIONERY, INCLUDING INGREDIENTS

A panel which includes representatives of several member firms has been set up to study fat quality. A preliminary investigation into the creaming values of two different fats showed that comparable results could be obtained by several investigators, irrespective of the creaming methods used. A reproducible laboratory test of this type is essential before accurate guidance can be given to the industry on this subject. The wide variety of fats now available has made this work of some urgency.

Heat sterilization and the use of semi-moisture proof packaging film are under investigation as methods of controlling mould development in packaged cake. In the former method, cakes have been sealed in moisture proof cellulose film and sterilized by heating in an oven. This has successfully increased the shelf life of the cakes, although the mould population on the cake surface was not entirely eliminated. In the latter method, cakes sealed in semi-moisture proof cellulose film did not develop mould to the same extent as those in moisture proof film. They did, however, dry out more rapidly.

The use of papers impregnated with anti-mould agents has been studied in preventing surface mould development on cake but the method shows litttle real promise.

Experimental work continues on a comparison of shell, frozen whole egg and dried egg in cake making. Various samples of English frozen whole egg have been examined. Experiments have indicated the undesirability of including duck egg in frozen whole egg because there is some evidence that the food poisoning organism *Salmonella typhimurium* is more liable to be found in duck egg than hen egg.

Recipes and methods have been developed for the preparation of dry mixes from normal bakery ingredients for a wide range of products. These dry mixes may be made up weekly for use in the bakery as required and need only the addition of water (containing any desired colourings and flavours) to produce baked goods in every way equivalent to those obtained by more conventional methods.

BISCUITS, INCLUDING INGREDIENTS AND PACKAGING

Work on antioxidants to retard the development of oxidative rancidity in biscuits continues but has been mainly directed towards the use of butylated hydroxyanisole, propyl gallate and dodecyl gallate, singly and in combination.

The Preservatives Sub-Committee of the Food Standards Committee of the Ministry of Food has recommended that the present regulations should be amended to permit the use of the first two of these. The effect of adding

antioxidants at intervals during the storage life of fats is being investigated and linked with this are studies on the stability of biscuits made with these fats both with and without the presence of further antioxidants. There are indications that the addition of an antioxidant to a fat near the end of its induction period in the development of oxidative rancidity extends the life of the fat considerably.

The experiments commenced last year on gas packaging have been completed. Briefly, nitrogen, carbon dioxide and a vacuum afford equal and very good protection against the development of oxidative rancidity. The influence of the final moisture content, of the raising agents used, and of the pH value on the stability of the biscuit are also under investigation.

In view of the deterioration in quality caused when the finished biscuit absorbs atmospheric moisture, it was thought that simple humidity indicators might be useful in the factory and as a "tell-tale" in selected biscuit packs, and indicators similar to those already developed for use in biological research have been prepared. They are based fundamentally on the impregnation of a strip of a fine quality paper with a solution of cobalt chloride the colour of which changes with the absorption of moisture. The addition of various inorganic salts to the impregnating solution has been studied and the method of use is being explored in collaboration with a member firm.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st July, 1951 to 30th June, 1956 a block grant of £11 000 per annum is made provided £20 000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £8000.

The income of the Association for the last completed year was £44 186.

THE BRITISH BOOT, SHOE AND ALLIED TRADES RESEARCH ASSOCIATION

The Association's programme includes a comprehensive study of the properties of footwear from the wearer's viewpoint, such as comfort, appearance, suitability, serviceability and value for money. A detailed account of the whole programme is impossible in the space available and only selected items of particular interest are included in the following summary.

SHOE FITTING

The beginning of 1954 saw the completion of a detailed survey of women's feet during which well over 2000 subjects of all ages and groups in many different parts of the country were examined. The data are now being analysed statistically.

This women's foot survey follows an earlier survey of children's feet from which there have been interesting developments during the year. Apart from collecting many useful statistics about children's feet and shoes, the practical outcome of the children's survey was the release by the Association of the range of so-called "Satra" model lasts referred to in the 1951–52 Report (p. 120). The latest development is that a number of firms have arranged to use "Satra" model lasts for the production of shoes, and also to stamp the shoes with a mark clearly indicating to the purchaser that the shoes had been made on approved lasts. The conditions which have to

be satisfied in these arrangements are covered by formal agreements between the Association and the member firms concerned.

The work on the physiological aspects of foot comfort, which was initiated by Satra Research Fellowships at the Medical Research Council Laboratories at Holly Hill, Hampstead, is now being continued at Satra House.

SPECIAL PURPOSE FOOTWEAR

There has been considerable publicity recently about the need for industrial workers to wear boots or shoes which give adequate protection to their feet. Representatives of the Association not only serve on the Safety Boot Committee of the British Standards Institution, but in recent months the laboratories have been engaged in testing and appraising many submissions from different shoe manufacturing firms in order to be able to advise B.S.I. in the operation of the kite mark scheme for miners' and industrial safety boots.

As an interesting example of special purpose footwear, reference was made last year (p. 122) to the high altitude assault boots made by the Association for the successful Everest Expedition. Sir Edmund Hillary and other members of the climbing party visited the laboratories during the year and as a result it was agreed that, utilizing previous experience, the Association would produce and present to Sir Edmund's party the necessary high altitude assault boots for the 1954 Himalayan Expedition.

MATERIALS

The shoe trade uses an extremely wide range of materials of all kinds. Most of the newer plastics and synthetics are being used or adapted to produce components or materials of interest to shoe manufacturers and Satra House is the focal point of this development work. During the past year over 100 studies of materials have been undertaken each month on the special machines developed at Satra House for the testing and appraisal of shoe components and materials of all kinds. Requests are becoming more and more frequent; from both shoe manufacturers and producers of materials, for sample lots to be examined critically before mass production is undertaken. The value of this work to members, and indeed to the public also, cannot be accurately assessed but it represents a great advance on the old wasteful methods of trial and error.

In addition to synthetics and plastics, a great deal of attention continues to be devoted to the trade's traditional material, leather. Much experimentation is being done on both upper and bottom leathers and the joint committee of this Association and the British Leather Manufacturers' Research Association has made excellent progress during the year in dealing with subjects of mutual importance to the two industries.

PRODUCTIVITY STUDIES

The Industrial Division of the Association has continued its work on comparative factory productivity surveys and on methods investigation. This Division has also a major interest in the four Conditional Aid projects which have been included in the Association's programme, dealing with methods and training, machine controls, intelligence service and materials economy.

These four projects, which were started at the beginning of the year, are now well under way and their potential value is already becoming evident.

APPLICATION OF RESULTS

A permanent problem facing industrial research organizations is to persuade industrial firms to accept their results and put them into practice. There is no better barometer of success in this than that firms should constantly raise questions and queries of all kind. In this direction the Association's activity over the past year has been highly satisfactory, embracing well over 5000 such enquiries, excluding requests for copies of the Association's regular publications. A similar degree of interest was made manifest, when, to meet the requirements of member-firms in some of the more outlying parts of the country, miniature exhibitions demonstrating some of the major aspects of the Association's work were on display in Lancashire and in Leicestershire. On each occasion, over 300 representatives of member-firms visited the exhibition.

On the educational side, public health authorities, medical officers and educational organizations continue to ask for considerable quantities of the *Public Information Leaflets* on children's shoes and shoe fitting. The trade also has made wide use of these publications and of the range of similar leaflets dealing with various aspects of the care of boots and shoes.

At the beginning of the year the Association was included in the television series, "Science and Industry". Its Director, its Chairman of Council, and the President of the operatives union, who is a member of the Research Association Council, all appeared in person.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1953, to 31st December, 1957, a block grant of £10 000 per annum is made provided £25 000 of grant-earning income is received from industry, and an additional grant of £80 for each additional £100 contributed by industry up to a maximum additional grant of £8000.

The income of the Association for the last completed year was £53 133.

BRITISH CAST IRON RESEARCH ASSOCIATION

During the year under review, 25 research reports appeared in the B.C.I.R.A. *Journal of Research and Development.* Reviews have appeared in the B.C.I.R.A. *Bulletin* on the behaviour of cast iron in seawater, the effect of aluminium on cast iron, the manufacture of abrasive shot, the sodium silicate carbon dioxide process for curing moulds, and other subjects.

A conference entitled "Simplifying Foundry Operation", demonstrating the possibilities of applying work simplification in the ironfoundry, was held at Ashorne Hill in November, 1953, and its success was such that the conference was repeated in February, 1954.

The Council has approved the policy of holding Open Days in alternate years to enable members and others to visit the laboratories at Alvechurch and view the work in progress. Two Open Days were held in July, 1954, during which about 300 members, and 150 representatives of user-firms, other research organizations and Government departments, trade associations, technical institutions, universities, technical colleges, schools, and the press attended.

RESEARCH DEPARTMENT

Gases in Cast Iron

The application of the vacuum heating method for the determination of hydrogen in cast iron has been studied and suitable apparatus has been constructed. The hydrogen is estimated by measuring the change in pressure

on one side of a palladium thimble. The results show that hydrogen is rapidly evolved just below and well above the critical temperature range. The evolution is more rapid with white irons than with grey irons and appears to be incomplete in the latter case. The most rapid extraction of hydrogen is obtained with cylindrical samples with an axial hole. Apparatus has been developed for a study of the evolution of hydrogen at room temperature. Hydrogen is evolved continuously over periods up to at least 200 days.

The influence of oxygen on carbide stability has been studied and found to have no direct effect. Oxygen has an apparent carbide stabilizing effect when it combines with elements such as aluminium which have a graphitizing influence. The theoretical aspects of oxygen in cast iron have been reviewed. Field tests to determine the gaseous element content of irons produced in various foundries have continued. The partitioning of nitrogen between elements such as aluminium and titanium, etc., and iron has been studied by measuring the acid insoluble and the acid soluble fractions during the chemical determination of nitrogen. The neutralization of the effects of nitrogen by aluminium and titanium appears to take place by the formation of acid insoluble nitrides. This is not so in the case of boron. The neutralization of titanium by nitrogen in nodular cast iron has also been studied.

Moulding Sands

Using an apparatus which can determine stress/strain curves on compression test pieces at room and high temperatures, the influence of clays on the properties of sand at high temperatures has been studied.

Apparatus to produce shell mould test pieces has been constructed and work has been carried out on the effects of resin percentage, and sand type, on the influence of clay content, curing temperature, curing time, gas content and breakdown.

An investigation into the effects of burnt or "dead" clay on the properties of moulding sand has been carried out for various clays used with synthetic and also natural sands. The influence of grain size distribution on some properties of sand has been studied. A method of computing the average distance between adjoining sand grains has been developed and used to study the effect of grain size distribution on permeability, metal penetration and thermal conductivity.

An investigation has been completed on the influence of sand type, ramming and moisture content on surface finish.

Dephosphorization

A preliminary survey of the problems involved in reducing or removing the high phosphorus content of British pig irons has been published.

Corrosion

Field tests have continued on the application of cathodic protection to cast iron ship propellers. Special attention has been paid to prolonging the anode life.

Existing cathodic protection schemes for buried cast iron pipe have been under observation and soil surveys have been made to determine the need for cathodic protection.

Porcelain Enamelling

Work has continued on defects arising from the vitreous enamelling of iron castings. Actual temperature cycles obtained in industrial furnaces

have been determined in the laboratory. The evolution of gases during the enamelling cycle is studied by heating samples in a stream of purified argon and analysing the gases evolved by means of an infra-red gas analyser.

Cracking

An investigation has been carried out in co-operation with a member-firm on cracking in bath castings, and a correlation was obtained between the percentage of cracked castings and the amount of enamelled scrap included in the cupola charges. Cracking appears to be promoted by the pick-up of antimony, boron and lead by the metal from the enamel.

Fluidity

Further work has been carried out on the fluidity of cast iron. The fluidity of hypo-eutectic cast irons increases with carbon equivalent for a fixed pouring temperature. When the normally accepted value for the eutectic composition is exceeded, fluidity continues to increase until at some critical carbon content it is rapidly reduced.

Mechanical Properties

Preliminary work has been completed on the fatigue properties of nodular cast irons of various silicon contents in the as-cast and heat-treated conditions. The effects of under-stressing and over-stressing have been examined and a programme of work on the effect of under-stressing on the fatigue properties of nodular cast irons has continued. A preliminary account of the effect of surface rolling on pearlitic flake graphite irons has been published. Fatigue tests have been carried out on hardened and tempered nodular cast irons and on nickel-free nodular cast irons.

Tests are still continuing with the object of collecting comprehensive data on the mechanical properties of the various grades of cast iron.

Galvanizing embrittlement of blackheart malleable cast iron and temper embrittlement in nodular cast irons have been investigated. Work on the mechanical properties of flake graphite irons has been completed. The influence of sulphur and manganese content and degree of decarburization on the impact transition temperatures of whiteheart malleable have also been studied.

Soundness of Iron Castings

The influence of mould factors on the soundness of iron castings has been investigated. Measurements have been made of changes in mould cavity dimensions and casting dimensions during solidification. The effect of dry sand moulds in producing sounder castings than green sand moulds has been studied.

Work is in progress on the effect of moulding materials and metal composition on pinholing in nodular cast irons.

The influence of metal composition and section size on solidification sequences of irons of various compositions is being studied, using thermocouple and quenching techniques.

White Irons

A survey is in hand on the problem of hot tearing of white iron castings. A relation has been discovered between the mechanical properties and macrostructure of white cast irons. Work has been carried out on the influence of casting temperature on chill depth.

Solidification of Cast Irons

Further experiments have been carried out to elucidate the mechanism of formation of undercooled graphite in cast irons, on which there is still considerable disagreement. Cooling curve and quenching experiments have been carried out in an attempt to explain the solidification of nodular cast irons and an account has been published of earlier work on the solidification of iron-phosphorus-carbon alloys.

Methods of Analysis

Much work has continued in co-operation with other laboratories on improvements in routine chemical analysis.

The spectrographic work has been concerned with the analysis of slags, the determination of small amounts of residual elements and the continued application of direct reading methods.

Malleable Cast Iron

Work has continued on the influence of graphitization on the rate of decarburization with special reference to manganese and sulphur. A co-operative study is proceeding on the production of sound test bars in malleable cast iron.

OPERATIONAL BRANCH

The Operational Research Team made 150 visits to member-firms during the period under review, and the total number of visits to the end of the period covers foundries responsible for one-seventh of the output of the industry.

DEVELOPMENT DEPARTMENT

The Development Department has continued to give practical effect to the research work by providing the necessary liaison with the industry. Enquiries from the industry and users of castings are now more numerous than at any previous period and cover a wider range of subjects. An increased number of enquiries has been received from engineering firms seeking special information to enable them to make the most practical use of iron castings.

For example, information has been sought by such firms on magnetic properties, weldability, requirements for cast crankshafts, and bearing surfaces; the wide experience available at headquarters has enabled useful advice to be given. Some of these problems have prompted investigations on the brazing of cast iron, the oil firing of malleable annealing ovens, heat resistance, etc.

FOUNDRY ATMOSPHERES

This section is examining means of eliminating dust at the foundry knock-out, involving the determination of the critical air contours required to control dust plumes under widely varying shop conditions. Work is still going forward to control the dust produced by conventional stand grinders, and also by portable hand grinders and swing frame grinders. Advice is being given on working conditions in foundries. Factors affecting the rate of cooling of sand, and the effect of moisture on the evolution of dust from foundry sand have been studied. Preliminary work has been carried out in connexion with the problem of pollution of the external atmosphere.

SCOTTISH LABORATORIES

The laboratories at Blantyre also show an appreciable increase in the number of enquiries received, and the Scottish Committee dealing with these laboratories has expressed itself well satisfied with the services members have received.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st July, 1948 to 30th June, 1954, a block grant of £20 000 per annum was made provided £45 000 of grant-earning income was received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £20 000.

For the period 1st July, 1954, to 30th June, 1959, the block grant is £40 000 per annum, provided £100 000 is received from industry, and the additional grant £80 for each additional £100 contributed by industry up to a maximum of £16 000.

The income of the Association for the last completed year was £114 931.

THE BRITISH CERAMIC RESEARCH ASSOCIATION

The British Ceramic Research Association serves three main groups of industries. The pottery division caters for the needs of the industries concerned in the manufacture of tableware (both earthenware and china), glazed tiles, sanitary ware and electrical ceramics. The refractories division is in close touch with both the manufacturers of refractories and the users, such as the iron and steel, carbonizing and other industries. The heavy clay section covers bricks and roofing tiles, and has recently undertaken a programme of work on salt-glazed pipes.

A feature of the past year's work in all three sections has been an increasing contact between the Association and its members. Technical conferences and discussion groups have been held; liaison visits have increased; lectures have been given in many districts; and members have made increasing use of the information services of the Association.

POTTERY

The investigations in progress lie in three main groups, associated with raw materials, processes and finished products.

It has long been an important part of the work of the Association to build up such a body of knowledge concerning the essential raw materials of the industry as to make consistency of control much more easily attainable, and to enable changes in materials to be undertaken with far greater certainty. Previous reports have indicated the extent of the work on ball clays, and this work has now been completed. One important result is that manufacturers now have a catalogue of the properties of all the clays in current use, and the significance of many of these properties is more clearly understood. Much more testing of clays is now being carried out than was the case hitherto, and the setting up of laboratories in the ball clay producing areas is a welcome sign that the suppliers themselves are keen to take advantage of and contribute to the increasing body of technical information.

In a more restricted field, detailed studies have been made of deposits of clays in the Potteries area, used in the making of teapots. As a result of these studies, it has been possible to compound a body with superior

characteristics to those at present in use, and the geological facilities of the Association are being used to ensure that the clay is available for many years ahead.

In addition to these technological projects, work has continued on the fundamental aspects of the constitution of clay. Further measurements have been made on a large number of samples collected from Cornish Stone quarries, and relationships are being sought between the chemical composition, the mineralogical contents and the ceramic behaviour. A survey of the literature dealing with all types of ceramic raw materials has been made, and a memorandum has been prepared giving a summary of the relevant data in a form suitable for easy reference by members.

So far as processes are concerned, the Association is concerned with the elucidation of the underlying principles involved in such fields as mixing, casting, pressing, forming, drying and firing. The relationship of the properties of the materials to the best type of operation is also important, and the faults which occur during or after the firing are increasingly important because of the advanced state of value of the piece. A fault of this kind which is of special concern to the sanitary industry is the tendency of large pieces to crack either during the firing or immediately after, resulting in the loss of the whole piece. An investigation into this problem has been commenced, the main methods of attack being to measure the thermal and elastic constants of the material at high temperatures and to devise a method of simulating the thermal treatment received in firing. In the earthenware section, a particularly difficult fault known as spit-out, occurs during the decorating fire. During the past year a much better understanding has been gained of the mechanism of this phenomenon and this has formed the basis of present work designed to prevent its occurrence.

Other research projects are concerned with improvements in the nature of the finished product to maintain a favourable position in competition with other materials or in other countries. A great deal of attention has been given to the stability of the relationship between the glaze and the body. This may be influenced by the initial fit of the glaze on the body, small size changes in the body or the imposition of external stresses and all these are being investigated. So far as decorated tableware is concerned, a previous study of the durability of the decoration under the influence of various kinds of washing agents has now been followed by an attempt to produce colours of still greater resistance.

Strength is an important characteristic of all pottery materials and in the field of electrical ceramics is of special significance. Electrical porcelain bodies of high strength have been produced, and the importance of good glaze fit in maintaining this strength, or even increasing it, has been demonstrated. The conception of strength is gradually being widened and the work of the Association on this subject now includes thermal as well as mechanical endurance.

REFRACTORY MATERIALS

For many years it has been the policy of the Association to examine the linings of blown-out blast furnaces after a campaign has finished. A report has now been written reviewing the findings of examinations carried out on 80 blown-out furnaces over a period of 20 years. The report also contains certain recommendations relating to blast-furnace design and operation which may be expected to have a beneficial effect on lining life. Concurrently with this report, a second review has been prepared listing the types of refractory materials that are in use in furnaces now in blast.

The two reports are complementary and together give an overall picture of the improvements that have taken place in refractory materials for the iron industry.

The development of the "All-Basic Furnace" continues to be a major project in the researches undertaken for the steel industry. The history of a roof of exceptional life has been followed and samples of the bricks both before service and at the end of the campaign are being tested in the laboratory. One difficult feature of this project is that the life of the roof is dependent on many factors that operate simultaneously, and that relate to furnace design and operating conditions as well as to brick quality.

With a view to assessing the relative importance of these factors, a comprehensive series of trial-roofs is envisaged. Further, a special test-rig has been designed and built in the laboratory to subject a test panel comprising eight bricks to a series of combined slagging and thermal shock cycles. A second test has been designed to measure the creep properties of test-specimens taken at various distances behind the working face of bricks after use.

The rate of wear of steel ladle linings is of great importance because a lining that is quickly eroded away may affect the quality of the steel. It is now established that among the more important properties of ladle bricks are good shape, freedom from cores and low porosity. The relative importance of other properties such as bloating tendency, high alumina content and freedom from nuclear iron, is now being investigated both by laboratory experiments and by following trials of various bricks in steel ladles.

It is unsafe to assume with any plant, that the operating conditions which prevailed five years ago are the same to-day. As refractory materials improve in quality, the user industries are usually quick to take advantage by imposing more severe operating conditions in order to increase output. Investigations are therefore needed periodically to measure the operating conditions that the refractories have to withstand. At the present time, temperature surveys are being undertaken at two gas works where batteries of continuous vertical retorts have been rebuilt. During the re-building thermocouples have been incorporated so that continuous temperature records can be compiled at 16 positions in each setting. At a third installation a movement survey is being undertaken on four settings, each constructed with different types of refractory materials.

In the laboratory two investigations are being undertaken with a view to effecting the maximum economy in the raw materials for the manufacture of silica bricks. The first is concerned with the possibility of blending various grades of quartzites while the second aims at assessing to what extent adventitious iron spots can be considered as deleterious when they occur on the surface of silica gas-retort shapes. A long range fundamental research is centred on a study of the conversion rates of quartz in the presence of various mineralizing agents, such as the oxides of calcium, magnesium, iron and aluminium.

The Association is continuously concerned with improving existing test methods and introducing new ones. An apparatus has now been built for measuring simultaneously the creep of six specimens when loaded transversely at temperatures up to 1450°C, thus effecting a considerable economy in time and fuel over previous methods. Other well-known test methods being studied with a view to improvement are the refractoriness-under-load test and the percentage linear change test on reheating.

HEAVY CLAY PRODUCTS

During the past year most of the English manufacturers of salt-glazed products joined the Association and subjects for research of special interest to this new group of members have therefore been started. In the first instance the work has been directed to methods of improving the efficiency of firing salt-glazed products. Different systems of setting standard pipes in kilns have been investigated, and the design of improved fire boxes and kiln flues and floors is being considered. The effect on the efficiency of firing of using different kinds of coal and of oil is being examined.

Work has continued on the study of the relationship between the pressure used in shaping clay articles and the moisture content of the clay. Results now obtained on clays of high, medium and low plasticity have shown that not only the consolidation of the clay, but the strength of the goods when dried and fired are considerably affected by deviation of the moisture content from the optimum for the working pressure used. Improved works' control should follow from the knowledge gained.

Works' investigations of the roller batt-process of roofing tile manufacture have indicated the range in moisture content that may occur in the clay mix and the ware at different stages of manufacture. The effect of the moisture variations on further processing of the tiles has been examined. Evidence was obtained that at some works a slightly drier mix might be an advantage.

The drying of clay has been studied for several years from different points of view. The immediate object during the past year has been to determine the maximum stress set up in clay shapes dried under different conditions and hence their tendency to crack.

During the year two courses of lectures have been given to works' managers and foremen. The first was for the roofing tile industry and the second for the brick industry. Each course lasted two days and ranged over the whole field of manufacture. The lectures were based on observations of good practice in the industry and included also the results of laboratory and works' investigations.

FUEL AND KILNS

The collection of performance data relating to kilns in all sections of the ceramic industry has been continued. A survey of six kilns firing silica bricks has been carried out; other kilns tested have been firing ware ranging from building bricks to biscuit china. In the pottery industry interest has been shown in the possibility of using small intermittent electric kilns in circumstances where it was not possible, either on account of capital cost or space requirements, to install tunnel kilns. These intermittent kilns have been the subject of detailed investigation which is not yet complete.

In connexion with work for the salt-glazed pipe section, a study has been commenced at a number of factories of the effect of setting density on the firing, with a view to increasing the output per unit of fuel consumed.

In the field of steam generation and use, particular attention has been given to the balancing of heating and power requirements in the varying conditions which apply from factory to factory.

ENGINEERING

The investigation into the effect of various features of the design of pugs on their operation has been continued. Using blades of varying pitch, the corresponding rates of extrusion and power consumption have been determined and it has been shown that there are optimum blade angles to give

the maximum output or the highest efficiency. The arrangement designed for collecting the overspray in the glaze spraying operation has been developed a stage further, and is now being tried out on a factory scale in conjunction with both a hand-spraying booth and a continuous spraying machine. Work has also continued on the injection moulding of cup handles and the electronic method of sizing tiles.

Improved methods of making roofing tiles are being sought; in the first instance the relationship of the strength of the final product to the treatment received in the rolling of the batt and the subsequent pressing is being examined.

During the year the problem of dust arising from the fettling of pottery in the unfired state has been investigated. Using a light-scattering technique for determining dust distribution, improvements have been made in the design of exhaust hoods for use in the towing of flat ware and the fettling of hollow ware.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1953, to 31st December, 1957, a block grant of £30 000 per annum is made provided £80 000 of grant-earning income is received from industry, and an additional grant of £50 for each additional £100 contributed by industry up to a maximum additional grant of £20 000.

The income of the Association for the last completed year was £166 251.

THE BRITISH COAL UTILISATION RESEARCH ASSOCIATION

Not only has the number of members continued to increase as the Association's researches become better known in industry, but during the year some member-firms have increased their subscriptions in recognition of the value of the work. The research staff continues to devote time both to visiting members in industry and receiving their representatives at Leatherhead, the resulting exchange of information and advice being of great mutual advantage; the number of such visits during the calender year 1953, in one direction or the other, amounted to more than 500. Some major examples of collaboration with members are given below. Representatives of a number of member-firms have also spent periods of a week or more at the Research Station, discussing their own problems and studying the work of the Association at first hand.

STEAM RAISING

Results of the first experiments on a coking stoker suggest that small strongly caking coals cannot be burned on this appliance as efficiently as on a travelling grate stoker, although with graded coal there is little difference between the two stokers. The manufacturers collaborating in this work have been able to effect improvements which are now available to their customers.

The investigation into furnace baffles, mentioned in the last Report (p. 136), has been completed. Their development was carried out in conjunction with a member-firm after preliminary tests on an industrial boiler. Manufacture under licence is proceeding and already many hundreds have been installed. The original purpose behind this development was to promote turbulence in the gas stream, in order to improve the combustion in the furnace tubes.

It was soon discovered, however, that the turbulence not only improved the combustion and hence the heat transfer, but also largely prevented the deposition of dust in the furnace tubes of Lancashire boilers. The result is a gain in efficiency exceeding the 2 per cent observed with clean boilers, since, as the Fuel Research Station have shown, some 7–8 per cent efficiency may be lost owing to accumulation of dust in the flues and furnace tubes. Some installations have now run many thousands of hours without cleaning. In other cases, where coals of low ash fusion temperature are being used, more frequent cleaning may be necessary.

Air distribution through fuel beds is being studied by means of two-dimensional flow models; it would appear that the heavy slag deposits often found on the front wall of water tube boilers near the secondary air ports are caused by eddies occurring near these ports, which bring hot fly ash into contact with the hot walls. A modification of the secondary air stream appeared to move the eddies outwards into the furnace. A test on these lines, carried out by a member-firm, showed that such modification greatly reduced slagging.

From work on glass models, it has been found that, with wet steam, once the critical velocity through the steam conveying pipe has been exceeded, all the moisture in the steam is precipitated on to the walls of the pipe. With this knowledge it has been possible to design a precipitator of high efficiency, which can be used either as a steam separator with the object of drying the steam, or as a device for measuring the amount of moisture present. This work is being extended to full scale tests.

Owing to the shortage of domestic smokeless fuel it has been suggested that it might be possible to operate chain grate stokers in such a way that coke would be produced at the ash discharge. A wide range of coals tested on a combustion pot, which broadly represents the chain grate method of combustion, showed that coke satisfactory as regards size and strength could not be produced. When the pot was operated on the overfeed principle a more promising product was obtained.

DOMESTIC HEATING

The second series of field tests, which was completed during the 1953-54 winter, compared the performance of free-standing convector fires having restricted throats with that of ordinary open fires. It was shown that the higher bench efficiency of the former was, in domestic use, translated partly into a saving of fuel (of over a quarter) and partly into the maintenance of conditions of increased comfort. The Association's work on the development of this type of appliance is now bearing fruit, and during the year two member-firms have commenced production of free-standing fires incorporating the recommended features; it is understood that other firms are following suit.

Work on central heating by forced circulation through small bore piping has been continued; various types of pump have been investigated and new types are being developed in collaboration with the makers. Trial installations in a few houses are being arranged in order to obtain operational data under household conditions.

The new laboratories referred to in the last Report have been rapidly equipped. A large sectional boiler has been installed for tests on alternative systems of firing suitable for medium-scale central heating installations. Preliminary tests with hand firing have been carried out and a small chain grate stoker has been obtained for first trials on mechanical firing.

Equipment is now available for detailed study of the behaviour of appliances both on the bench and in the calorimeter room. The objective has been to evaluate factors contributing to room heating efficiency, and it has been found for example that the heat contribution from the chimney breast and tiled surround when using an ordinary open fire does not exceed 4 per cent of the heat in the fuel.

An electrostatic method of measuring smoke emission from appliances by total precipitation has been further improved. This is the most reliable method available and is being used in the programme on smoke emission from domestic appliances of different types and on the relative smoke forming tendencies of various fuels, including new types of smokeless fuels. Smoke emission has been found to vary with burning rate, and emissions of up to 6 per cent by weight have been measured at the lower burning rates.

FUNDAMENTAL STUDIES ON COAL VOLATILES

In a fundamental study of the release of volatiles, loss of weight/temperature characteristics have been determined for a number of coals of varying rank and particle size when heated at a constant rate up to 600°C. Particle size has been found to have a significant effect both on the rate of loss of volatiles and on the maximum loss of weight. Further studies have been made of the influence of hot surfaces, in the form of electrically heated wires, on the ignition of coal volatiles. The quantity of smoke can be reduced by catalytic combustion on surfaces with a platinum base, but not by other oxidation catalysts which have been tried.

COMBUSTION OF COAL BY CYCLONE SYSTEMS

This work (under an arrangement with the Department for research on solid fuel firing for gas turbines) has been continued and operation free from major difficulties has been obtained at atmospheric pressure. Most of the work has been with one type of coal with an ash content of about 20 per cent, but tests with a coal containing 7 per cent ash have shown that the higher ash content does not affect performance adversely. Further information has been obtained on the design of cyclone type dust separators and on methods of predicting their performance under gas turbine operating conditions.

In the present combustor, in which the gases leave the chamber from the top, no sulphuric acid dew point has been found. With the earlier arrangement in which the gases left by the same outlet as the slag at the bottom, an acid dew point of 250-300°F was found. In both cases the same coal of 2·7 per cent sulphur content was used.

In the light of the Association's experience, a member-firm has built (under contract with the Ministry of Fuel and Power) an experimental slagging cyclone combustor and is now about to carry out tests running at about 4·7 atmospheres in conjunction with a 2000 kW gas turbine.

GAS PRODUCERS

Tests on a typical steelworks installation suggest that producer offtake temperatures of as low as 520°C (which is possible with the B.C.U.R.A.–Kent system of automatic control) can be obtained provided that the mains are insulated. A producer gas having a high calorific value was made consistently. Also the Association was invited to collaborate with member-firms in the glass and steel industries in carrying out furnace performance trials and acceptance tests of two-stage producer plant.

PELLETING AND AGGLOMERATION OF FINES

The process for pelleting coal slurries on a vibrating tray has attracted interest in connexion with other materials, including cement, iron ore, and various chemicals. The operation of the tray at carbonizing temperature, to produce agglomerates of fine coal, is being studied to see if a coke of satisfactory physical properties can be obtained.

COAL CHEMISTRY

Earlier pictures of the fine structure of coal have been modified as a result of recent measurements of heats of wetting, density and adsorption isotherms, made with reference to the production of respirator charcoals. The measurements suggest that coals contain relatively wide flat internal passages with heights of molecular dimension and interrupted by constrictions; about 90 per cent of the internal surface area of a coal resides in such passages. It has been established that the crucial point in carbon manufacture is the extent to which the internal structure closes during the carbonization that precedes and accompanies activation; this closing must not be allowed to proceed too far, but it must occur sufficiently to prevent the structure becoming too coarse during activation. For this reason, an industrial process with relatively fixed operating conditions is very selective of coals used, whereas a wider range of coals may be successfully processed, in the laboratory, to yield a product of suitable activity.

The study of solvent extracts of coal has been continued. Measurements of osmotic pressure, light scattering, diffusion and behaviour on ultra-filtration indicate the presence in solution of particles with a wide range of size, the larger particles probably being aggregates of smaller molecules; the distribution depends on solvent and concentration.

The coal extracts have, as shown by infra-red and X-ray examination, substantially the same structure as the original material. However, they may be separated by chromatography into fractions, some at least of which—representing little more than 1 per cent of the coal—have distinctive properties (e.g. a colourless fluorescent substance is obtained). Certain chemical reactions of the extracts have been followed by infra-red spectroscopy, e.g. the weakening of hydroxyl bands and appearance of other bands following acetylation, which constitute clear proof of the presence of phenolic hydroxyl groups in lower rank bituminous coals; several other reactions are under investigation.

PARTICLE MECHANICS

Using a cyclone probe, which permits dust samples to be collected over periods as short as two minutes, it is possible to obtain rapidly the local dust concentration in a flue. A statistical procedure has been worked out which enables mean dust burden to be obtained with an accuracy of about 98 per cent even under fluctuating conditions: this requires only thirty incremental samples which can be collected in a period of about two hours. To aid the application of this technique a nomogram for rapid calculation of the analysis of variance has been devised. The method, so far applied to power station boilers, is being used on other industrial plant.

The field tests on an industrial pulverizer, carried out under the guidance of a joint committee of the Fuel Research Station and the Association, have been completed. The major factor determining useful output appears to be the recirculating load in the mill and a subsidiary one the pressure at the grinding elements. Allowing for such factors the mean power requirements for each coal were in the order of their grindability indices.

EXTERNAL DEPOSITS AND CORROSION IN BOILER PLANT

The programme relating to boiler deposits, particularly in relation to pulverized fuel fired boilers and carried out in collaboration with the Boiler Availability Committee, has been continued.

A number of tests, of up to 72 hours duration, have been made with air cooled metal probes on a further six pulverized coal fired boilers. The probes were inserted in the gas passes between the primary and secondary superheaters and the surface temperatures were varied from 650 to 950°F. Although the sulphur contents of the coals fired varied from 1·2 to 3·5 per cent and the sulphur/chlorine ratios from over 35 : 1 to 4·3 : 1, the probe deposits were all of a loosely adherent type and no significant differences in composition have, so far, been found.

Measurements have been made on the flame formed during the combustion of a coal of high chlorine content in a small experimental pulverized-fuel furnace. The flame temperature and the rate of deposition of alkali salts on steel surfaces maintained at 550°C were found to be at a maximum when the carbon dioxide content of the flue gases was 12·5 per cent.

It has been found that in synthetic flue gases containing alkali salts and sulphur oxides the rate of scaling of metal surfaces is increased by the presence of alkali chlorides. Further studies have been made to determine the influence of hydrochloric acid on the corrosion of steels by the combustion products from sulphur-carrying fuels. Severe corrosion has been found to occur when films of dilute hydrochloric acid condense at temperatures near the water dew point.

Several members have sought advice and assistance on corrosion problems on industrial and power station plant. Amongst the field investigations in this connexion are :—

(i) The addition of powdered dolomite to the flue gases in a travelling grate fired boiler:—In contradistinction to reported American experience with dolomite additions to oil fired boilers, no differences were found in the condition of economizers or in acid dewpoint temperatures between boilers with and without additions.

(ii) The effect of treating the surface of superheater tubes with carbon and of using aluminized tubes on the acid dewpoint characteristics of the gases in a stoker fired boiler burning coke breeze-coal mixtures. No effects which could be attributed to the surface treatments were noticed. Increasing the proportion of coke breeze had a beneficial effect on reducing the amount of free acid produced.

(iii) Methods of reducing sulphur trioxide formation in oil fired boilers. Decreasing the air-fuel ratio to values approaching stoichiometric and introducing some of the oil through auxiliary burners which produced a coarser spray than the main burners, both had a beneficial effect on acid dewpoint characteristics. The reduction in the rate of acid build-up with increasing carbon dioxide content confirms previous measurements on an oil fired boiler.

(iv) A comparison between producer gas and fuel oil firing of a glass melting tank. In neither case was any sulphuric acid dewpoint found, presumably due to the presence of fine dust, but chemical determinations showed that the acid concentration was two to three times greater with fuel oil than with producer gas under oxidizing conditions. In each case some acid was present even under reducing conditions.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1953, to 31st December, 1957, a block grant of £45 000 per annum is made provided £190 000 of grant-earning income is received from industry, and an additional grant of £500 for each additional £1000 contributed by industry up to a maximum additional grant of £30 000.

The income of the Association for the last completed year was £298 084.

BRITISH COKE RESEARCH ASSOCIATION

In carrying out research into all problems connected with the production and utilization of coke made in coke ovens, the Association has continued to maintain a balance between the effort on fundamental problems and technical investigations of more immediate practical application. During the year there has been some extension of field work involving large scale tests on a blast furnace and at a foundry in co-operation with members. There has been continued collaboration with overseas organizations interested in the subject of coke, and mutual benefits have been derived from these relationships.

CONFERENCE

A Conference on fundamental studies of carbon and coke was held in October 1953, in co-operation with the Coke Oven Managers' Association, and attracted a large representative audience, including scientists from Belgium, France and Germany. The Conference considered some aspects of the theoretical work carried out by the Association during recent years, including the X-ray investigations of coal and coke structures, the polymerization reactions which play a part in the formation of coke, the combustion and reactivity of coke, and the effect of the physical and chemical properties of coke on its combustion. The success of this Conference showed the importance of maintaining programmes of long term fundamental studies which are so necessary to ensure progress and new development—one of the principal functions of a co-operative research organization.

FIELD INVESTIGATIONS

Field work was carried out during the year in South Wales relating to the influence of coke quality on the efficiency of blast furnace operations. A study of the wide range of problems concerned with the use of coke in blast furnaces was initiated by a survey of the thermal and material balance of a furnace working under normal operating conditions. An attempt was also made to do some initial work on the coal/coke quality relationship, and on the size degradation of coke during transit from the coke ovens to the blast furnace. It was also possible to commence previously planned field tests on industrial cupolas in the Midlands to determine the influence of coke size on cupola performance.

INTERNATIONAL COLLABORATION

At the request of the Charbonnages de France the Association has examined certain French coals which were proposed for use in a large coke oven installation in France, and has submitted a report detailing the characteristics of these particular coals. The Dutch State Mines also requested facilities for the testing of certain coals. A short group of tests has been carried out and the results of this investigation have been discussed

with the appropriate officials. As a result of this work the Dutch authorities have been able not only to interpret previous difficulties, but also to adjust their operating procedure accordingly. Both the Charbonnages de France and the Dutch State Mines propose to proceed with the erection of a movable wall oven of the type adopted and modified by the Association, and hope to utilize the techniques which have been elaborated as a result of several years' work by the Association. The Dutch are particularly interested in the problem of damage to oven walls and they are proposing at a suitable opportunity during the course of 1956 to test the strength of the hot wall in a commercial plant. The Association has been invited to send representatives to co-operate in these experiments which should provide useful information in this field of interest to British coke oven operation. The Director and senior members of staff have continued to participate in work for the O.E.E.C. and a report dealing with new coking processes was issued by the latter in 1953.

TESTING AND ANALYTICAL WORK

During the year the Association's laboratories at Sheffield have carried out further work on the standardization of tests for determining the efficiency of certain items of coke oven plant equipment, and an improved method for the determination of naphthalene in coke oven gas has been evolved. The method is now being subjected to trials under operating plant conditions. The further development of a suitable method for the estimation of benzole in gas has also been under examination during the year, in co-operation with an industrial firm.

Other testing and analytical work has been concerned with an investigation of the breakage of coke on dropping, and studies of sampling, analysis, and testing of coal and coke. The object of the work on coke breakage is to determine the cause of breakage so that a shatter test can be devised to give more fundamental information than that provided by the tests which are now in use.

PHYSICAL AND CHEMICAL PROPERTIES OF COKE

Problems concerned with sulphur in coal and coke continue to form part of the research programme, and this work is being developed. During the year investigations have continued on the influence of the chemical and physical properties of coke on its performance in the blast furnace. This has included studies of factors controlling coke formation, the interfacial tension between slag and coke, and the determination of the strength of cokes at furnace temperatures.

Blending studies have been continued, especially in regard to the development of very small scale ovens in which such tests could be made. An oven of approximately 10–15 lb capacity has been designed, which is heated from two sides, and preliminary tests have been encouraging.

TEST OVEN WORK AT PONTYPRIDD

The new programme of work initiated at Pontypridd has been continued during the present year. This has been largely concerned with fundamental studies using the movable wall oven and investigations concerning the effect of the size characteristics of coal. In order to carry out this programme, some modifications to the testing procedure were required. The fixed end of the oven was rebuilt and provision was made for a large number of measuring points. It is now possible to measure the internal pressure at three points simultaneously, thus allowing the progress of the

plastic layer across the oven to be followed. The levelling system of the oven was also modified, and further automatic temperature control of the heating flues was incorporated. A bulk density apparatus has been constructed in order to measure the bulk density before the charge is placed in the oven, and it has been established that with dry coal the maximum probable error of this apparatus is very small. An attempt is also being made to obtain a measure of the plasticity of the coal under actual operating conditions in the test oven as distinct from laboratory methods. Certain portions of the programme of fundamental work were completed in 1953. The effect of the addition of breeze to the charge has been examined with reference to rates of heat transfer, temperature distribution in the charge, and carbonizing time. Two different sizes of breeze were employed in this work in order to examine the possible effect of voids created in the charge. The influence of the addition of breeze on coking pressure and on coke quality, as indicated by shatter indices, abrasion index, and coke size range, were also examined. This series of tests indicated that there appeared to be a decrease in the thermal conductivity of the charge with the addition of breeze, and it was confirmed that coking pressure is reduced with increasing breeze addition. From the point of view of coke size and 2-in. shatter index, earlier findings that there seemed to be an optimum breeze content of about 10 per cent were confirmed. On the other hand, as would be expected, the abrasion index was adversely affected by any addition of breeze.

A study of the effect of adding oil to the charge has been initiated.

FUNDAMENTAL STUDIES

Fundamental studies of coke formation, the nature of coking coal and the reactivity of carbon continued at Newcastle.

It is now established that two principal components participate in the primary structure of coke and "amorphous" carbons, namely:

(*a*) minute graphite layers which may be present singly or in clusters ("crystallites") of parallel but randomly orientated layers; and

(*b*) unorganized carbon atoms or amorphous carbon which, by X-ray examination, exhibits no extended regular arrangement.

The low reactivity of coke is inconsistent with the presence of many free valencies despite the indications of classical theories of chemical valency in this respect. Modern valency theory implies that the four valencies of the carbon atom can constitute a flexible system of which distortion of the tetrahedral valency angles is possible. It is, therefore, suggested that the amorphous constituents of coke may consist of continuous and essentially disordered glass-like structures having a distorted diamond-like arrangement of carbon atoms. A three-dimensional structure of this kind could enter into combination with two-dimensional systems (for example, graphitic layers) without the formation of a high proportion of unsaturated edge valencies in the graphitic layers.

The fragmentary graphite planes which are present in cokes can be regarded as giant molecules, since inter-planar effects are largely of Van der Waals character; their presence accounts for the characteristic diamagnetic properties of coke.

Methods have been investigated for the further study of the microstructure of carbons by X-ray methods and measurements of the following characteristics have been considered: degree of crystallinity, microporosity, shape and size distribution of pores, shape and size distribution of crystallites, shape and size distribution of crystallite aggregates.

Studies of pyridine-soluble constituents of coal have shown that the soluble constituents comprise substances having a wide range of molecular weight. The *beta* constituents (soluble in pyridine, insoluble in chloroform) tend to have relatively large molecular weights, in certain cases up to several thousand ; but the *gamma* constituents (soluble in pyridine and in chloroform) have molecular weights less than 1000 in general, and usually of the order of 500. The amount and average molecular weight of the soluble constituents and of their *beta* and *gamma* components may vary, according to the coal from which they are derived.

Continued study of the reaction $CO_2+C=2CO$ has elucidated factors of importance both from the experimental and theoretical viewpoints. The need to know the quantitative changes in the extent of surface oxide formation has necessitated changes in design of the apparatus used. The general effects of inorganic impurities in carbon upon the reaction rates are known, but recent study has shown that small concentrations of iron exert appreciable effects. Attention has been given to the method of introduction of the iron salt and to its decomposition upon the carbon surface.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1952, to 31st December, 1953, a block grant of £20 000 per annum was made provided £40 000 of grant-earning income was received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £20 000.

For the period 1st January, 1954, to 31st December, 1958 the block grant is £20 000 per annum, provided £60 000 is received from industry, and the additional grant £50 for each additional £100 contributed by industry up to a maximum of £20 000.

The income of the Association for the last completed year was £60 438.

THE BRITISH COTTON INDUSTRY RESEARCH ASSOCIATION

The major reorganization of the basic structure of the Association, referred to in last year's report (p. 141), is now functioning smoothly, and is already increasing the effectiveness of the Shirley Institute's work through an accession to membership of firms in sections of the industry not previously represented on the Council. Two of these, The Condenser and Allied Spinners' and Manufacturers' Association and The Cotton Yarn Doublers' Association, are concerned with processing and are co-operating enthusiastically in the research programme. Close contact with most of their members has already been established. The Merchant Converters form the other new group, and many of these firms are now applying for membership.

Some examples of current investigations of particular interest are described in the following paragraphs.

FIBRE BLENDS

It is increasingly evident that one of the great textile developments of the future is in the use of "blends" of various textile fibres to produce yarns and cloths having specific pre-determined properties. Reference was made to this in last year's report (p. 143) and to the extensive programme of research that had been commenced at the Institute. Fabrics have so many widely different uses, each calling for a particular combination of properties,

that in few instances can a natural or man-made fibre give the maximum satisfaction or serviceability. The natural fibres have proved, and still prove, to be adequate for many purposes, because they possess to a moderate degree the required combination of properties. On the other hand, the man-made fibres tend to be outstanding with respect to some properties, but deficient in others. The widespread interest in fibre blends is prompted by the attractive possibility of choosing the fibres and their proportions in the blend so that the fabric will have an outstandingly suitable balance of properties. But neither the behaviour of a blend in spinning, nor the properties of the yarn can be assessed by a proportionate addition of the properties of the component fibres: differences between the fibres in one property can influence the extent to which other properties are realized in the blended yarn. Taking the strength of blended yarns as an example, it is known that in some cases the addition of less than a certain proportion of the stronger fibres gives yarns which are weaker than those spun from the weaker fibre alone. Similar considerations apply to other properties.

The extent to which the fibre properties are realized in cloths made from blended yarns is further modified by the details of the yarn and cloth construction and the effect of varying these details must be examined for each blend if the best result is to be obtained.

All these aspects of the fibre mixture problem are being examined as fundamentally as possible for nylon/cotton mixtures. The object of this work is to provide a background of basic information so that less extensive investigations will be required to obtain all the necessary information concerning other blends.

CALENDERING AND MANGLING OPERATIONS

Work has continued on the general problem of the mechanics of the passage of cloth between two rollers, an operation fundamental to most dyeing and finishing processes. From a technical point of view, the chief features of interest are the factors governing (*a*) the uniformity of pressure across the width of the cloth, and (*b*) the pressure distribution in the direction of motion of the cloth and its effect, for example, on the expression of water. Arising from the Institute's work, methods have been developed for the rapid assessment of nip uniformity; they have been successfully applied to faulty industrial mangles. A common cause of lack of uniformity is the deflection of the rollers under load; an instrument for the rapid and accurate measurement of such deflection has been developed recently and has already found considerable use.

The problem of pressure distribution has been approached quite fundamentally and a technique has been evolved which provides a pictorial record of the magnitude of the pressure at every instant of the passage of cloth through the nip. The effect on the pressure of such factors as roller diameter and hardness is being systematically investigated and general relationships are being sought.

These studies are greatly increasing the understanding of the technical operations of calendering and mangling. The industry is particularly receptive to new ideas on mangling at the present time, for many of the newer dyeing and finishing processes demand more uniform and better controlled impregnation than was formerly required.

Again, in the interests of fuel economy, it is essential that before drying by heat as much water as possible should be removed from a cloth by mechanical means. In this connexion it has been estimated that if the average mangling performance throughout the industry were improved to the

extent of a general reduction of 5 per cent in the weight of water retained, a saving of coal of the order of 10 000 tons a year would be achieved. The results of this research work to date already point to ways in which significant economies can be effected.

TECHNICAL ECONOMY DEPARTMENT

In the 1950-51 Report (p. 109) the activities of the Technical Economy Department were described as "settling down", but during the past three years the department has been extremely active. Mention was made last year (p. 142) of a forthcoming lecture course for managers and foremen of spinning mills, made possible by the analysis of the data from the Institute's mill surveys of O.H.P. (Operative hours per unit of production). The course was designed to enable the mill man to make use of the Institute's work on productivity in a practical way by adjusting his technical conditions and machine staffing to the best advantage. This course was held in the autumn of 1953, and consisted of four Saturday morning sessions. It proved so popular that it had to be run three times to accommodate the 150 managers and foremen who enrolled.

PRODUCTIVITY STUDIES

It is perhaps an indication of the close touch between the Institute and the industry that investigations in the field of technical economy have tended during the past two years to become concerned quite as prominently with the problems of costs of production and quality as with the utilization of man power. In dealing with costs, the approach has been to lay out on paper a composite mill, representing normal industrial practice as determined from the surveys, and notionally to introduce various types of new machinery or new methods of processing into this mill, to staff it according to modern practice, and to apply current wage rates. From these figures, the savings due to the new arrangements can be calculated, and these may be treated in one of two ways. The first is to find the capital outlay that the savings will justify if the money is to be recovered in a given period. The second is to find what period is needed to recover a known capital outlay. These figures provide a guide to individual mills on the intrinsic possibilities of new ideas, and, when the details are published to the members, they can study the basic data on which the conclusions are founded, in order to see to what extent these tally with their own data; hence they can assess the probable effect of the introduction of the changes in their own particular mill. In dealing with quality, the approach has been to use modern statistical methods to study, stage by stage in the mill, the variability of technical factors that are likely to affect quality, the variability of the material's properties that are useful as a measure of quality, and hence the establishing of control points and control charts.

The willingness of members to provide information and facilities for experiment indicates their interest in this type of work, and members have been very helpful in this way. In addition, close co-operation has been received from the trade associations, in particular from the Federation of Master Cotton Spinners Associations, Ltd., who made the results of several projects the subject of special circulars to their members.

The Institute has been given a grant from Conditional Aid funds, which has been allocated to the development of productivity studies in the spinning and finishing sections of the industry.

SHIRLEY DEVELOPMENTS LIMITED

The new exploitation company has made considerable progress during the past year. Arrangements have been completed for a number of the "Shirley" textile testing instruments to be manufactured for it, and marketed by the company. From January, 1953, to March, 1954, more than eight thousand pounds' worth of instruments were sold and dispatched, and sales have been running at a much higher rate in the first half of the present financial year. In addition, royalties on "Shirley" equipment received by the company during the last financial year represent many thousands of pounds' worth of new machinery supplied to the industry.

These promising results in the establishment of Shirley Developments Limited's name and aims were greatly assisted by the success of the company's stand at the Belle Vue (Manchester) Exhibition in October, 1953, and have been helped also by the sales brochures and advertisements published by the company, by its ability to give early delivery, and by close co-operation between the company and the Institute, to ensure good service for users of the "Shirley" devices.

WEAVING EXHIBITION

Reference was made last year (p. 142) to the forthcoming special exhibition of the Institute's researches in connexion with the process of weaving. During the winter 1953-54 this was staged in the provincial centres of Burnley, Bury, Blackburn, Nelson and Preston, and attracted altogether some 4700 managers and operatives from 450 member firms. In this and many other ways personal contact with members is encouraged, in the belief that this is the sure way—certainly in the old craft industries—of achieving most rapid appreciation and application of the Institute's work.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st April, 1952 to 31st March, 1954, a block grant of £50 000 per annum was made provided £180 000 of grant-earning income was received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £30 000.

For the period 1st April, 1954, to 31st March, 1957, the block grant is £50 000 per annum, provided £220 000 is received from industry, and the additional grant £100 for each additional £100 contributed by industry up to a maximum of £40 000.

The income of the Association for the last completed year was £396 482.

CUTLERY RESEARCH COUNCIL

In November, 1953, during the official Opening of the British Iron and Steel Research Association's Sheffield Laboratories, parts of the work of the Cutlery Research Council were demonstrated to His Royal Highness the Duke of Edinburgh. Among the items shown were the hardening of pocket knife blades using induction heating, microscopic examination of a razor edge, and electrolytic polishing of table knives.

In March, 1954, the Council held its own Open Week, when a comprehensive display of the work was visited by 200 people from 60 member firms, or one third of the total membership. As a result, various firms made major changes in their production processes.

During the period covered by this Report, the Council has produced and patented a tool for the rapid measurement of thickness of steel sheets up to 24 in. wide, and this is now being developed by a toolmaking firm for general sale to sheet users.

A prototype electrically heated small forging furnace was built, tested, and shown to be fourteen times as efficient as the older type gas furnaces commonly used in cutlery production. It was also shown that each such furnace installed would reduce heating costs by about £100 per annum, which represents a potential saving to the industry of at least £10 000 per annum, or more than twice the annual cost of the Research Council to the industry. The prototype is now being developed into a production model.

Work on the properties and heat treatment of cutlery stainless steel has shown how to achieve more uniform and, if necessary, greater hardness, of blades, and the investigation is now dealing with corrosion properties, which are of great interest to the trade.

The cause of pink staining of celluloid handles on table knives has been established and is concerned with the type of preservative used in the case or package glue. In collaboration with the British Gelatine and Glue Research Association a non-staining preservative has been selected. Action is in hand to publicize this finding amongst case makers and to secure the general use of non-staining glue preservative.

In pen and pocket knife manufacture, it has been shown that rivet holes can be punched instead of drilled, punching being a quicker and cheaper process. Previously it had been considered that these holes were too small in diameter as compared with the thickness of the part to permit of successful punching.

Over 100 technical enquiries were received and dealt with, and about 100 visits made to the works of member firms.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1952, to 31st December, 1954, a block grant of £3000 per annum is made provided £4000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £3000.

The income of the Research Council for the last completed year was £7095.

THE BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

The main work of the Association continues to be concerned with the generation of electrical energy, its economical transmission and distribution, its most efficient utilization and the reliability of equipment. A great deal of fundamental research is carried out.

Building began early in January, 1954, at Leatherhead, on new laboratories comprising a main laboratory block, a high voltage laboratory suitable for 2 to 3 million volts (impulse) and a workshop block together with a substation. The site adjoins the Coal Utilisation, Printing and Packaging and Food Manufacturing Industries Research Associations. The supply substation of the B.E.A. 275/400 kV. experimental line is on the site, as is also

the E.D.A. Testing Station. The B.E.A. Research Laboratory is close by. The first stage of building should be complete by the end of 1955 and the greater part of the work will be moved from Perivale in 1956.

The Department is making a capital grant of up to £100 000 towards the excess of the cost of these buildings above £300 000 provided by £200 000 from industrial capital contributions and £100 000 from the Association's reserves.

GENERATION OF ELECTRICITY

Steam Turbines

Research on the thermodynamic properties of steam up to 6000 lb/sq. in. and 1400°F continues at Imperial College, London, and an international discussion on results has taken place in the U.S.A. The higher efficiency and the simplifications in boiler design with pressures well above the critical pressure are attractive. Research on the steels necessary for such projects continues to be actively sponsored at the National Physical Laboratory, British Iron and Steel Research Association and by steel makers. An intermediate problem concerns the endurance of welded joints, and a full-scale test rig at a power station has been designed. A final report on the cracking of molybdenum steel steampipes in service has been issued. Work has begun on tooth-ripple losses in alternators. Work continues at the British Non-Ferrous Metals Research Association on corrosion in condensers.

Wind Power

Wind speed measurements have continued at some forty potential windpower sites in the British Isles, and more detailed studies of wind behaviour at a few selected sites are planned. Further tests are in progress on the 100 kW. wind-driven generator in Orkney and preparations made for testing the 100 kW. Andreau-type machine for the British Electricity Authority, prior to erection at a permanent site.

The Windmill Testing Station at the College of Aeronautics, Cranfield, deals with the behaviour of available types and strain-gauge studies of stresses in propeller blades with a view to new economical designs.

In several countries E.R.A. wind survey methods have been adopted and the results made available. Collection of experimental data to assist in the development of machines suitable for remote areas is one of the main aims of the present windpower work. A paper on windpower was presented to the World Power Conference in Brazil and a study of British Somaliland as a typical arid zone has been made for UNESCO.

Fuel Cells

Hydrogen-oxygen cells have now been run for several hundred hours and series operation has been demonstrated, e.g. at the Production Exhibition at Olympia in July, 1954, 6 cells in series were shown. Although some research problems remain, particular applications are being studied with a view to directed development, selected after economic appraisal.

Associated with this are investigations on the redox principle and on nominally solid electrolyte cells, financed by the B.E.A. and Ministry of Fuel and Power. At the same time some possible basic improvements in the lead-acid cell have been proposed.

TRANSMISSION, DISTRIBUTION AND UTILIZATION

D.C. Transmission

There is increasing interest here and abroad in H.V. d.c. transmission, and a course of six lectures was given at Manchester College of Technology in the autumn of 1953. Three of these lectures were given by members of E.R.A. staff and were later published. Investigations on a model circuit lasting over several years are now complete and the results, including some of an economic character, have been issued to members. Some have been published and patents have been secured on control, operation and design.

Network Analysis

The E.R.A. Network Analyser was inaugurated in April, 1954, and is still being extended. It has a versatile and high performance and will give steady state, transient and harmonic solutions on the same equipment. Requests already received from this country and overseas will occupy the Analyser for some time to come. The E.R.A. has provided a set of standard definitions of terms used in system analysis which the British Standards Institution will probably soon publish. Another subject under investigation is the accuracy with which the constants of synchronous machines can be found from design data.

Cables, Conductors and Wiring

The huge capital represented by cables in supply systems, factories and houses gives national importance to any economy in their use. As an example, paper insulated lead sheathed cables up to 33 kV. have been re-rated in accordance with the increased temperature rise now permissible; similar data for aluminium sheathed cables will follow. Another problem concerns the influence on the rating of buried cables of moisture movement in the soil with the increased thermal gradients. A simple means of calculating rating factors for arbitrary daily load cycles will shortly be available. Ratings at 400 c/s have been confirmed: this frequency is often economical in factories, ships and aircraft. The closer rating of house wiring will lower the cost of domestic installations. Short-circuit ratings will soon include polythene cables. These ratings are caused by the growth of the fault currents in modern supply systems, which, until recently, were rarely high enough to damage cables.

A three-year survey of the incidence of fires in wiring installations is complete and analysis is in progress. On the safety aspect of consumer protection, a draft code of practice on earthing has been submitted to the Codes of Practice Council.

Insulation in Service

The E.R.A. Dispersion Meter has found a new and valuable use in determining the completeness of the drying of transformers and cables during manufacture. The use of the A.C. Discharge Detector for testing transformers, bushings, cables, etc., to detect incipient breakdown has extended but a lengthy analysis is needed to establish quantitative standards of tolerable discharges, although engineers are using the apparatus advantageously based on qualitative experience.

Voltage Waveform, Telephone and Radio Interference

Tertiary delta windings on the 132/275 kV. Supergrid transformers cannot economically be justified for the reduction of harmonics, although they may be sometimes essential for other reasons. A text book on telephone interference is in draft form and will be the only book of British origin

so far published on this subject. Meanwhile, members have been advised on important aspects of proposed regulations governing inductive co-ordination both here and overseas, and the Association is advising the International Telephone Consultative Committee (C.C.I.F.) on the revision of the international Directives on this matter.

Radio Interference

The Association has continued to assist the committees advising the Postmaster-General on regulations for radio interference. Attention has been directed to economic methods of suppression for the present television frequencies, Band 1, but a start has also been made on measurement and suppression at the higher frequencies particularly in Bands 2 and 3.

Switch and Control Gear

The importance of post-zero current and of energy balance in determining circuit interruption, proposed by the Association in 1939, is now recognized and was the subject of papers from various countries at the Conference Internationale des Grands Réseaux Electriques, (C.I.G.R.E.), 1954. Although long term work has included high power experiments at a testing station, the growth of supply systems lends greater importance to methods such as synthetic testing by which the most onerous conditions are limited to the short intervals when they have the greatest effect. In this way the total, as opposed to the instantaneous, power can be reduced to a convenient level.

Work has started on the high vacuum switch in addition to further development of the arc chute invention reported last year, and study has continued on gas flow in air blast breakers and voltage division between the breaks in series, which high system voltages require. The survey of the restriking characteristics of the British 132 kV. network has been completed and an assessment made of those of the 275 kV. Supergrid.

Recent experimental and theoretical investigation of the electric arc has led to a derivation of its characteristics from first principles, such as the transition and ionization potentials. The increased understanding of the physical processes governing its temperature, dimensions and volt-ampere characteristic has considerably clarified many of its practical applications, including the mechanism of the high current searchlight arc, the welding arc and the cutting arc, as well as arc extinction in circuit breakers. An image converter camera has been built and high speed photographs obtained of the arc near zero in an axial air blast circuit breaker.

Transformers

The experimental verification of methods for calculating short circuit stresses in transformers has been completed and published. In a research on temperature distribution in power transformers, an instrument for recording the effective value of a variable ambient temperature has been developed. The time constant is adjustable over the complete range of practical values.

The stability and regulation of a long transmission line can be improved by inserting a capacitor in series with the line, but system faults can impose excessive voltages. One proposed protective device has been tested and, with the co-operation of the B.E.A., tests on a number of others are projected.

Lightning and Switching Surges

Surge propagation tests have been made on a typical 11 kV. line of "unearthed" construction. With improved techniques, comprising a surge generator and 3 high-speed cathode ray oscillographs, useful results were obtained in a few short periods of about 2 hours each. The recording by automatic oscillographs of switching surges at various points on transmission systems has yielded sufficient results for statistical study. Measuring points can now be chosen on theoretical grounds.

UTILIZATION

Rural Electrification

The development of an all-electric drier for grass and grain has reached the stage where three full-scale models are in use on farms. A simple mechanical form of grain moisture meter has been developed and an electrical method of measuring soil moisture content *in situ* is under way. Pest destruction in grain by high frequency fields remains promising. Electric weed-killing is being applied to eradicating bracken but one or more seasons must elapse before results are definite. A suitable tensioned cable seems the remaining problem in the mains-driven electric tractor.

Mixed soil-warming and air-heating in glasshouses greatly reduces electricity consumption. Artificial irradiation is also interesting and a means of automatic glasshouse shading has been devised.

The Ministry of Agriculture and Fisheries continues to support the majority of these researches.

Space and Water Heating

Special consideration has been given to comfort conditions with radiant heating, as from electrically heated floors where thermal storage gives an off-peak load. Results on the domestic drying of laundry indicate an optimum value of heat input per unit volume of the drying cabinet. A double-purpose heat pump to provide hot water and larder cooling has reached the commercial stage and some trials will be made on a housing estate. Another double-purpose heat pump in the prototype stage cools milk and supplies hot water for the byre. A talk has been given in the Home Service of the B.B.C. on heat pump applications and the domestic heat pump has been shown on television.

Electric Equipment of Automobiles

The low voltage surface discharge ignition system is still limited by erosion of the plug insulation but the mechanism is now understood which will assist in the development of a suitable ceramic. Investigation of the effect of circuit inductance on the metal transferred between noble metal contacts for low voltages has shown that some inductance will reduce the transfer. Two papers have been published.

Safety Problems

Augmentation of research on safety problems to cover industrial hazards generally has been widely discussed by the Ministry of Fuel and Power, other Government departments and the Association. A programme has been drawn up and discussed with users, manufacturers and other interests. This will cost up to £30 000 per annum, of which up to £10 000 per annum may be provided as a special contribution from Government sources.

Arc Welding

Conditions for improving inert gas arc welding have now been met in practice by the suitable design of electrical power equipment. This has made possible a much greater degree of "self-adjustment" of arc length and a marked simplification in operation. The E.R.A. Surge Injector system for low voltage, radio interference-free welding by the argon arc process has advanced considerably at home and overseas. The British Welding Research Association collaborates in all this work by financial support and technical assistance.

MATERIALS AND COMPONENTS

Insulation

Further advances in the mechanism of electric failure have concerned the behaviour of breakdown channels starting from a needle point embedded in solid insulation. This technique permits study under controlled conditions of the impact of discharge streamers on the surface. A partial breakdown channel begins when the local stress at the needle point (or at the end of a discharge streamer in the practical case) reaches the intrinsic strength of the solid. The average stress within the material is, of course, much lower, so that discharges can cause the apparent electric strength to fall much below the true electric strength. The dependence of this apparent strength on sample thickness can be quantitatively related to the geometry of the system, so disposing of a problem which has been recognized for more than fifty years. The stress at the point may itself be much below that indicated by a purely electrostatic calculation. This arises from a stress-enhanced conductivity and the embedded point technique is a useful method of studying this otherwise elusive property. In moulded plastics with organic fillers the resistance to erosion by discharges largely depends on a surface layer of pure resin. Once the surface is penetrated either by erosion or by machining, the interior has little resistance. Inorganic filled interiors have a much higher resistance. Mouldings of unplasticized polystyrene show an unsuspected form of rapid failure. The discharges liberate a trace of the monomer (styrene) which causes stress-crazing of the material, with rapid breakdown through the resultant cracks. Work has begun on the discharge resistance of plastics exposed to neutron irradiation to promote cross-linking.

The thin dielectric film of dry aluminium oxide has been further developed and capacitors have been constructed, and shown to the British Association, with high working stress and wide temperature range. A logarithmic relation between the resistivity of an electrolyte and the maximum thickness of oxide film which can be formed in it has been established over a range of 10^4 to 1 in resistivity.

The E.R.A. programme at the National Physical Laboratory has extended its comprehensive study of dielectric properties up to the highest frequencies, to silicone liquids, greases and rubbers and also to new ketone resins prepared at the Chemical Research Laboratory. Examination of moisture sorption of dielectrics, using the sensitive microbalance previously described, has revealed a component agreeing qualitatively with the theory of multi-molecular layers adsorbed on internal surfaces.

Regarding industrial standardization and test methods, international controversy has arisen over the classification of insulation, all the more difficult to settle owing to the arbitrary nature of many industrial tests. This has emphasized the importance of industrial studies which include glass fabrics, fabric and plastic sleevings, surface tracking, the effect of lubricants

in spinning on cotton insulation, films of silicones and carbon-halogen compounds, the maintenance of and use of inhibitors in insulating oils and their behaviour at the high pressures which have made possible the increase of system voltages to 400 and 500 kV.

Magnetic Materials

Low-loss oriented silicon sheet steel is now available in this country but not with the quality, uniformity and cost to give British electrical manufacturers an advantage. Accordingly the British Iron and Steel Research Association in co-operation with the E.R.A., has instituted fundamental researches. On the electrical side high flux densities are now important so that measurement of losses has been taken up to 23 000 gauss. Hysteresis loss concerns domain behaviour and their study in single crystals of various metals has revealed, *inter alia,* the widespread effect on domain movement of isolated impurity centres. The permanent magnet alloy "Alcomax" shows an unexpected ageing at −50 to −70°C.

Resistors

Life tests on synthetic resin moulded carbon resistors have shown the advantage of suitable impregnation. Resistors consisting of a conducting carbon coating on a glass tube embedded in an insulating plastic suffer from rather larger changes in resistance during the first weeks of use, and greater sensitivity to gross overloading, but are more stable over long periods of load. Both crazing of the enamel and electrochemical attack can cause the failure of vitreous enamelled resistors.

Semi-Conductors

The supply of germanium for the production of semi-conductor devices in this country was surveyed and a report prepared for the Natural Resources Committee of the Advisory Council on Scientific Policy. As a result a working party has been set up by the Department to co-ordinate the whole field of germanium recovery, together with a research study group.

FUNDAMENTAL RESEARCH

The scientific and industrial importance of ferroelectrics grows. The structure of Perovskite has been carefully studied and its relation to ferroelectric properties elucidated to some extent. An interesting discovery is the existence of both ferroelectric and anti-ferroelectric properties at different temperatures in single crystals of a niobate. The reports from abroad of ferroelectric properties in tungsten oxide appear to be unfounded.

The publication of an integrating paper "Physics of Long Chain Crystals" in *Advances in Physics* completes a stage in the study of one group of high polymers and establishes the value of the thermodyamic approach to this aspect of solid state theory.

The reduction to canonical forms of the general theory of electrons in solids has been demonstrated. One concept is that of the "polaron" or element of polarization energy arising from the interaction between the electron and the dielectric structure.

In addition to the theory of the "cold cathode" arc mentioned under switchgear researches, work on the hollow cathode gaseous discharge is complete and has been published in the Proceedings of the Royal Society. Apart from the development of a cathode beam technique for exploring the cathode space a quantitative theory is available for the fields and space charges. Attention is now given to cathode mechanisms and a simple

explanation has been found for the movement of the cathode spot on a mercury surface, a well-known phenomenon in mercury-arc devices. Other work on gaseous discharges includes the growth and distribution of ionization and radiation in the spark discharge, for which high speed methods of observation have been developed, the nature of the corona discharge with transient voltages, important in modern high-voltage transmission, and a new theory of gaseous breakdown at centimetric and shorter waves which concerns one of the limitations of the power transmissible by wave-guides.

INFORMATION AND LIAISON

A discussion with interested members was held in London on electric fuses. It was the first of a series in which particular subjects will be considered directly with industry to explain reports, stimulate application and guide future work in association with technical committees. Its success augurs well for the future. Provincial meetings on the work of the Association will begin shortly. In the limited field of faults due to lightning a scheme has been running for some time by which fault reports are analysed and periodic discussions held with the engineers of Area Boards. The integration of these discussions with the technical committee system is straightforward but there are interesting problems in co-ordination with services such as technical liaison visits, technical enquiries, consultation with research staff and the provision of abstracts, bibliographies and translations. Indeed, the growth of these existing services seems to have been stimulated and urgent steps had to be taken during the year to strengthen the available resources.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st October, 1951 to 31st December, 1956 a block grant of £50 000 per annum is made provided £120 000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £50 000.

The income of the Association for the last completed year was £294 048.

THE BRITISH HAT AND ALLIED FELTMAKERS RESEARCH ASSOCIATION

The following account describes selected items from the Association's research programme. Whilst emphasis may appear to be on work in the technological field, this arises from the fact that the carrotting of fur has been chosen as an example of a discovery recently made by the Association which is considered to be of primary importance to a large section of the industry.

FUNDAMENTAL RESEARCH

Research with the objective of increasing the industry's knowledge of its raw materials is in progress and is adding to the Association's growing fund of information. The work includes an investigation of rabbit fur and the carrotting process, a study of damage, both mechanical and chemical, of wool noils and the physical characteristics of shellac in relation to the proofing process. In the case of wool noils the objective is to examine

existing methods of assessing different types of damage and then to relate these to the behaviour of the noils in processing. This is proving to be a complex and difficult problem but some progress has been made. In addition the study of the physical properties of felt has continued to yield valuable data.

Information which can be immediately applied by the fur felt section of the industry has been obtained from a study of the effect of sulphuric acid solutions on rabbit fur. The loss of protein from fur can be related to the degree of carrotting of the fur, the strength of acid used in processing and the temperature and duration of processing. The Association is now in a position to advise its members but more detailed information is still being sought to establish the best conditions to apply in factory trials.

TECHNOLOGICAL RESEARCH

Investigation of the day-to-day problems of the industry has continued on such topics as waterproofing of felt and blending of fibres. In the research programmes, the machine efficiency studies in members' factories continue to make progress. The survey of bumping machines is almost complete and has shown the importance of such factors as the loading of the machine, the concentration of acid, the temperature of operating and the method of heating. A comparative study of the dyeing machines at present used in the industry is being made on the basis of the quality of felt produced and some significant results regarding the type of machine and the temperature and time of dyeing have already emerged.

It has been shown that felt quality depends on the fur grade, on the degree of preparation or carrotting and on the amount of processing. The main source of variation in felt quality is the carrotting process. A programme just completed gives a comprehensive analysis of the factors involved in carrotting fur and shows how these factors alter the Hafra number which is known to be related to the felting performance of the fur. From the fundamental studies of carrotting, mathematical equations have been evolved which relate the degree of carrotting to composition of the liquor, and to the amount of liquor applied to the fur. By the strict control of these factors as predicted by the equation it is possible to improve the uniformity of the carrotted fur and in addition to produce fur of any required degree of carrotting. With this control as an aid to research, it will now be possible to investigate processing factors such as temperature of stoving, and to study the comparative effectiveness of hand and machine carrotting. The industrial uses of the control equation are of immediate benefit. Already it has found application in the preparation of a series of furs of different and progressive degrees of carrotting which have been processed on a factory scale to the finished felt stage. From these trials it has been shown that there is an optimum degree of carrotting above which any increase in the felting speed or rate of production is obtained by sacrificing quality and below which there is both reduced quality and rate of production. Whilst many applications can be foreseen for these controls and although a few manufacturers are already using them, they are at present passing through the development stage when members require technical guidance.

Control equations have been worked out for both mercuric, and non-mercuric carrotting agents. The optimum degree of carrotting for optimum felt quality has already been found for two grades of fur in three separate factories and work continues on the further development of the system.

INFORMATION SECTION

During the past year, members have made increased use of the section as judged by the number of enquiries received. The chief source of information to the industry is the *Bulletin* which is published bi-monthly. In the present year, four Technical Reports have also been published which discuss in detail the results of research projects. In addition to these a number of reprints of lectures given to societies and of papers of interest to the members have been circulated as a means of carrying information to the industry. A successful conference was also held at which speakers from the staff reviewed their work, followed by free discussion amongst the members present.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st April, 1952, to 31st March, 1956, a block grant of £7000 per annum is made provided £10 000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £5000.

For the period 1st April, 1956, to 31st March, 1959, the block grant will be £9000 per annum, provided £12 000 is received from industry, and the additional grant £100 for each additional £100 contributed by industry up to a maximum of £5000.

The income of the Association for the last completed year was £18 212.

THE RESEARCH ASSOCIATION OF BRITISH FLOUR-MILLERS

With the decontrol of cereals there is an even greater interest on the part of flour millers in the quality of home grown wheat for bread and biscuit making. As far as wheat variety is concerned the work of the Research Association, over the past 7 years, has been summarized and made available in leaflet form to flour millers, farmers and seedsmen. The collaborative work with the National Institute of Agricultural Botany in the testing of trial wheats has been continued and extended.

MILLING PROBLEMS

Results of practical importance in flour milling have followed a systematic investigation of the effects of variation in temperature of the wheat passing to the first break rolls. Customarily the wheat feeding these rolls is at, or very slightly above, atmospheric temperature. It has been shown, however, that there is a considerable advantage in warming the wheat to a temperature in the range 100–110°F immediately before the first break, the resulting ground stock being then cooled prior to further treatment. By such treatment the bran coats are kept in larger pieces throughout the milling processes and the friability of the endosperm is increased so that less power is consumed by the reduction rolls and the production of bran during the reductions is minimized.

FLOUR STORAGE

A number of tins of flour which had been stored as emergency rations in lighthouses for periods up to 27 years have been examined. The majority of the tins were found to be non-gastight and usually contained flour of 13–14 per cent moisture content. In general the flour was perceptibly

rancid in those tins which had been stored for about 5 years but baking quality remained satisfactory up to ten years. The fat in the stored flours was generally extensively hydrolysed. The quantity of extractible fat tended to fall on storage, the fall being associated with deterioration in baking quality. A pH value below 5·15, determined in dough made from stored flour, was associated with deterioration in baking quality. Above 14 per cent moisture content mouldy taints were found. Gas-tight tins showed a trend towards zero oxygen content with the carbon dioxide content rising to a limiting value of about 9 per cent. In gas-tight tins the safe storage life is about 8 years but if the flour is also packed in an inert gas such as nitrogen or carbon dioxide its storage life will be still further increased.

FLOUR IMPROVERS

Processes involving the mixing of doughs or flour-water batters in air or oxygen have been investigated as possible alternatives to nitrogen trichloride and other chemicals for improving the baking quality of flour. As the partial pressure of the oxygen is increased the volume and general quality of the bread is improved and the crumb colour is bleached in the same way as when the flour is treated with nitrogen trichloride. These effects pass through an optimum as they do with the gaseous chemical improvers. When the atmosphere is sensibly pure oxygen the quality of the bread deteriorates markedly showing similar defects to those produced by an overdose of a chemical improver.

Further work has also been carried out on the chemical changes induced in flour by the oxidizing agents used as improvers and by atmospheric oxygen. These investigations have been mainly concerned with the effect of these agents upon the lipid fraction of flour, including some of the components of the unsaponifiable material. This work has indicated methods of differentiating between flours which have been treated with certain of the improving agents and those which are untreated but have aged in air. Oxidation of the lipids of flour is also important in relation to the storage life of flour.

BIOCHEMISTRY OF WHEAT

A further study of the distribution of essential nutrients within the wheat grain has been published, based on microbiological assays of the content of riboflavin and pantothenic acid in dissected fractions of the grain. The distribution of these two vitamins is different from those previously investigated in that a large proportion, 30 per cent and 40 per cent respectively, is found in the endosperm. About 40 per cent of each vitamin was found in the aleurone layer and the nutritional importance of this portion of the grain is thus further emphasized. An examination of a series of flours of different extractions suggests that pyridoxine and folic acid are distributed in a similar manner to riboflavin.

A study is being made of those inhibitors of germination and seedling growth which may be naturally present in oats and wheat. It has been found that extracts derived from oats have a higher activity in this respect than those from wheat. Of the various anatomical parts the husk of the oat appears to contain the highest concentration of material inhibitory to germination. Accordingly extracts of oat husk are being fractionated with a view to the isolation and identification of the inhibitory substances.

In association with the Physics Department of Birkbeck College work is continuing on the examination of protein fractions, from wheat and flour, by the methods of X-ray analysis.

OAT AND OAT PRODUCTS

Experimental work has shown that the thorough cleaning of parcels of oats contaminated by rodents is impracticable without the sacrifice of an unreasonably large proportion of the oats. Means for preventing the contamination of stacked grain have therefore been investigated and two articles dealing with the construction and use of staddles, and describing the advantages of taking anti-rodent precautions on farms, have been published in the agricultural press.

The characterization of oat varieties for quality—both established varieties and new varieties undergoing trials—has been continued in collaboration with the National Institute of Agricultural Botany, and with the Scottish Colleges of Agriculture. Data on the kernel content of spring and winter varieties, perhaps the most important characteristic of milling oats, have been published, while data for protein content, and for oil and free fatty acid content, are in course of publication.

TERMS OF GRANT AND INCOME

Under the special terms of grant which terminated on 31st December, 1953, a grant not exceeding £32 000 was receivable provided £14 500 of grant earning income was received from industry.

For the period 1st January, 1954, to 31st December, 1955, the block grant is £20 000 per annum, provided £30 000 is received from industry and the additional grant £75 for each additional £100 contributed by industry up to a maximum of £3750.

For the subsequent three years the terms will be further modified.

The income of the Association for the last completed year was £46 406.

BRITISH FOOD MANUFACTURING INDUSTRIES RESEARCH ASSOCIATION

During the year considerable thought has been given to the extent to which the results of research on food technology can be applied in industry. At a meeting of the combined Research Panels of the Association held under the Chairmanship of the Association's President, Sir Frank Engledow, C.M.G., F.R.S., Drapers' Professor of Agriculture at the University of Cambridge, a most useful discussion took place on the means available for closing the gap between scientific knowledge on the one hand and current industrial practice on the other. The achievement of this desirable objective was felt to need renewed efforts by the Association and member-firms alike, the former by improving and extending the form of its publications and by sparing research workers for contacts and visits, the latter by directors, scientists and technologists in industry taking a closer interest in the work of the Association and approaching it more frequently for information and advice. In this connexion, the Council has approved tentative plans for the launching of a special Consultative and Advisory Unit to extend and augment existing facilities for consultation.

PUBLICATIONS

The output of *Research Reports* and of *Scientific and Technical Surveys* has been maintained, and the issue of *Technical Circulars* on matters of particular current interest, or as interim reports on research work in progress, has been increased. The monthly issue of *Abstracts*, started in January, 1953,

has continued, covering a wide field in the chemistry, biochemistry, microbiology and analysis of foodstuffs and also processing, preservation and packaging problems.

RESEARCH PROGRAMME

Some indication of the extent and nature of the research programme can be seen from the following items, grouped under the six main sections of the membership:—

Bakers' Prepared Materials

Investigations have included the influence of beating time and concentration on the expansion ratio of egg-albumen foams in the presence of sugar, the jellying properties of agar (a report on the subject has been prepared), and the prevention of mould growth and fermentation in macaroon paste. Practical modifications to the composition of certain lemon curds have been successful in preventing boiling-out during baking in open tarts.

Cocoa, Chocolate and Sugar Confectionery

An investigation of the comparative usefulness of a number of different types of viscometer has been completed as part of a general investigation of the rheological properties of chocolate. Part of this work has been carried out in conjunction with the Technical Commission of the International Office for Cocoa and Chocolate.

The scarcity and high price of cocoa beans has led to an intensification of the studies of the behaviour of the glyceride constituents of cocoa butter and alternative fats. Data on the proportions of liquid and solid phases present in cocoa butter and its mixtures with other fats are being collected with a view to examining the suitability of these alternative fats when used in chocolate.

Work on the keeping qualities of high boiled sweets has been completed and a report prepared. This has involved an extension of previous work on the effect of composition on the equilibrium relative humidity of boilings and has included studies of the storage of boilings and toffees at elevated temperatures likely to be encountered in certain export markets. The manufacture of some other types of confectionery involves the use of starch as a moulding medium and the moisture equilibrium of maize starches has been investigated. The drying of confectionery in different types of drying stoves has been studied on a factory scale.

Jam

Examination of new varieties of strawberries and raspberries in relation to their suitability for jam manufacture has continued in collaboration with horticultural stations. Studies of the effect of the presence of moulds on strawberries in inducing breakdown in sulphited pulp are being extended. This work includes investigation of pectic enzymes present in strawberries. Work continues on the time-temperature conditions for the sterilization of mould spores.

In collaboration with a firm of instrument makers, an improved model of what was originally known as the B.A.R. Jelly Tester has been developed and will shortly be available as the " FIRA " Jelly Tester.

Margarine and Compound Cooking Fats

Work has been extended on the storage behaviour of margarines both from the organoleptic aspect and as regards stability of the vitamins. Studies

of the possible correlation of the onset of oxidative rancidity in fats and oils with the measurement of unstable peroxide content have been carried out and the work is proceeding.

Meat and Fish Products

A *Technical Circular* discussing the problems connected with the manufacture and marketing of sausages has been issued and a fundamental investigation of changes in the colour of meat pigments under different conditions has been continued. The fading of the various muscle pigments in cured meats has also been studied and the value of ascorbic acid as a colour stabilizer at different oxidation and reduction potentials is being examined.

Other investigations have been concerned with means for avoiding certain defects which arise in fish pastes, including the prevention of separation and shrinking, and the permeability of different types of rubber rings for the phoenix closures used in the normal package for both fish and meat pastes.

Pickles and Sauces

Problems connected with the preservation of pickles, including the effects of salt in conjunction with both acetic and lactic acids have been studied. A report on the pasteurization of pickled onions in low-acid packs has been issued, as has also an interim report on the softening of pickled red cabbage.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1952, to 31st December, 1953, a block grant of £9000 per annum was made provided £20 000 of grant-earning income was received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £6000.

For the period 1st January, 1954, to 31st December, 1956, the block grant is £12 000 per annum, provided £30 000 is received from industry, and the additional grant £100 for each additional £100 contributed by industry up to a maximum of £10 000.

The income of the Association for the last completed year was £43 574.

THE FRUIT AND VEGETABLE CANNING AND QUICK FREEZING RESEARCH ASSOCIATION

The activities of the Association have expanded generally during the year. Membership has increased, and so has the number of technical enquiries received and the number of special problems sent to the laboratories for investigation. The newly established advisory panels on canning, quick-freezing and engineering have had a total of ten meetings and have proved their value as centres for the discussion of technical and scientific problems associated with the various sections of the industry. Alterations have been made to the main building of the Research Station so as to improve access to each laboratory and there has been a substantial addition to the equipment of laboratories and experimental rooms. The inspection of canned fruit and vegetables for quality has been continued as a service to the industry.

RAW MATERIALS AND PROCESSES

As for many years past attention has been given to the testing of new varieties of fruit and vegetables for their suitability for canning and freezing. Special efforts were made to discover suitable new varieties of strawberries,

in view of the sudden deterioration in vigour of one of the principal varieties in cultivation at the present time. The variety trials covered strawberries, raspberries, cherries, green peas, stringless and runner beans, broad beans, broccoli and cauliflower, Brussels sprouts, and new potatoes.

The work on the causes and cure of stone-gum in Victoria plums was continued, the factors examined being the type of rootstock and the presence of virus infection. Forty-five lots of fruit were included in the canning trials but no correlation was found between the degree of gumming and the factors tested.

The studies on the changes occurring during the ripening of green peas were continued for another year, the chemical and physical characteristics of six varieties of peas as they ripened being compared with measurements made on the *tenderometer* and the *maturometer* described last year and these, in turn, correlated with the quality of the canned peas as determined by tasting tests. Efforts have been made to find a method of calibrating the *tenderometer*.

Tests were made in collaboration with the Home Grown Threshed Peas Joint Committee, representing the growers, pickers and canners, to show the effect of fertilizer treatment on the texture of harvested pea crops used for canning as processed peas. The tests included sixteen combinations of fertilizers in duplicate at four centres, but practically no significant differences were noted in the texture of the skin and flesh of the peas from any of the treatments. This may have been due to an overriding seasonal effect which made all the peas abnormally soft. This work formed part of a more general laboratory investigation of the causes of variation in texture of processed peas.

Experiments conducted in collaboration with the National Vegetable Research Station, Wellesbourne showed the effect of using seed dressings containing BHC on the flavour of canned carrots. Another set of tests was made in collaboration with the Home Grown Threshed Peas Joint Committee to show the tainting effects of spraying fresh peas and harvested peas against aphis with BHC, 'Systox', schradan and endrin. The effect of using seed dressings containing dieldrin on the flavour of canned carrots was also noted.

A method of obtaining high vacua in cans by an operation known as *steam flow closure* was thoroughly tested using a seaming machine operating at high speed. The next stage in the application of this new method of closure to canned fruit will be full-scale experiments conducted in canneries.

CHEMICAL STUDIES

Rapid analytical methods have been devised for the assay of pectin and of phytin as a necessary part of the programme of research into the changes that take place in dried peas and which affect the texture of the canned product.

The immediate cause of red pigmentation of an unusual kind in dried peas has been traced to the presence of a leuco-anthocyanin in the testa of the seed. The prime cause of this abnormality is being sought.

Studies on the composition of Victoria plums in connexion with their corrosive behaviour in cans have resulted in the identification of several constituents and an indication of considerable variation in the quantities

of these constituents. Quantitative analyses of plums from thirteen sources are now to be made.

A rapid method for testing the strength of sulphur dioxide solutions for use in fruit pulping has been devised in collaboration with the British Food Manufacturing Industries Research Association, and apparatus for the purpose is being marketed by a firm of laboratory suppliers. The method is intended for the use of semi-skilled personnel, with reagents in tablet form, and will permit much better control of the preservation of surplus fruit than has been possible hitherto.

BACTERIOLOGICAL STUDIES

In undertaking studies on the possible use of disinfectants for the destruction of heat-resistant bacterial spores carried on vegetables in canneries a start has been made with peracetic acid. Its effectiveness, in practicable concentrations, in killing spores of spoilage bacteria has been demonstrated, and trials under cannery conditions will follow. At the concentrations likely to be effective health hazards appear to be ruled out, apart from those incurred in handling the concentrated solution.

Studies have been made on heat penetration into cans containing solid particles of various sizes and a liquid phase that allows convection. The use of spheres of waterlogged balsa wood to represent peas, beets, potatoes, etc., have facilitated this work, making it possible to use the same closed can for a number of runs. It has been found possible to predict the heat-penetration curve from a knowledge of the curve in the case of a can containing the liquid phase only and from the size and total volume of the solid particles.

INFORMATION SERVICES

The library of books, periodicals, bulletins and reprints is available to members and is used extensively in connexion with technical enquiries. The first number of a *Statistical Review* was compiled during the year. This contained twenty-five tables showing the production and consumption of the principal types of canned foods in the United Kingdom, the tonnage and value of imports of canned fruit and vegetables, the production of various types of canned fruit and vegetables in other countries, the production of quick frozen fruit and vegetables and the acreage and production of raw fruit and vegetables in the United Kingdom. An interim report entitled *Research and Development* appeared for the first time in January and contained short articles dealing with recent progress made in canning and quick freezing both at home and abroad. A bulletin giving chemical laboratory methods for use in fruit and vegetable canneries was also published during the year, together with various leaflets and memoranda on scientific or technical subjects.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st April, 1952 to 31st March, 1957 a block grant of £6000 per annum is made provided £9000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £5000.

The income of the Association for the last completed year was £21 912.

RESEARCH AND INFORMATION COMMITTEE OF THE FURNITURE DEVELOPMENT COUNCIL

The publication of the Standard for Upholstered Furniture in March, 1954, concluded work on Performance Tests and the Research Department has been able to concentrate on research of a more basic nature. Current investigations include:—

(*a*) The relative importance of the various factors affecting the strengths of glued joints, such as dowel or mortise and tenon joints; amongst the factors being investigated are moisture content and fit of parts.

(*b*) The factors affecting the elasticity and durability of an upholstered seat: this work is commencing with an investigation into the distribution of pressure between the sitter and the seat and the development of apparatus for measuring this.

(*c*) The deterioration of upholstered furniture in normal use in the home, by means of some small scale field tests.

(*d*) A study of the factors affecting the rigidity and strength of articles of carcase construction, with a view to rationalization of design and consequent economy in the use of materials. This work includes, amongst other things, the influence of boundary conditions, and stiffness, on the rigidity of panels.

(*e*) The properties of chipboard, including dimensional stability, screw holding, creep under sustained load, veneering, and other properties, with a view to defining the desirable characteristics for its use in furniture manufacture.

The work on spray polishing and related problems was discontinued at the end of 1953, but efforts will be made to restart this work as soon as possible.

Up to the present, three students from the industry have spent a period in the Laboratory, carrying out investigations chosen by themselves. These have all been concerned with the work on joints mentioned in (*a*) above. A further student is expected shortly.

TECHNICAL INFORMATION SERVICE

The collection and recording of information likely to be of value to the industry and to the Research Department continues to form the major feature of the work of this Service. Although there has been some extension of the range of journals purchased and a rather wider intake of reports has been arranged, there has been no major change in the policy.

The distribution of information to industry is now effected through four channels. The first of these, the *Technical Bulletin*, contains abstracts of published literature and is sent to furniture manufacturers on request. There is also an appreciable paid circulation outside the furniture industry. The *Newsletter* is prepared quarterly and presents a selection of the information which has appeared in the Bulletin, and other items of general interest to the industry. The preparation of *Information Reports* has continued and it has been found useful to have available these summaries of published information on various technical topics. In many cases, this information is not readily available elsewhere, and it has been found that its distribution in this form has served to stimulate interest in the subject. The remaining channel is the handling of enquiries from individual furniture manufacturers. Where it is felt that the published information available is inadequate, the enquiry is passed to the Research Department for consideration as to whether a laboratory investigation would be justified.

EXHIBITIONS AND CONFERENCES

The policy of visiting exhibitions and conferences has been continued, but this year a new feature was the arrangement of a group visit of furniture manufacturers to Germany. The party, consisting of 31 members, visited the Hanover Fair and four furniture factories in the surrounding area. This visit proved to be successful and has served to stimulate interest in a number of new technical developments which are taking place on the Continent. The interchange of information with the furniture industries in other countries has been a welcome feature of work in recent years.

At the British Furniture Exhibition, a display of information and research activities was arranged and this provided a useful method of contacting furniture manufacturers and their employees.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1953, to 31st December, 1955, a block grant of £5000 per annum is made provided £8000 of grant-earning income is received from industry, and an additional grant of £75 for each additional £100 contributed by industry up to a maximum additional grant of £3000.

The income of the Committee for the last completed year was £21 316.

THE BRITISH GELATINE AND GLUE RESEARCH ASSOCIATION

The steady growth of information based on the fundamental research work of the Association has made possible in the last twelve months an expansion of the applied side of its work. This is divided into two sections, one concerned with the manufacture of glue and gelatine and the other with the uses of the products in other industries. The expansion has taken place without curtailing the fundamental research programme.

The publications of the Association, including the Abstracts and reprints of published papers, are receiving a wide circulation, especially in the U.S.A., where the work carried out has aroused considerable interest both in the gelatine and glue industry and in academic circles. The next few years are likely to see an increase in academic and medical research on gelatin, both on account of intrinsic interest and as a result of its close relationship to collagen. This latter aspect was brought out at the seventh meeting of the Research Panel of the Association, when papers on soluble collagens were contributed by Dr. R. W. G. Wyckoff, For. Mem. R.S., Dr. J. H. Bowes, Dr. D. S. Jackson, Dr. R. Consden and members of the staff of the Medical Research Council Biophysics Research Unit at King's College, University of London.

Two aspects of the work of the Association have been chosen for description, one from the applied side, the other being concerned with the composition and structure of the gelatin molecule.

EMPIRICAL STUDIES ON THE MANUFACTURE OF GELATINE AND GLUE

Preliminary investigations have been completed using miniature versions of the works processes for the manufacture of gelatine and hide and bone glue. The process variables, type of raw material, pretreatment, extraction conditions, etc., which affect the quality of gelatine and glue produced have all been examined. The results, although in the main confirming industrial

findings, form a valuable background for further work. Certain investigations on gelatine manufacture can be carried out on a reasonably small scale, (100 g raw material), but the estimation of total yields of product presents severe sampling difficulties.

The investigations completed so far have underlined the essential similarities of all the raw materials used in gelatine and glue manufacture, except those originating from fish. Fish collagens show lower shrinkage temperatures, less resistance to enzymes, and easier conversion to a soluble form, than mammalian collagens.

As an intermediary to the works scale, plant has been constructed to handle up to ½ cwt of raw material for gelatine. This plant, which includes a paddle washer, aluminium extraction vessel, all-glass evaporator, and an effective tunnel dryer, produces several pounds of finished gelatine or glue which can be used in subsequent investigations. On the basis of small scale studies, two works trials of process modifications have been carried out.

Bone glue manufacture cannot, owing to sampling difficulties, be carried out on the test tube and beaker scale. The equipment used in the laboratory includes an autoclave taking up to 1 cwt of bones, ½ cwt being considered the minimum for adequate sampling. The effect of varying the steam pressure, the duration of steam application, and the temperature and duration of the subsequent liquoring operations, which constitute the central features of bone glue manufacture, has been studied in detail. Although individual manufacturers have information on the process variables, there has previously been no published information which could be examined and criticized.

COMPOSITION AND STRUCTURE OF THE GELATIN MOLECULE

Over the past year many complete amino-acid analyses of gelatins and collagens of differing origin have been carried out, using the technique of Moore and Stein. The main conclusion arising from these measurements has been that all mammalian gelatins have almost identical amino-acid compositions. Slightly larger differences observed for the parent collagens may be attributed to impurities, which cannot be removed without modifying the collagen itself. Fish collagens and gelatins, show in contrast significant differences from mammalian materials particularly in the hydroxy-amino acids. This is of interest since the physical behaviour of these materials is also significantly different.

Chemical modification of a number of the active groups in the side chains on the gelatin molecule has failed to show any effect on the ability to form gels. This is valuable in narrowing down the possible centres of cross linking in gel formation.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st October, 1953 to 30th September, 1955 a block grant of £6000 per annum is made provided £8000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £4000.

For the period 1st October, 1955 to 30th September, 1958 the block grant will be £6000 per annum, provided £10 000 is received from industry, and the additional grant £100 for each additional £100 contributed by industry up to a maximum of £4000.

The income of the Association for the last completed year was £21 577.

THE HOSIERY AND ALLIED TRADES RESEARCH ASSOCIATION

The Hosiery and Allied Trades Research Association has now completed its first five-yearly period. Throughout the period its staff and research facilities have continued to grow, and in consequence the scope of its programme of research and investigation into the many and varied problems associated with the production of knitted products is now large. Early in the period the Council of the Association provided a large machine laboratory equipped with a range of knitting machines of the types in use by the various sections of the industry and this has ensured, not only that factory production processes could be studied in detail, but also that research results could be applied quickly and effectively. During the last year a new workshop, equipped with an adequate range of machine tools, has been added, and this has greatly facilitated the construction of prototype instruments and devices developed by research, in readiness for factory trials; it has also enabled special research equipment to be constructed. The Association begins its second five-yearly period firmly established as an essential part of its industry and in a position to carry out research on a scale commensurate with the size and importance of the British hosiery industry.

TECHNOLOGICAL INVESTIGATIONS

During the past year, substantial savings in time, effort, and money have resulted from an increased use by the industry of the Association's consulting service. Through this service the hosiery manufacturer has been able to call upon the specialized research knowledge of the staff and apply it to specific production problems. In consequence many hosiery production processes have been made to function more smoothly and numerous cases of consumer dissatisfaction have been eliminated.

The scope of the Association's technological research has been very wide indeed. The industry is concerned with a great variety of products made from a whole range of fibres, both natural and synthetic, and from mixtures of them. Investigations have been carried out on problems concerned specifically with hosiery yarns; faults related to unsatisfactory winding, lubrication problems, defects arising from variations in friction and fluctuating tensions in the yarns, the causes of spirality in knitted fabrics, difficulties associated with varying moisture content, and so on, have all received attention and the results have been applied. Equipment designed to overcome these difficulties in the cases of particular yarns, such as a yarn lubricator which can be attached to a circular machine and an elastic yarn unwinding device, is finding increasing use in the industry.

Excellent progress continues to be made towards eliminating the largest single knitting problem of the hosiery manufacturer, namely the variations in dimensions and quality of knitted fabrics and garments. The Association's earlier research established that these variations arise from fluctuations in the length of yarn which forms a single knitted stitch and various means of controlling the length of yarn per stitch were devised. During the year much of the effort has gone into perfecting these new instruments and equipment. A Yarn Speed Meter, used for the accurate alignment of the feeders on rotating cylinder knitting machines, is now in the hands of members and is functioning excellently. A Yarn Length Counter, which applies a similar principle in the cases of rotating cam box machines, and will eventually be used for all types of flat machines, has passed its factory trials satisfactorily and is now in production. A Stroboscopic Control Unit,

which allows a still wider application of the technique, has also given satisfactory results in factory trials. Meanwhile, progress is being made towards the ideal, namely fully automatic control whereby the machine itself maintains constant length of yarn per stitch without the need for any manual adjustment. These developments, when perfected, will give the British hosiery manufacturer definite advantages over his competitors as regards the appeal of his products.

Work on the finishing of hosiery products has continued. Good results from applying the Association's enzyme method of removing "seeds" from cotton have been obtained in trials on a factory scale. Advice which has been applied practically has been given as a result of the research on the scouring of knitted goods. The installation of preboarding equipment in the laboratories has enabled problems arising during the "setting" of garments made from synthetic fibre yarns to be studied in much greater detail.

The behaviour of a garment during wear provides the ultimate test of its quality. The increasing part played by the Association in the careful planning and analysis of wearing trials, in some of which it has also participated, has resulted in much more reliable information being obtained from such trials.

FUNDAMENTAL INVESTIGATIONS

A detailed study of the bending and torsional properties of hosiery yarns has continued. Apparatus devised for measuring these properties is being used in practical investigations. Since very low yarn tensions are used during knitting, tension fluctuations can have a very noticeable effect on the quality of the final fabric. For this reason a detailed study of yarn friction, variations in which can cause such fluctuations, is in progress.

The study of fabric geometry, which has led to the development of the various knitting control devices already referred to, has been extended to cover an examination of how the physical properties of a knitted fabric are related to the length of yarn per stitch. Results of considerable practical importance have already been obtained. For instance, a knowledge of the length of yarn per stitch in a fabric will allow an accurate estimate to be made of the relaxed dimensions of the fabric and similar fabric properties to be forecast. This work has called attention to the importance of length of yarn per stitch as a basis of quality control in a factory.

LIAISON

The Association received a grant under Conditional Aid to provide an advisory service to the industry on the most effective methods of applying research results in the factories so as to improve production efficiency. The service commenced in January, 1954, and is proving successful. Factory visits are made and new developments are demonstrated; in some cases opportunities of instructing foremen and operatives have been provided. Throughout the summer operatives from hosiery factories have visited the research station on Saturday "Open Days" and, on each of these, the attendance has been very large indeed.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st July, 1949, to 30th June, 1957, a block grant of £16 000 per annum is made provided £32 000 of grant-earning income is received from industry, and an additional grant of £100

for each additional £100 contributed by industry up to a maximum additional grant of £12 000.

For the period 1st July, 1957, to 30th June, 1959, the block grant will be £20 000 per annum, provided £40 000 is received from industry, and the additional grant £100 for each additional £100 contributed by industry up to a maximum of £8000.

The income of the Association for the last completed year was £57 869.

THE BRITISH HYDROMECHANICS RESEARCH ASSOCIATION

The four Research Committees have met more frequently during the past year and as a result of their deliberations several new projects have been undertaken. The rapid growth of activity has necessitated a 10 per cent increase in staff and re-arrangement of the premises. Work has been done on the following subjects as well as on several others which have not yet progressed far enough to report.

CENTRIFUGAL PUMP IMPELLERS

Because the performance of an impeller and the casing into which it fits is closely bound up with the internal velocity distribution, an experimental method of measuring the actual velocities in the impeller is desirable. The method used is to attach a small hot wire anemometer to the impeller so that the magnitude and direction of the relative flow can be determined at that point while the impeller is rotating. Traversing this device across a vane passage gives the velocity distribution.

For the purpose of observing flow, a test rig has been constructed in which a transparent impeller can be rotated inside a large cylindrical tank, fitted with transparent windows at top and bottom, and photographic techniques are being developed to record the paths, within the impeller passages, of tracers introduced into the flow.

DIFFERENTIAL PRESSURE CELL

In the study of transient phenomena in hydraulic systems an instrument is needed to measure instantaneous velocities. A pressure cell is being developed comprising a diaphragm whose deflection is measured by a strain gauge, and it is hoped that its use with a pitot tube or orifice will give a fairly accurate indication of fluctuating velocity.

FLOW OF OIL THROUGH SMALL ORIFICES

In designing hydraulic control valves and dashpots, it is frequently necessary to estimate the resistance coefficients of small orifices. The flow through orifices of various length-diameter ratios is being studied, also the effects of roughness of the upstream face and the condition of the inlet edge.

VORTICES IN PUMP SUMPS AND TURBINE FOREBAYS

The formation of air-entraining vortices is being studied in model sumps, and experiments have shown that they arise from asymmetrical approach of the water towards the suction inlet. The inter-relation of inlet velocity, water depth, submergence of inlet and proximity of the boundary walls has been determined and results are being correlated with full-scale data.

SEALS AND GLAND PACKINGS

Conventional types of rotary seal are being tested to determine their performance under a wide range of conditions, and studies of the fundamental processes involved are being continued.

HYDRAULIC TRANSPORT OF SOLIDS

In a number of important instances the transport of solids in pipes by flowing water or other liquid is very convenient. Because of the possibility of widening its field of application an investigation into several aspects of the flow in pipes of solid-liquid mixture is being undertaken.

The basic problem is determining the pressure drop required to move the mixture along a pipe. It is not answerable to theoretical approach and experimental work to provide data and clarify the mechanism of flow has been done.

One of the practical problems involved is the raising of the mixture of solids and water to the required pressure, and the Association is developing mechanical feeders which deliver solids into the pipeline where the water has previously been raised to high pressure by conventional means.

In connexion particularly with the probable hydraulic transport of coal it is important to know the extent to which the coal will be broken up and the pipeline eroded. To determine this a toroidal or endless wheel pipe has been used and it has been found that the damage is usually very slight (1 to 3 per cent per mile).

FLOW THROUGH DISC VALVES

A static rig has been constructed to investigate in detail the flow pattern through disc valves of different types. Pressure loss measurements are made to determine the discharge coefficient and the effect of cavitation is studied by varying the absolute pressure in the system.

MODELS OF SPILLWAYS

Special investigations have been made on behalf of a member into the design of spillway structures for a hydro-electric scheme. Scale models of two complete structures have been constructed.

AIR CURTAIN

A member was considering the use of a vertical slot jet covering a complete cross section of a room to isolate one end containing dust-laden air from the other end which was required to be clean. The problem was to determine the ratio of the air flow required to be extracted at the roof to that introduced in the slot jet.

A small water model slice of the room was made with a "Perspex" wall, the water on one side being coloured. It was found that on the other side of the jet the water remained clean, provided the extraction at the roof was equal to the jet flow plus the flow entrained naturally by it in its course to the roof.

It appears that one end of a foundry of reasonable size could be kept clean with a total fan power of about 30 h.p.

INFORMATION AND ADVISORY SERVICE

Twenty Research Reports, Technical Notes and Translations have been published and about 140 technical queries answered.

In addition to the normal work of this Department, the Association has undertaken to operate for 3 years a free Advisory Service to Industry in the field of hydraulic machinery and fluid dynamics, supported by Conditional Aid funds. It has taken some time to make the service known but an increasing number of requests for advice are being received.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st October, 1953 to 30th September, 1958 a block grant of £9000 per annum is made provided £18 000 of grant-earning income is received from industry, and an additional grant of £75 for each additional £100 contributed by industry up to a maximum additional grant of £9000.

The income of the Association for the last completed year was £39 021.

BRITISH INTERNAL COMBUSTION ENGINE RESEARCH ASSOCIATION

To mark the tenth anniversary of the Association, a special demonstration was held at the Laboratories on 15th and 16th October 1953, at which were shown a number of devices developed since its formation. The main exhibits included a servo-operated fuel injection system; a rotary positive displacement air compressor; a constant pressure head fuel flowmeter; a method of determining the stiffness of crankshafts; a fuel pump delivery valve for eliminating secondary injections; automatic variable ratio pistons; a method of avoiding the corrosion of fuel injection nozzles; and an engine indicator.

Following a survey by members of the research projects in hand and proposals for new ones, the research programme has been revised and has proceeded as follows:—

TORSIONAL VIBRATION

The Bicera method of crankshaft stiffness evaluation, having been applied by members to over sixty crankshafts and checked by natural frequency measurements, has now been recommended with confidence to members as the most accurate method available.

Torsional vibrations have been responsible in the past for numerous failures of shafts and it is a matter of vital importance to engine designers to be able to predict the cyclic forces which give rise to these vibrations. For this purpose the Association has analysed pressure diagrams of a large number of engines, and the resultant curves of the harmonic components of gas pressure torque in different types of engines have been used by engine designers.

Couplings of various types have been under investigation and the study of damping pursued.

The success of the Torsional Vibration Panel is attributable to its wholehearted adherence for over ten years to the principles of co-operative research. The blending of theory with practice in such a complicated subject depends upon the availability of ample practical results. These results are contributed to the pool of knowledge by the staffs of member

companies and of the Laboratory, and the dependence upon accurate instrumentation is obvious. To ensure this, various torsiographs, frequency analysers and amplifiers used by member companies have been compared on a test engine with those at the Laboratory.

The greater part of the work of compiling a handbook on torsional vibration has been completed.

PRESSURE CHARGING

To the research reports on various positive displacement pressure chargers has been added a comprehensive report containing comparisons of performance, design and noise. The detailed information provided in these reports on pressure chargers enables engine makers to select compressors best suited to the engines and their particular duties.

Study of the flow conditions in the Bicera compressor has led to the use of a new form of rotor lobe, giving a marked improvement in performance.

The experimental turbo-charging of a four-stroke cycle engine showed that in a highly pressure-charged engine a single mechanical compression ratio does not give satisfactory cylinder pressure conditions over the range of working loads. An automatic variable-ratio piston was devised and Bicera pistons of this type have been used successfully in the engine, which is now capable of accepting much higher boost pressures. This development has given emphasis to the need for more effective turbo-chargers, and further work is proposed. The Bicera fuel injection system used on the same engine has been found particularly valuable for development work by virtue of the ease with which fuel injection conditions can be varied.

The relative merits of oil, water and air as coolants for pistons were examined, and a report has been issued.

NOISE REDUCTION

Several questions concerning combustion noise have been clarified in further investigations. The influence of design on valve gear noise has been studied and the requirements for quiet operation established. Further progress has been made in the reduction of exhaust noise.

COMBUSTION

The spectroscopic study of the process of combustion in a high-speed engine has continued. In the engine tests on means of combating the wear caused by using low grade fuels, the number of hours run by the seven test engines employed has risen to 35 000 and recommendations on the findings to date have been issued to members.

A separate investigation has thrown new light on the cause of the rapid wear and has indicated a new line of approach to the problem.

STRESS ANALYSIS

Strain gauge equipment has for a long time been a regular tool of the Laboratory. A polariscope and equipment for the use of brittle lacquers have now been added. Contributions from members on methods of design and operating experience, supplemented by laboratory work, have provided working material for the technical panel's investigations.

GENERAL

The servo-system for operating fuel injection pumps has been developed further and designs produced to meet members' specific needs. More applications of the Bicera fuel pump delivery valve have been studied. In addition to meeting day-to-day laboratory needs, the Instruments Section has produced improved designs of transducers for indicating cylinder pressure, fuel line pressure and nozzle needle movement. The work on the six bearing testing machines has been extended to cover the use of low viscosity lubricating oils, and the effect of connecting rod design on bearing performance.

INFORMATION SECTION AND PUBLICATIONS

Ten research reports and six translations have been issued to members and Government departments. Library and information services have been extensively used by members, and the issue of weekly technical abstracts in card and sheet form has continued. A paper entitled "An experimental investigation into the effect of fuel addition to intake air on the performance of a compression ignition engine" was presented at the Institution of Mechanical Engineers in January, 1954.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st April, 1950, to 31st March, 1954, a block grant of £15 000 per annum was made provided £25 000 of grant-earning income was received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £10 000.

For the period 1st April, 1954, to 31st March, 1955, the block grant is £22 000 per annum, provided £40 000 is received from industry, and the additional grant £100 for each additional £100 contributed by industry up to a maximum of £20 000.

The income of the Association for the last completed year was £56 119.

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION

The British Iron and Steel Research Association was founded only in 1945 but the industry it serves has a long history of collaboration dating from the first world war. The Association was therefore able to start with a substantial nucleus of research teams which had been set up earlier in various parts of the country and it has now a total staff of about 450. It is a decentralized organization with laboratories in London, Sheffield, Swansea and Middlesbrough, used by one or more of its five research Divisions of Ironmaking, Steelmaking, Mechanical Working, Plant Engineering and Metallurgy (General) and its Departments of Physics and Chemistry. Each Division serves a section of the industry as its name indicates and covers a wide range of materials and processes. The five examples which follow have been chosen out of more than 200, to illustrate some of the ways in which the Association is applying its results in the iron and steel industry.

SINTERING OF IRON ORE

The Ironmaking Division's purpose is to apply scientific methods to assist planned increases in iron production on which steel production depends. During the last six years British pig iron production has increased from about

9¼ million tons per year to over 11 million tons per year and it must continue to increase. This can be done both by building new blast furnaces and by increasing production from existing furnaces. In the latter case this can be achieved either by speeding up the rate of operation, or by introducing ore that is richer in iron.

Much iron ore, especially that imported, is so finely divided that if it were put into the furnace as received, it would choke the flow of hot gases and slow production. To avoid this, the fine ore is sintered, a process which consists of burning it mixed with fuel in a moving downdraught grate until sufficient heat is produced to melt some of the particles so that the ore coheres in lumps.

In 1956 Britain will make 8 millions tons of sinter per year, compared with 6 million tons this year and 4·6 million tons in 1950. It has already been found that sintering, once regarded as an expensive nuisance, can prove of great benefit to a works, and blast furnace burdens of 100 per cent sinter, now regular practice at one of the largest works in the country, have saved up to 5 cwt. of metallurgical coke per ton of iron made at that works. The prospects of improved production held out by the extended use of sinter, and the urgent necessity of preparing much of the 10 000 000 tons of iron ore imported every year, stimulates research on sintering.

The need to increase the production of sinter was forecast in 1946 and British work on sinter since then has given this country an acknowledged technical lead in this subject. When the Association began to study the problem, it had first to determine what caused variations in quality and then to control them. The first part of this work was completed some years ago and established the over-riding influence on quality of the amount of carbon used as fuel and the thoroughness with which the materials were mixed. It was next shown that output was influenced mainly by the ease with which air could be drawn through the sinter bed. Enough air must pass through the sinter mixture to burn the fuel completely and the more suction required to draw this air through, the greater the horsepower required. Tests on commercial plants and in the laboratory showed that the amount of air required to sinter a given quantity of the raw mixture depends on the nature and proportions of the materials in it. If, however, the mixture can be made more permeable, more air can be drawn through using the same horsepower. The fuel then burns more quickly and more sinter is produced in a given time. Permeability can be most easily controlled by varying the dampness of the raw materials. A very dry mixture takes a long time to sinter ; when water is added the permeability is increased and sintering is quicker, but too much water again decreases the permeability and makes the mixture difficult to ignite. Up-to-date sinter plants are applying the results of this research by providing means of measuring the permeability of the sinter bed continuously, so that the operator can control it by adding more or less water as required.

An example of what can be achieved with existing plant is given by one member firm which asked for the collaboration of the Association in an attempt to increase production in a large sinter plant from 16 000 to 20 000 tons per week. Within six months 23 000 tons per week were produced and this has been maintained and has since been increased to 30 000 tons per week.

In addition to the work described, the design of sinter plant is being studied. New plants now coming into commission benefit from the resulting experience, in particular with regard to the cooling arrangements which are found to affect sinter quality very materially.

OIL BURNER FOR OPEN HEARTH FURNACES

In most burners the oil is atomized and accelerated by a sudden blast of steam. The work on flame radiation by an international team at Ijmuiden indicated that it is not enough for the oil merely to be effectively atomized. It is also important that the oil droplets should be accelerated by the steam in such a way that they reach the speed of the steam with as little slip as possible. In this way energy losses are minimized with a saving of up to one third of the steam consumption. Further, more efficient flame combustion should improve output and cut fuel costs, since there is no tendency for the oil to drop from the tip of the burner, as there is in many back atomized burners.

Laboratory tests of a prototype burner based on this principle were successful and led to the development of a simpler version for steelworks use. This design in turn has been modified for use in works using oil and coke oven gas together. The two works versions are now on extensive tests in the works of two large member firms. So successful have even these preliminary tests proved, that both firms are now fitting these burners to all the furnaces in their melting shops. One firm reports a 10 per cent fuel saving when the furnaces are kept at their previous driving rate, and the other reports that furnace life has been substantially increased and fuel has been saved.

HOT DIP ALUMINIZING

New markets are being opened to the steel industry by the development of a hot dip method of coating steel with aluminium. Since aluminium coated sheet is resistant to acid atmospheres, it should be valuable in such buildings as locomotive sheds, and as it is able to withstand temperatures up to 600°C, it can be used in chemical plant and many industrial processes operating at comparatively high temperatures. Aluminium coated body members in motor and railway vehicles, which can be bonded to aluminium body sheets, should reduce loss due to corrosion and prolong their life. Many other uses are waiting for this material if it can be produced cheaply enough.

Two main obstacles have hitherto held up the development of hot dip aluminizing. A hard and brittle layer of alloyed iron and aluminium is apt to form instead of a soft and ductile coating that can be shaped and manipulated as industry requires; and a skin forms on the aluminium bath which gives an uneven surface to the dipped steel. Fluxes to liquefy the skin are acid and would be unpleasant to work with.

The first difficulty can be overcome by adding silicon to the coating bath and this method is used for aluminium coated strip which is regularly produced in the U.S.A. The methods in use there, however, required a controlled atmosphere to protect the steel and molten aluminium from oxidation. In this country very few plants could install such equipment without heavy capital expenditure. The Association has now developed a method that can be introduced with little expense into works equipped for galvanizing. In this method careful preparation of the steel surface is necessary, after which a film of glycerol is applied to it. The strip or wire enters the bath through a protective box and the glycerol burns quietly, preventing the ingoing strip from oxidizing. Further, the time and temperature of dipping are such that heavily cold worked steel can be annealed at the same time as it is coated and this may, in some cases, save both time and fuel.

ALLOY COATING OF STEEL

Another new coating method that is being developed is the simultaneous electrolytic deposition of iron and zinc on steel sheet to give alloy coatings of controllable proportions. The coatings are hard, strongly adherent to the steel base and, for low zinc contents, are very nearly as bright as a perfect mirror. The corrosion resistance improves as the zinc content increases but generally the brightness diminishes. Another most important property of such coatings is their "smoothing" action, as the alloy is deposited first in the hollows of an uneven surface. This may be particularly useful if the alloy coating is developed as a substitute for nickel as an undercoating for chromium plate. These coatings may also be useful for goods which are ordinarily galvanized, such as roofing sheets, wire and hollow ware. Work is now being directed to combining high corrosion resistance with an attractive finish.

CONTINUOUS CASTING OF STEEL

The Association's research during the last seven years on continuous casting of steel has now reached the stage of commercial application. An experimental production plant financed co-operatively by eleven interested firms has been erected at the works of William Jessop and Sons Ltd. in Sheffield where 4-inch square bars of high speed, stainless and other alloy steels are being cast.

The idea of continuous casting is not new. Henry Bessemer foresaw it a century ago, as he foresaw so many things in steel manufacture, and brass and aluminium have been continuously cast commercially for twenty years or more. The continuous casting of steel, however, has been more difficult.

On the one hand, because of its very high temperature, liquid steel radiates heat much more rapidly than non-ferrous metals, and has to be kept from freezing in the pouring ladle and in the runners from ladle to mould for considerable periods. On the other hand, it is a poor conductor of heat and once in the mould cools relatively slowly, so that the solidified skin ruptures easily. To ensure that plant developed from the Association's work should not be subject to irritating and expensive initial difficulties and delays, the fundamental problems of mould friction, heat transfer and rates of solidification had first to be investigated in detail.

Because of this approach, progress has been slower in the United Kingdom than in some other countries, and a plant built under foreign patents is already in operation in this country. The plant using the B.I.S.R.A. methods is, however, independent of foreign patents and, intended to go almost straight into commercial scale production, has justified this policy.

It produces 70 ft of 4-in. square bars from a furnace charge of about 1½ tons. The bars are cut to length during cooling as they are continuously drawn from a water-cooled spring-mounted mould. Because discards are thus confined to the ends of continuous lengths, a yield of about 90 per cent of the steel charge is obtained. This makes continuous casting particularly attractive for high-speed, stainless and other highly alloyed steels, which are expensive.

The experience gained in the design, construction and operation of this plant opens the way to wide development of continuous casting by the British steel industry.

INFORMATION SERVICES TO INDUSTRY

The Association provides extensive information services to the industry and circulated over 28 000 copies of 320 papers last year. It has recently increased its facilities for answering members' enquiries and as a result of

a special grant from Conditional Aid funds has set up a small advisory team to investigate problems of organization occurring in individual firms.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1953 to 31st December, 1957 a block grant of £75 000 per annum is made provided £400 000 of grant-earning income is received from industry.

The income of the Association for the last completed year was £498 491.

THE BRITISH JUTE TRADE RESEARCH ASSOCIATION

The activities of the Association have continued to expand as a result of an increase in staff employed and the installation of additional items of plant and machinery. The number of technical enquiries received has reached nearly 960 per annum, representing an increase of 12 per cent over the previous year, but the knowledge continuously accumulating as a result of the general researches undertaken has enabled enquiries to be dealt with more rapidly and concisely than in the past. The instruction of selected personnel from member firms in quality-control methods has continued with undoubted benefit, and in an endeavour to improve the spread of information about the work of the Association, meetings attended by supervisory personnel from member firms have been arranged, at which practical processing aspects, introduced by the reading of a short paper by one of the Association's staff, are thrown open for discussion. Three successful gatherings of this nature have taken place during the year.

In the past twelve months, fourteen reports have been communicated to members. Research progress is reviewed below.

RAW MATERIALS

Further samples of bast and leaf fibres grown in different parts of the Commonwealth have been submitted for assessment, and the techniques and methods developed as a result of basic researches have continued to prove useful in providing important information concerning the properties of the different fibres in which the Association is interested. Various factors influencing the microbiological extraction of fibres from bast ribbons have been investigated on small-scale plant, and the information obtained has been of value in large-scale experiments with jute and *Hibiscus* material. The continued interest in methods of accelerating microbiological retting by the addition of chemicals, and of fibre extraction by chemical reactions alone, has prompted laboratory studies from which have developed an analytical method for the rapid determination of the alkalinity limits which can be tolerated without degradation of the fibre.

PREPARING AND SPINNING

Research is in progress on various factors involved in batching, with particular reference to the temperature changes which occur during the maturing period. A simple but accurate method has been developed for measuring low concentrations of carbon dioxide in small samples of air, with the object of establishing the relationship, if any, between carbon dioxide production and micro-organism activity. With the installation of additional items of machinery, work has now commenced on the physical aspects of the carding process, and detailed studies are being made of the action of the drawing frames, with particular regard to the effects of faller-bar characteristics on the extent of irregularities in the sliver produced. This work has been

carried out in conjunction with investigations of the effects of variations in the draft, pin density, and pin separation. In addition, a new approach to the analysis of drafting waves is being examined with the object of speeding-up wave-length determinations.

A comprehensive study of the fundamentals of flyer spinning has provided useful data regarding the radial variation of bobbin packing density, and this information may well lead to a significant increase in spinning efficiency; in parallel with this study the variation in physical properties of yarns with the tension applied at spinning has been investigated. The important subject of changes in yarn twist during winding and weaving has also received attention, and the findings have been summarized in a report: in addition to providing a diagrammatic appreciation of the changes occurring, this presents results which, in combination with others previously obtained, give quantitative data on the effect of such twist changes on the breaking strength and the variation of strength of jute yarns.

WEAVING

The need for an improvement in the sizing of jute yarns is increasing, partly because of the greater number of automatic looms in use in the industry and the installation of looms for weaving tubular cloth. The Association has collaborated with a number of member firms in the organization of large-scale practical sizing trials, and in most cases this close collaboration has resulted in considerable improvement in sizing techniques. Partly as a result of this work, laboratory investigations on instrumentation for moisture content measurement have been intensified.

The examination of the influence of changes in constructional details on the physical properties of loom-state hessians has continued, and with the installation of a calender the Association is now in a position to assess changes occurring during subsequent finishing of the cloths, under carefully controlled conditions as regards moisture, time, temperature, and pressure.

FINISHING

A further series of experiments has been commenced in connexion with the effect of sea-water exposure on rotproofed jute cloths, and many compounds have been examined, both alone and in admixture. The results so far obtained emphasize the differences in the effects of sea-water immersion and land exposure, and the influences of seasonal changes in the sea-water temperature are being assessed. The rotproofing of sewing twines used in jute bags has been investigated and the general position in this respect has been clarified. The rapidity and reproducibility of a new method of test developed to assess the rate of degradation of jute materials under conditions of profound infection have proved of great value in rotproofing studies in general.

Results from the work carried out on the mechanism of the combustion of jute have provided information regarding the relationship between fibre temperature and time of exposure for jute fibres maintained in air streams at different temperatures, and have proved of use in dealing with a number of enquiries received by the Association. A study has also been made of the effects of high temperatures on the breaking load and shear properties of jute yarns treated with a number of fireproofing agents. It has been shown that many compounds suitable for use when the material is subsequently employed at normal temperatures possess strongly degrading properties at temperatures in excess of 120°F. Special attention has been given to insoluble fire-proofing treatments, and a particular one-bath emulsion process has been

examined in detail. Laboratory tests show this particular process to be very satisfactory as regards smoulder and glow resistance after leaching.

The treatment developed by the Association to minimize the degrading action of acidic atmospheres such as are generated by many granulated fertilizers has already proved to be effective under many conditions of use. With certain types of granular fertilizer, however, the rate of acid liberation can be exceptionally rapid, and the protective process has been improved in order to impart sufficient resistance to jute subjected to such severe attack. Field trials are in progress.

BASIC RESEARCH

Considerable progress has been made with the research into the degradation of jute by gaseous oxidation in the presence of alkali. Factors influencing the rate of oxidation under such conditions, including the effect of oxygen pressure, temperature, and the concentration and volume of alkali solution per unit weight of fibre, have been investigated.

Work has been commenced on the measurement of the frictional properties of jute and certain other natural cellulosic fibres, a study of direct interest in connexion with fibre-processing practice. The coefficient of friction between single jute fibres has been determined over a range of moisture contents. Different values have been established for *capsularis* and *olitorius* jute. In addition, a study is being made of changes in the coefficients of static and kinetic friction with increasing oil content.

A study has been made of the electrical properties of jute, with particular reference to the changes in dielectric constant and power factor of the fibre with changes in moisture regain within the temperature range 0° – 45°C, using frequencies from 1 kc/s to 12 Mc/s. The information has been used in the design of electronic instruments for the measurement of the moisture content of jute by an indirect method.

INSTRUMENTATION

The Engineering Section has continued to provide special testing equipment and new research instruments for use in the various investigations in progress in the laboratories. Particular mention can be made of a machine which has been designed and built for the automatic recording of sliver, rove, and yarn irregularity.

SURVEYS

Two new surveys concerned with both the physical and chemical properties of manufactured jute products have been commenced in the year. Part of this work has originated at the direct request of Supplier's Committees, and the data obtained have provided a basis for the setting-up of statistical quality control in industrial practice.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st July, 1951 to 30th June, 1956 a block grant of £9000 per annum is made provided £15 000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £9000.

The income of the Association for the last completed year was £38 772.

THE LACE RESEARCH ASSOCIATION

Expansion of the services of immediate direct benefit to members has been the feature of the year. This has meant an increase in textile testing work, and additions to the equipment in this section have widened the scope of the investigations which can be undertaken. The chemistry section has also been engaged in some of the tests in this connexion. The value of this type of work is greater than the immediate benefit to the individual member, in that it creates a fund of goodwill between the members and the staff of the Association. At the same time it ensures that the staff are in constant touch with the current trends in the industry, and it also brings to light fundamental problems worthy of long term research effort.

Members are now submitting problems to the Association at a rate which has increased by 30 per cent over the previous year. This expansion has taken place without interfering with the progress of other research projects, such as the continuing work on lubrication, winding and working new types of yarn, or the development of dyeing, dressing and finishing techniques.

A full-time Information Officer, responsible for publications and the library, has been appointed to improve the communication of information to members. This has been achieved by the regular production of monthly *Newsletters*, in which current items of interest are spotlighted, and by the production of two printed *Bulletins* containing records of work, and information of more lasting interest. In the absence of a journal producing regular features of interest to the lace industry, these publications serve also to call members' attention to articles and announcements in the trade press, which otherwise they might not see.

WORKING OF THE LACE MACHINE

A programme of study of the mechanical motions of the lace machine has been started. Lengths of film have been taken, using high speed cinematography technique, at speeds of 500 frames per second and above. These have proved valuable in revealing timing faults, as well as showing where modifications may lead to improvements in the running of the machines. In the development of this work collaboration with the Mechanical Engineering department of Nottingham University under the direction of Professor Pope is planned. Improvements in the speed and productivity of the machines should result from these studies.

Other work in the machine room has been directed towards yarn tension on the machines, which in its turn reflects on winding techniques. Experiments have been carried out to determine the most satisfactory forms of yarn treatment and winding technique to provide even length and tension of the bobbin yarn when working in the machine. The production of lace in yarns made from the new fibres has afforded valuable experience in the handling of these materials, and provided useful information on their suitability for the different products of the industry.

NEW TYPES OF YARN

The many new fibres being introduced at present into the textile industry require a considerable amount of work to evaluate their usefulness in the lace industry. New fibres always require a period of experimentation before they can be satisfactorily handled in commercial production, which means delay in their exploitation. Investigation of their physical properties, such as friction against metals, the need for techniques for the elimination of static charges, as well as tensile tests and the development of modified

winding techniques, occupy much of the time devoted to yarns made from these fibres. In this way the Association is building up a fund of information for members, which will be of considerable value in reducing the delay between the time when the yarns become available in adequate quantities, and their use in the production of lace fabrics.

LUBRICATION

Steady progress has been made in the improvement of "Lacra" lubricant, and different grades have been developed to suit variations in the gauge and type of machines in the industry. The increased confidence of members in the value of this lubricant is reflected in the change of emphasis which has been evident during the year. Formerly a member would convert only one or two of his machines as an experiment. Now a number of factories, particularly in the Furnishings section, have changed over to "Lacra" lubrication throughout. This provides an opportunity, not previously possible, to clean and redecorate the premises. Thus the conversion not only produces cleaner lace, but at the same time creates brighter working conditions in the industry.

In one firm in the Furnishings section, making a line of cotton goods in which soiling could represent considerable losses, the reduction of damaged pieces from this cause, when the plant was converted to the use of "Lacra" lubricant, effected a 90 per cent saving on the previous losses. Increasing use of man-made fibres in the lace industry has re-emphasized the need for the clean "Lacra" lubricant to replace graphite. It has already proved its usefulness in the manufacture of nylon lace on the Leavers machine, and in the production of elastic fabrics on the Bobbinet machine. Although nylon has not been much used in the Furnishings section, new fibres such as "Terylene" are likely to be widely used when they become more readily obtainable.

The lubricant, and the technique of its application, are available solely to members of the Association.

CONDITIONAL AID PROGRAMME

A grant has been awarded from Conditional Aid funds for a study to be undertaken of productivity in the lace industry. Four ancillary operations in the production of lace have been selected for methods study: brass bobbin winding, carriage threading, lace jennying, and spool winding. The programme will be spread over at least two years.

Previously the techniques of work study have not been widely used in the lace industry. This work should therefore provide some very useful data not formerly available. It should also lead to recommendations resulting in positive improvements in existing methods of work and in the training of new workers. The first two operations selected for study will fit in well with the programme of work already in hand on the technical aspects of the working of the brass bobbin in the lace machine.

Equipment recently acquired for use in making pilot surveys of machine motions by means of high speed cinematography, will also play an important part in the methods study work. Eventually a series of training films suitable for students and new recruits to the industry, can be built up from the shots taken in the course of these programmes of work.

FLAMMABILITY OF FABRICS

The passing of the American Flammable Fabrics Act has involved the Association in work on the flammability of the products of the different sections of the industry. The apparatus prescribed in the Act has been

imported. Many tests of lace fabrics have been made in the course of the service rendered to members and in the work on flammability being done in the laboratory. In general it has been found that the large majority of the products of the industry satisfy the requirements of the Act without special treatment. Nevertheless, with certain limited classes of goods which pass the prescribed test, it is felt that the flame resistance properties could be improved. Therefore work has been undertaken on finishing treatments, which have led to recommendations being made to members.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1949, to 31st December, 1955, a block grant of £7000 per annum is made provided £10 000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £10 000.

For the period 1st January, 1956, to 31st December, 1958, the block grant will be £12 000 per annum, provided £15 000 is received from industry, and the additional grant £100 for each additional £100 contributed by industry up to a maximum of £5000.

The income of the Association for the last completed year was £17 971.

BRITISH LAUNDERERS' RESEARCH ASSOCIATION

The Association staged a comprehensive exhibit at the Laundry, Dry Cleaning and Allied Trades Exhibition held in London during July, 1954. This event provided good opportunities for discussion between members and staff, including a one-day conference, attended by members and overseas visitors.

During the year applied research and development have continued on washing processes based on laboratory observation and on such matters as heat transfer in laundry equipment.

DIRT REMOVAL AND REDEPOSITION

Previous studies having thrown much light on the constituents of natural soiling matter, this work was extended during the year to cover, amongst other items, the relationship of fabric composition and construction to dirt removal and redeposition. Examination of soilings have been made both on fabric and on single fibres.

Studies of the greasy soiling matter extracted from soiled sheets, pillowcases and underwear have enabled an artificial soiling mixture of similar composition to be prepared. Further experience has confirmed that cleansing trials on fibres or fabrics soiled with this mixture give results not unlike those obtained with natural soilings, whereas earlier soiling mixtures often failed to give good correlation.

Artificial soiling mixtures usually contain greasy or oily matter together with a black or coloured pigment. Measurement of the colour of washed samples gives information mainly about the quantity of pigment remaining but gives little or no indication of the quantity of residual grease, although this is at times important. For example, the yellowish discoloration sometimes evident on the centres of sheets and pillowcases after laundering is due to greasy material which has not been removed. As the normal method of extraction and estimation of grease takes a considerable time, trials were made with a rapid small scale method which had been devised for use in

the textile industry. This proved satisfactory and a note was published in the *Journal of the Textile Institute,* 1953, **44**, T658.

In addition to trials with soap and synthetic detergents, work has also been carried out on other substances. Ethylenediaminetetracetic acid has been suggested as a desirable addition to detergent liquors for reasons in addition to its sequestering power for hardness-forming salts. Redeposition trials, however, did not give very promising results. It had been suggested that the use of tetrasodium pyrophosphate in a wash liquor would allow the quantities of detergent materials to be reduced even in soft water. With liquors containing smaller amounts than usual of soap and sodium metasilicate, the addition of tetrasodium pyrophosphate improved dirt removal but did not affect dirt deposition. With less soap than usual and the normal concentration of metasilicate, the cleansing was not affected by the addition of tetrasodium pyrophosphate but, rather unexpectedly, deposition increased with increasing concentration of the complex phosphate.

WOOL WASHING

Continuation of the work on the effect of the degree of alkalinity on the behaviour of wash liquors has led to the development of a process for wool washing which has been circulated to members of the Association. The conditions are such that they minimize difficulties like the yellowing of white wool or loss of colour from dyed wool which sometimes occur when the degree of alkalinity is excessive.

TRIALS IN THE EXPERIMENTAL LAUNDRY

The equipment on test during the year has included two "dipless" washing machines, which are designed so that the liquor is in continuous circulation. It is picked up from the case by scoops attached to the cage and after passing through the load, it returns by another route to the point at which it is picked up. In some machines it passes through an external circuit with a tank and the circulation is sometimes assisted by a pump or steam injector. Rinse waters are not re-circulated in this way; instead, a steady stream of fresh water flows continuously through the machine and runs to waste. The standard washing processes in which several separate rinses are specified are not directly applicable to these machines but the preliminary trials suggest that with suitable processes these machines will give shorter overall times than have been customary with conventional methods.

Details of the B.L.R.A. Short Washing Process mentioned last year have been circulated to members and this process, in which cold rinsing is employed, has given satisfactory results in continuous use with machines of conventional type both in the Experimental Laundry and in the laundries of a considerable number of members. The saving in time is of advantage when washing capacity is inadequate or scarcely adequate for the amount of work being handled and this saving in time results in a certain saving in power. The process also gives a substantial saving in fuel compared with previous washing and rinsing procedures, the saving amounting to some 20 or 25 per cent of the total fuel used in the laundry. Some members who generate their own electricity are finding that with this process a change to purchased electricity would be more economical and are contemplating placing their steam engines and generators in reserve.

TEXTILE PROGRESS

Problems arising from new textile developments often become apparent during laundering. Many of the older difficulties too are still far from complete solution and work has been continued on items like shrinkage

and colour fastness. The widespread use of collar-attached rayon shirts as working clothes has meant that many of them reach laundries in an exceedingly soiled condition. The washing process appropriate for rayon is distinctly milder than that used for cotton and does not give adequate cleansing of exceptional soilings. It is unlikely that any process will be found which will deal with the worst examples and part of the solution must lie in educating the user that articles—whether made of rayon or any other textile—should be washed before they become too heavily soiled. Work is in progress to see if processes can be worked out which will give adequate cleansing of most of the heavier soilings without appreciably shortening the life of the garments.

Difficulties of chlorine retention by resins used in crease-resistant or embossed finishes have been known for some time but it has now become apparent that albuminous stains caused by certain foodstuffs and body secretions become very firmly fixed on these fabrics unless washed within a short time. Once the stains are well set they respond only to prolonged treatment with some digestive agents or to boiling in caustic soda solution. Neither treatment is generally applicable to coloured goods and it is these goods which are most usually affected.

Fluorescent blues or "optical brighteners" are coming into wide use as constituents of domestic washing powders. They are colourless dyestuffs which have a blue fluorescence when exposed to ultra-violet radiation. There is enough ultra-violet in ordinary daylight to produce a marked emission of blue light which serves to counteract any faint yellow tint which may have developed on a white fabric, thus giving a very brilliant effect. Trouble has sometimes been experienced when goods have been treated at home with one of these substances and have subsequently been sent to a laundry using an invisible marking system. A fluorescent ink, visible only under an ultra-violet lamp, is used for marking and if the whole article is brilliantly fluorescent the mark may not be easy to read. Difficulties have also been encountered when they have been used on pastel shades, particularly cream or beige. The blue fluorescence masks the pale yellow and leads to an impression that the dye has been removed.

PRODUCTIVITY

Economical working in a laundry depends on many factors and, since labour is the largest individual item of cost, such factors as suitability of plant, convenience of lay-out and methods of working are of prime importance. Mention was made last year of a report entitled *Laundry Productivity* prepared jointly with the trade association: sales of the book were so heavy that further supplies had to be ordered within a few days of publication. Reports from members who have been able to make improvements in their methods of working, whether in a small detail or in a whole section of the laundry, have amply proved the value of the information contained in the book.

SERVICES TO MEMBERS

Visits by Technical Officers to the laundries of members continue to be one of the most useful services. Bulletins, Reports and other printed items provide a great deal of useful information but there are many instances where local circumstances make it desirable to modify or adapt general recommendations to the conditions in a particular plant. In general these matters are dealt with during the routine visits but special visits are sometimes required when the matter is urgent. Despite the fact that charges

are made for these extra visits, there has been a substantial increase in the number of requests that have been received during the year.

The number and type of enquiries reaching the analytical and textile laboratories have not shown much change. The number of articles damaged by bleach liquor shows no diminution and it is clear that the need for using bleach very sparingly and carefully *in the home* is not well appreciated.

TRAINING COURSES

In addition to the six months' courses in the Principles of Laundering, short courses of an essentially practical nature have been arranged at intervals for washhouse men and there has been a continuing demand for the correspondence course in washhouse methods.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st October, 1949, to 30th September, 1957, a block grant of £10 000 per annum is made provided £20 000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £10 000.

For the period 1st October, 1957, to 30th September, 1959, the block grant will be £12 000 per annum, provided £25 000 is received from industry, and the additional grant £100 for each additional £100 contributed by industry up to a maximum of £10 000.

The income of the Association for the last completed year was £39 656.

BRITISH LEATHER MANUFACTURERS' RESEARCH ASSOCIATION

The long-term research on the constitution and structure of the industry's main raw materials—collagen fibres, and vegetable and mineral tannins—has been maintained at a level representing about a third of the total effort of the Association. This has been achieved in spite of increased attention to production problems, briefly described below, which are of immediate interest to the industry.

QUALITY OF IMPORTED "CRUST" LEATHERS

A relatively large section of the British leather industry imports roughly vegetable-tanned hides, sheepskins and goatskins, chiefly from India, Pakistan and Ceylon. These so-called "crust" leathers are partially stripped of vegetable tannins, retanned with chrome tannins, and then finished for upper, clothing and gloving leathers. Like tanners almost everywhere, tanners in these Eastern countries have had to modify their traditional methods, because political and economic changes have interfered with the availability of their normal tanning materials and auxiliary products. Such changes of methods, which are not revealed to buyers of the leather, have caused trouble and financial loss to British leather dressers. When appealed to for assistance, the Research Association was handicapped by a lack of detailed knowledge of modifications to tanning methods used in the producing countries. Assisted by a grant from Conditional Aid funds, the Research Association has sent a member of its staff with tanning experience to visit tanners in India, Pakistan and Ceylon to study the methods used by producers of "crust" leathers, and to give them advice, when using new tanning materials,

on how to avoid changes in these leathers which cause trouble to our leather dressers. Reports received already show that direct contact with the tanners is proving valuable.

RAPID VEGETABLE TANNAGE

Whilst the tanners of the Far East have not been able to cope rapidly with the changes called for by alterations in their supplies, changes forced upon British tanners seem to have benefited them. Before the last war they used blends of tanning materials imported from many different parts of the world. The Association found that such blending was undertaken mainly so that the tan liquors contained a certain concentration of salts and weak acids. During the last war, when interruption of supplies made blending impossible, the Association was able to tell tanners how much salts and acids to add to the available tanning materials in order to correct for any deficiencies. The use of such methods has, however, also revealed the somewhat unique character of mimosa bark extract. With most tanning materials, the hides during tanning absorb the different tannins they contain at different rates. Recent observations have indicated that the tannins in mimosa extract are so much alike in character that they are absorbed at very much the same rate. After having been weakened by tannage, mimosa liquors can therefore be concentrated by the addition of solid extract, and the reconstituted liquors tan in very much the same manner as the original liquors. Consequently, provided the tanner adopts mimosa, suitably acidified, as his main tanning material, it is possible for him to tan rapidly in concentrated liquors in a very limited number of pits. By this system, sole leather is being tanned in 10-14 days. Some tanners consider it is not so good as the leather tanned in blended extracts, but laboratory investigations and tests suggest that the loss in quality is very small and is outweighed by savings in space and labour and the simplicity of the process.

DRYING OF LEATHER

There is ample scope for economies in fuel consumption in the drying of sole leather, since a survey has shown that about one ton of coal is used to dry one ton of leather, and it is estimated that this could be reduced by two-thirds. Because moist leather can be damaged by heat, it is dried at relatively low temperatures. When a controlled, closed drying unit is used, it has been found on an experimental plant that a heat pump can be used to control the drying capacity of the air with a significant saving in the heat required. A heat pump unit suitable for installation in a large experimental drier in the tannery of a member has been designed and constructed, and will shortly be in operation. Under conditions normally used in sole leather drying (70° to 80°F dry bulb with a 10°F temperature difference), the unit is expected to remove 12 lb water/k.w.h. when electrically operated, at a cost estimated to be half that of a highly efficient steam-heated unit with controlled recirculation. The heat pump operates as a self-contained conditioning unit, and within its range of operation can be set to produce any prescribed drying conditions. This eliminates the need for the expensive control equipment essential for steam-heated drying plants.

EFFLUENT PROBLEMS

Leather production calls for the use of large quantities of lime and lime liquors containing sulphides, the disposal of which in urban areas presents many problems. The removal of sulphide by means of air, flue gases and chlorine has been studied, and the economics of the various methods are

now under consideration. The flocculation of spent lime liquors by poly-electrolytes has proved very effective, the flocculated lime being in a condition in which it can be removed by pressure filtration. The Association is indebted to the Mineral Dressing Group, Atomic Energy Research Establishment, Harwell, for drawing attention to these flocculating agents. A cyclone separator has also been constructed to test the efficiency of this apparatus in lowering the water content of lime sludge.

PROPERTIES OF LEATHER

Even traditional materials such as leather have to change to meet fashions in wear and also the development of new methods of shoe construction. To assist in the readjustments that become necessary, a joint committee with the British Boot, Shoe and Allied Trades' Research Association has been formed. After three meetings it has become evident that the exchange of information between the two Associations is of considerable value, and that the bi-annual meetings, held alternately at the headquarters of each Association, are likely to become a permanent feature of their work.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st October, 1949, to 30th September, 1954, a block grant of £14 000 per annum was made provided £27 000 of grant-earning income was received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £12 000.

The income of the Association for the last completed year was £60 544.

LINEN INDUSTRY RESEARCH ASSOCIATION

The research programme of the Association includes investigations in every section of the linen industry—spinning, weaving, bleaching, dyeing, and finishing. Undoubtedly, the most striking feature of the research in the past year has been the increasing application of new physical and chemical discoveries to the textile industries. These sciences have provided new instruments for the investigation and control of textile processes, as well as new chemicals for modifying the properties of yarns and fabrics, all of which affect the different sections of the industry as described below.

SPINNING

There are four main objectives of the spinning research programme on flax and man-made fibres, viz.—

(i) Devising improved methods and instruments for testing the properties of materials and products;

(ii) Improving yarn quality by reducing irregularities caused by the drafting operations;

(iii) Reducing costs of production by increasing the efficiencies and rates of production of machines;

(iv) Reducing losses due to waste of material, or to faulty finished goods arising from defective mechanisms or careless or unskilled work.

Results of practical importance have been obtained in pursuit of each of these objectives.

Improvements have been made in the design and performance of integrators used on electronic irregularity testers. Investigations are in progress to determine (*a*) the most suitable form of supply of man-made fibres for satisfactory processing on flax machinery, and (*b*) the properties of yarns spun from mixtures of the different fibres.

The investigation of dry spinning of flax yarns has resulted in a recommendation to standardize the settings of the drafting control devices at specified values to effect an overall improvement of yarn regularity and quality. The effect of humidity on dry spinning efficiency has also been determined. Fundamental research on irregularity and on the mechanism of drafting has led to the design of a new system of drafting control, preliminary tests of which have given very promising results on a flax spinning frame.

Increases in efficiency and productivity in flax preparing and wet spinning should result from three modifications developed from experimental investigations. The efficiency of flax preparing may be increased by using rubber-covered pressing rollers of specified types under modified conditions which reduce lick-up to a very low level. A standardized method has been described for the manual adjustment of drag cords on flyer wet spinning frames by which the difference in efficiency of frames minded by skilled and unskilled spinners is reduced. An improvement to wet ring frames has been developed which enables higher spindle speeds to be used.

Wastage of yarn occurs when yarn packages contain unequal lengths, and is prevented by a mechanism which controls the length during winding. New methods have been described for lubricating wet spinning frames in such a way as to reduce the losses caused by oil stains.

WEAVING

Yarn preparation has been improved in a number of ways. For example, a special machine for winding yarn at high speed from hank has had a successful factory trial, and a prototype production model is now being built. A simple yarn clearing device of novel design has given promising results ; the device is selective and distinguishes between knots which should be allowed to remain in the yarn and other faults which should be removed. Efficiency surveys of winding processes have yielded information that has enabled production and efficiency to be increased.

The making of short sample lengths of cloth by the normal factory processes is time-consuming and wasteful of yarn. Equipment has been devised to enable samples to be made quickly and from small quantities of yarn. The warp yarn is sized, warped, and beamed in a single process, and is subsequently woven in a normal loom.

Various improvements have been made in weaving linen :—Warp sizing materials made from cellulose derivatives have been applied to linen yarns with successful results in weaving ; these materials are removed without difficulty in subsequent finishing processes. A new loom picking motion has been developed as a result of fundamental studies of the mechanism, and is giving good results under factory conditions. The self-threading shuttle used in automatic looms has been improved to make it more suitable for linen yarns. An investigation has led to a new structure being suggested for the linen harness cords used in Jacquard looms. Cords of the new structure are long-wearing, and are little affected by changes in atmospheric conditions.

PHYSICAL PROPERTIES OF YARN AND CLOTH

A comprehensive study has been made of the relationship between yarn strength and the strength of the woven cloth in a limited range of structures. In addition to providing information of value in making new cloths to specification, the study has led to a better understanding of the fundamentals of cloth structure.

There is a considerable public demand for linen handkerchiefs, and as absorbency is one of the most important properties required, a water-absorbency test is needed which discriminates in this respect between the different classes of fabrics used. There are various forms of such a test, the commonest of which measures the amount of water taken up over a period of minutes. But what matters most for handkerchief absorbency is the amount of water taken up in the first second or two of contact, as it is a person's reaction during this period by which the handkerchief is judged. Various testing procedures have been examined and it appears that the order in which a series of handkerchief fabrics is placed by the common test is substantially different from that of a test based on immediate moisture take-up, the results of which have been found to be more in line with common experience.

BLEACHING, DYEING AND FINISHING

Further work on the crease-resisting process for linen fabrics has resulted in improvements which give a closer approach to the ideal of super crease-resistance combined with higher quality. Marked improvements in the wear resistance of linen fabrics have been achieved with a corresponding increase in the service which these fabrics will give. Modifications have been devised in the method of waterproofing flax canvas for wagon covers with the object of extending the useful life of the covers.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st October, 1950 to 30th September, 1955 a block grant of £10 000 per annum is made provided £20 000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £12 000.

The income of the Association for the last completed year was £70 825.

THE PARSONS AND MARINE ENGINEERING TURBINE RESEARCH AND DEVELOPMENT ASSOCIATION

The Parsons and Marine Engineering Turbine Research and Development Association (Pametrada) has now been in existence for 10 years. Its object has been the steady improvement of marine turbine machinery.

The Association undertakes the large experimental research projects necessarily associated with progress in the development of marine turbines and makes design schedules available to members. Full-scale trials are conducted on prototype machinery, both for the Royal Navy and Merchant Marine.

Over 300 000 horsepower of Pametrada-designed machinery were commissioned during the year. One more marine engineering firm has been admitted to membership of the Association, bringing the total number to 20.

The Research Station at Wallsend is functionally divided into three main departments, Design, Research and Full-Scale Prototype Trials, with supporting facilities, which include a Drawing Office, Laboratories, Test Houses and Experimental Workshops. The total number of employees at present is 320.

BUILDING EXTENSIONS

During the year two new buildings have been completed, the first a block comprising a new Drawing Office, Noise Laboratory and other offices, a council room, lecture room and canteen, and the second a new workshop for more economical and rapid production of research rigs and experimental components. A number of technical staff hitherto accommodated in temporary wooden huts will now be properly housed. Accommodation has also been provided for a library and an instrument standards room.

Other extensions include the doubling of the capacity of the pump house, thus enabling adequate supplies of circulating water to be provided for trials on prototype machinery of greater power than the 30 000 h.p. hitherto tested.

STEAM TURBINES

Work on steam turbines during the year includes the provision of tendering particulars to the member firms for 64 vessels or groups of vessels, including several relating to Naval vessels for foreign governments. The first turbine of Pametrada design to be constructed by a foreign licensee is now in service. It is perhaps interesting to note that the designed fuel consumption quoted for recent designs at 600 p.s.i., 950°F, is 0·52 lb/s.h.p.-hour, all purposes, against a figure of 0·68 lb/s.h.p.-hour which was considered good in 1944 when Pametrada first came into existence.

A new design of double casing high pressure turbine particularly suitable for higher temperatures and pressures has been developed and a prototype is now under construction. Model tests are also being carried out with a view to proving its superior stability against thermal transients. Extensive testing has been carried out on an experimental high pressure, high temperature steam turbine designed by the Association for operating steam conditions of 1100 p.s.i. and 1150°F. Much useful information is being collected on the distortion of turbine casings and its prevention, as well as on behaviour of various materials under these conditions. Full-scale trials have been completed on a set of prototype machinery for an anti-submarine frigate for the Admiralty, and have now been reported. A further set of Naval machinery is being installed and will commence trials shortly. In order to allow these trials to be carried out concurrently with gas turbine testing, an additional 60 000 h.p. brake has been installed. A separate condenser and pump equipment has been erected outside the Test House on the jetty for boiler trials associated with this machinery.

The Association has, as usual, been represented on sea trials of ships with machinery of Pametrada design, and various technical investigations at sea have also been carried out, not only on vessels with Pametrada machinery but also on other vessels.

It has often been found that machinery troubles have resulted from maloperation, and courses of instruction in steam turbine machinery are therefore being initiated for the benefit of superintendent engineers, seagoing engineers and junior technical staff of member firms. The first of these courses is being held at Pametrada in October, 1954.

Work on power transmission includes the design of all gearing associated with Pametrada machinery and also full scale back-to-back testing of various

types of gearing. Several of these trials are being carried out under Admiralty contract and represent very high tooth loadings which, when satisfactorily proved, will result in large savings in weight in Naval machinery. Work has proceeded on the development of hydraulic reversing means for uni-directional turbines and the Association is now in a position to design such equipment for use at sea. Experimental and theoretical investigations on journal bearings for high speed machinery have yielded very encouraging results during the year. These results are being applied to designs now under construction and will give enhanced reliability and lower losses.

GAS TURBINES

In the gas turbine field it has been decided that the 3500 s.h.p. marine gas turbine will remain at Pametrada for experimental work on the burning of residual fuel oil, and the development of control gear for seagoing gas turbines. In view of its potential economic importance a great deal of effort has been put into the solution of the problem of burning residual fuel oil in gas turbines and much success is being achieved.

A new design of marine gas turbine of 9000 h.p. for seagoing installation has been prepared. This installation comprises in effect two units of 4500 s.h.p. each, driving through a common double reduction gear to a single propeller shaft. The intention is that after construction and testing at Pametrada this set will be installed in a commercial vessel as the sole method of propulsion. The fuel consumption, burning residual fuel oil, is anticipated to be below 0·5 lb s.h.p.-hour.

A great deal of progress has been made with the development of a liquid cooled gas turbine to run at a gas temperature of about 2200°F with a thermal efficiency over 40 per cent. The construction of a single stage experimental version, together with auxiliary machinery, ducting, test cell and combustion chamber, sponsored by the Admiralty, is well under way, and it is hoped that tests will commence at the turn of the year.

OTHER RESEARCH

Other subjects to which considerable effort has been applied during the year are noise and vibration investigations, measurement and analysis of non-condensable gases in steam, condenser research, pressure drops in pipe and valve systems, high pressure, high temperature steam valves, aerodynamic work on turbine and compressor blading and other items, and metrology in general, with particular reference to measurements required during machinery tests. Some special instruments under development include a dilatometer for measuring the expansion of turbine rotor bores in operation, an engineer's pocket noise meter, an integrating torquemeter, and a rotor balancing instrument which enables a turbine rotor to be balanced in its own bearings without removal from the ship.

PATENTS

The Association has filed 105 patents in the United Kingdom, of which 45 have been granted to date. A number of corresponding cases have already been granted in U.S.A., Holland, Sweden, Switzerland, Germany and France.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1950, to 31st December, 1954, a block grant of £35 000 per annum is made provided £80 000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £35 000.

The income of the Association for the last completed year was £217 799.

THE MOTOR INDUSTRY RESEARCH ASSOCIATION

During the autumn of 1953 the new laboratories at Lindley, near Nuneaton, were completed and brought into full use, portions having been occupied by the Association's staff in increasing numbers from the end of 1952. The completion of this final part of the building added electronics, acoustics and chemical laboratories to the previously finished engine and materials-testing laboratories and machine shop, as well as full drawing office, library, and office accommodation for technical and administrative staffs.

In May, 1954, the formal opening ceremony of the new Laboratories and High-Speed Track was carried out by the Minister of Transport, the Rt. Hon. A. T. Lennox-Boyd, M.P.

PROVING GROUND

Work on the Proving Ground throughout the year has been concerned chiefly with maintenance of the existing facilities, in particular the re-surfacing of parts of the high-speed and low-speed circuits. New constructional work consisted of an extension to the cross-country track, an assortment of ruts, pot-holes, and other features, which will, when finally completed, envelop the 2·8 mile long high-speed circuit.

The number of vehicle-testing hours during the year was 20 342, an increase of 1855 over the corresponding figure for the previous year.

PROGRESS OF RESEARCH

Lubricating Oils for High-Speed Compression-Ignition Engines

The aim of this work is to develop laboratory test procedures, using a small single-cylinder compression ignition engine, which will reproduce within a reasonable time, the type of piston failure in road service which can be attributed to failure of the lubricating oil. It has been shown that with a plain mineral oil as lubricant, compression ring sticking is very readily induced by operating at high jacket and sump temperatures. A second type of failure, which is a most serious problem in the operation of compression-ignition engined road vehicles in this country, is scraper ring plugging. This has proved to be very difficult to reproduce in the laboratory. Eventually a procedure was evolved which subjected the scraper ring to high temperature and much soot-laden blow-by gas. By this procedure plugging of the scraper ring was practically 100 per cent after 100 hours using a plain mineral oil. Additive-type oils of U.S. and British official specifications when subjected to the same procedure resulted in completely free scraper rings. This procedure has, however, been found to be very sensitive to fuel composition. Two fuels, complying with the same specification, gave results which differed by approximately the same amount as those given by straight mineral and heavy-duty oils. This fuel aspect is being investigated.

Use of Low Viscosity Oils in Internal-Combustion Engines

The benefit to be derived by reducing the viscosity of the lubricant in a compression-ignition engine has been accurately measured over a wide range of engine load and speed, lubricant viscosity and temperature. Under any given conditions of engine speed and load, the fuel consumption can be reduced either by using a thinner oil, i.e. an oil of lower S.A.E. viscosity grade, or by increasing the temperature at which the oil is supplied to the bearings, or by a combination of both methods. The use of S.A.E. 5W grade, the thinnest grade of crankcase oil catered for in the S.A.E.

classification, in place of the popular S.A.E. 30 grade improves fuel consumption by about 4 per cent at full throttle, rising to about 9 per cent at quarter throttle. Replacing S.A.E. 30 by S.A.E. 10W improves fuel consumption by about 2 per cent at full throttle rising to about 6 per cent at quarter throttle. Hence the exact saving in fuel to be expected in any particular application will depend on the nature and extent of the part-throttle running involved. An increase of 25°C in the oil delivery temperature can be expected to reduce fuel consumption by 3–4 per cent on average variable-throttle running, but, again, this saving is dependent on load and falls to 2 per cent at full load.

Fatigue Strength of Crankshafts

A comparison has been made of the torsional fatigue strength of crankshafts made from four different cast materials. These are: a chrome-molybdenum alloy iron; low alloy inoculated iron; pearlitic malleable iron; and "graphitic cast steel"; having tensile strengths of 22, 26, 33 and 51 tons per sq. in., respectively. The fatigue strengths of the crankshafts were not as different as the tensile strengths would suggest. The fatigue strength of "graphitic cast steel" shafts, for example, was only 30 per cent greater than that of shafts of low alloy inoculated iron, although its tensile strength was twice as great. In earlier tests, however, bending fatigue strengths of these materials had been shown to be roughly proportional to tensile strengths. Present tests are concerned with the influence of crankshaft shape on torsional fatigue strength.

Further tests have been carried out in connexion with the rolling of fillets using steel balls under heavy load. In "reversed" bending tests, this process improved the fatigue strength of some forged steel production crankshafts by about 60 per cent, and in "one-way" bending, the improvement was about 80 per cent. Some production crankshafts of "graphitic cast steel" were similarly strengthened by about 60 per cent in reversed bending. A separate investigation to determine optimum conditions of rolling for different materials and different fillet sizes is at present in progress, and this is being carried out on stepped-bar specimens.

Operating Loads in Crankshafts

Measurements of operating loads in crankshafts have shown that in a medium sized 4-cylinder engine a cast iron crankshaft is subjected to slightly lower bending loads than a forged steel shaft, and has demonstrated that bearing clearances affect bending loads considerably. This work helps the application of the Association's work on bending fatigue and is being extended to ascertain if there is any simple correlation between measured loads and engine dimensions.

Fatigue Strength of Gears

A comparison has been made of the bending fatigue strengths of gears hardened by gas and pack carburizing, and quenched in different ways, and gears hardened by the induction method. A 3 per cent nickel-chromium steel was used for the carburized gears, and a few of these carburized gears were also induction hardened. Most of the induction hardened gears were made from a 0·55 per cent carbon steel. However, with the induction method it was not found possible with the equipment available to overcome a marked variation of hardness pattern which existed along the length of the teeth, and the induction hardened carbon steel gears gave only about a third of the strength of conventionally carburized and heat treated nickel-chromium steel gears. The latter, carburized and induction hardened with a fast rate of heating, similarly gave poor results, but slow induction heating on these

gears gave fatigue results similar to those obtained with conventionally carburized and heat treated gears. Pack carburized gears and gas carburized gears, heated and quenched in a conventional manner, gave similar results.

An investigation has been started, using a low-alloy economy-type steel, to determine the influence on bending fatigue strength of carburized gear teeth of such factors as case depth, case hardness and case structure.

Tests in connexion with a determination of the "pitting" resistance of a wide range of carburizing gear steels have continued and so far three typical American steels and a British steel with a similar composition to one of them have been examined.

Strength of Splined Shafts

An investigation has been started to determine the influence of design on the strength of splined shafts. In order to determine a realistic test procedure, tests have so far been confined to reproducing the type of service fractures which are found in axle shaft splines. Encouraging results have been obtained using mixed high and low torsional loads.

Brake Research

It had been previously shown that heat treatment by baking improved the fade resistance of brake linings, and now the effect of baking on wear properties has been examined. Both laboratory and service measurements have shown that baked linings wear more rapidly than unbaked ones. A brake squeal investigation is directed towards the elucidation of the fundamental factors involved, and various hypotheses are being examined.

Noise in Vehicles

To facilitate accurate measurements of noise, a new tape recorder has been constructed which embodies a number of improvements found desirable from previous experience. The new recorder has an exceptionally good frequency response, is stable and operates at a comparatively low power input.

In order to facilitate measurements on vehicles indoors and under controlled conditions, an echoless chamber has been constructed. The dimensions of the space available for this project precluded optimum acoustic treatment of the surfaces of chamber and some compromise had to be made. The construction of the chamber follows the modern practice of using wedges of absorbent material on all internal surfaces of the chamber. The available space, after treatment, permits the largest passenger car to be accommodated in the chamber. Rock wool was employed as the absorbent material using wedges of base dimensions 6 in. × 6 in. On the short wall and ceiling it was possible to use wedges 2 ft. 6 in. high but on all other surfaces the wedge height had to be limited to 9 in. The characteristic of the chamber approximates very closely to free field conditions down to 125 c/s and is now being used extensively for both measurements and the calibration of measuring apparatus.

Visibility From Cars

A rig has been erected for determining the visibility from cars. This work is to provide information on which new visibility recommendations can be drawn up in collaboration with the Society of Motor Manufacturers and Traders.

INFORMATION SECTION

Since occupying its permanent quarters in the new laboratory building, the Information Section has gradually resumed its full activities.

The quarterly bulletin, which had been discontinued during 1953, was started again at the beginning of 1954.

The translation service was also restarted at the beginning of 1954, and in the first half of the year nine translations were completed, all from German sources.

The abstracting services were maintained in full throughout the year, an average of 40 loose-leaf abstracts and a list of additions to the library being produced each month.

The number of enquiries of a technical or bibliographical description dealt with exceeded 130. All material which has been abstracted or translated, is of potential value in answering these enquiries, and 880 such items were added to the library catalogue during the year.

Some 5000 requests for the loan of documents were dealt with by the library. A document photo-copying service was introduced approximately half way through the year. This service has replaced 50 per cent of the loans service since its introduction.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st July, 1953 to 30th June, 1955 a block grant of £30 000 per annum is made provided £60 000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £30 000.

The income of the Association for the last completed year was £146 238.

BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION

To cover the varied research needs of the Association's membership (now at its highest ever level, 609 companies) the research programme is surveyed and modified annually by the Research Board, aided by the advice of committees representative of various sections of the industry. Of the 41 researches in progress the majority are primarily selected to meet the needs of particular sections of the industry, including light metals, copper and nickel, lead and tin, zinc and galvanizing, metal finishing. The remainder cover a variety of subjects of general interest to the whole industry. It may be mentioned, however, that the results of all researches are freely available to all members of the Association. A few representative researches are discussed below. Further information on the Association's work is set out in its *Annual Report* which is obtainable on request.

MELTING COPPER ALLOYS

Undoubtedly the most efficient means of melting metal is by induction, and low-frequency electric furnaces employing this principle have been used for melting brass for many years. The principle can be applied to melting most alloys, and there has been considerable interest in developing induction furnaces for melting copper and high-copper alloys such as cupro-nickels. Unfortunately, it was found that the refractory materials used for constructing these furnaces would not withstand the erosive effects of the slags formed

on copper and these alloys, and the Association was asked to investigate the matter on a co-operative basis. Association staff visited various works and thus prepared a survey of existing practice. This together with the results of laboratory studies led to industrial trials of improved refractory mixes and methods of application.

This research is now paying dividends. Thus, in the melting of phosphorus-deoxidized copper, in which linings in some melting shops formerly failed after as few as 50 heats, with the improved linings several hundred melts can now be carried out without relining the furnace, obviously with immense economy in labour and material, while irksome interruption of operations is avoided. It is hoped to effect still further improvement, as linings very recently investigated promise even longer life. Work is still in hand on the development of linings suitable for melting certain copper alloys, notably cupro-nickels.

RESEARCH, SPECIFICATIONS AND ECONOMICS

The aluminium casting alloy LM-4 (2–4 per cent Cu, 4–6 per cent Si), which is usually made from secondary material, has its zinc content limited by specification to 0·5 per cent. This makes it difficult to use zinc-bearing aluminium alloy scrap in producing LM-4, though considerable quantities of such scrap are becoming available as a result of the increasing use of high strength zinc-bearing alloys in aircraft construction.

A short investigation has indicated that the specified zinc content of LM-4 can, in fact, be quite substantially increased without any effect on its strength, ductility or corrosion behaviour. This will permit the producers to make wider use of zinc-containing scrap, and this wider choice of raw materials is of importance in the economics of production.

ECONOMIES WITH EXTRUSION TOOL MATERIALS

If better extrusion tool materials could be found, present metals and alloys could be extruded more economically to better dimensional tolerances and it might become possible to extrude harder ones. With this end in view the Association has made a survey of factors influencing the life of tool materials, based on the experience of both tool-steel makers and extruders. Experience indicates that in some cases cheaper steels could be used for the tools, with simultaneous increase in life, so that the total possible saving is considerable. The survey also indicates that considerable economies would result if better lubricants could be found, and some steps have been taken in this direction.

GAS TURBINES

Material for compressor blading in gas turbines has to operate at high temperatures, and the primary requirements therefore are good resistance to creep, fatigue and oxidation. Because of the large numbers required, blades must be cheaply and quickly produced, and good forging properties are necessary. Aluminium bronzes have useful properties for this application in the range 300°C–400°C, and an examination of the creep and fatigue properties of some complex alloys of this type has indicated the composition from which the optimum combination of high temperature properties and ease of production may be attained.

Another aspect of gas turbines in which the Association has been interested is the suitability of copper alloys for use in heat exchangers. Here again the materials, operating at high temperatures, are required to have good

creep strength and to resist the corrosive action of the turbine exhaust gases up to 500°C. Certain copper alloys offer promise in this application, and an important recent development is a simple treatment by which the corrosion resistance of the materials may be very considerably increased. Trials in a gas turbine heat exchanger are in progress.

NICKEL PLATING

The widespread adoption of bright nickel plating solutions in recent years as a means of reducing polishing costs, and so increasing productivity, has raised a number of technical problems concerning the maintenance of plating conditions for high-quality deposits. The Association is operating two pilot-scale production lines in which deposition is carried out from the two commercial organic bright nickel solutions most commonly used today, to demonstrate the correct plating practice for the successful production of high quality deposits. The opportunity is being taken to investigate methods for the control of composition of the baths and the quality of the deposits produced.

Besides these contributions towards the maintenance of high standards of quality in electrodeposits applied by the present method in industry, longer-term work is concerned with the fundamental processes of chromium deposition and of "levelling" action, i.e., infilling of scratches by electrodeposition

LEAD WATER PIPE

For over 100 years lead pipe, which is very widely used for water services and electric cable sheathing, has been produced by extrusion. It is a very reliable material, but as requirements grow more exacting, improved properties are required. An investigation on the extrusion of lead, sponsored by the Lead Sheet and Pipe Manufacturers' Federation, has therefore been undertaken. The present notes deal with lead for water pipe, but the principles discussed are also relevant to cable sheathing.

As regards mechanical properties, the first requirement of a lead water pipe is resistance to creep (*i.e.*, resistance to deformation by forces acting over a long period): resistance to fatigue (*i.e.*, vibratory stress) is usually a secondary consideration. The first requisite for good creep resistance of lead is satisfactory grain size, and in effect this research has been devoted to investigating conditions for producing material of suitable and stable grain size. The operative factors are the composition of the lead and the conditions of extrusion and manipulation of the extruded pipe. As a result of the laboratory work these factors are now clearly understood, and the results are being applied to industrial practice. This work may well pave the way to the more efficient use of lead for water pipe.

LIAISON AND INFORMATION

The liaison and information services of the Association have continued to operate under high pressure. In 1953, 49 per cent of the membership consulted the Liaison Department for practical advice on current technical problems, while 51 per cent availed themselves of the services of the Information Department and Library.

An appreciable increase was noted in the number of enquiries received in both Departments in 1953, and during the year total library external loans exceeded 9700.

CONDITIONAL AID SCHEME

Additional to the extensive liaison services which the Association provides to its membership, some further help is being given from a grant of £15 000 (to be spent in three years) from Conditional Aid funds to promote industrial productivity. This money is being applied in two directions. Firstly, a small team of investigators is, by invitation, visiting plating shops of different types and studying the principal factors in the technical aspects of plating practice. Individual firms receive confidential reports giving advice on improvements and economies. From the whole series of visits, the general conclusions on good practice and high productivity will be made known in due course to the industry, with due safeguards to those providing the info nation, who will be known only to the investigators. Moreover, the pilot scale plating plant mentioned earlier works in parallel with this field work.

The F.O.A. funds are also being applied to provide certain new technical services to the lead pipe industry. As indicated above, much information on the mechanical properties and extrusion conditions of the pipe has been accumulated and the Association is in a position to help the industry with advice on methods of controlling the properties of its products.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1952, to 31st December, 1953, a block grant of £24 000 per annum was made provided £52 000 of grant-earning income was received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £15 000.

For the period 1st January, 1954, to 31st December, 1956, the block grant is £28 000 per annum, provided £65 000 is received from industry, and the additional grant £100 for each additional £100 contributed by industry up to a maximum of £15 000.

The income of the Association for the last completed year was £134 208.

THE RESEARCH ASSOCIATION OF BRITISH PAINT, COLOUR AND VARNISH MANUFACTURERS

The programme of work in progress has continued on the general lines outlined in previous years, with particular attention to newer types of paint media and pigments.

PAINT MEDIA

New types of materials bring their own problems and the paints commonly described as "latex paints", "synthetic emulsion paints" or even "plastic paints," which consist of pigmented suspensions in aqueous media of synthetic resins suitably plasticized, have introduced some new conceptions in paint making. It remains to be seen whether this development will extend beyond the introduction of a new paint type of limited but valuable application, or whether it represents the beginnings of a new technology of wide significance for a variety of uses.

These paints differ in physical structure not only from the conventional types of oil paints, enamels and lacquers, but also from the older types of water paints based on oil-in-water emulsions. In this country the synthetic resin used is mainly polyvinyl acetate, to a less extent polystyrene, while there

is a potential availability of styrene/butadiene emulsions which have provided the main basis of development in the U.S.A. These styrene/butadiene compositions are closely related to certain types of synthetic rubber manufactured during the war in America where, as a consequence of ready availability, synthetic emulsion paints rapidly developed in the post-war years.

In the United Kingdom development came a little later, but very rapidly; there is now a considerable production of the primary emulsions but they are still largely dependent upon imported monomeric materials. The nature and extent of further development may well depend upon a variety of polymeric materials becoming available in emulsion form, the selection of plasticizers and other ingredients, and various manipulation factors involved in pigmentation, control of application properties, etc.

Greater understanding of the physical nature and film structure of such paints has been obtained by a systematic research programme—a necessary precursor of further advances. Such studies have been made with the aid of the electron microscope, radiochemical tracer techniques and other research tools.

An increasing number and quantity of materials used by the paint industry are closely allied to those commonly known as "plastics". To the example provided by the synthetic latex paints may be added another war-time development—the isocyanates. In this country the extent of use remains much behind that in Germany, but steps are being taken to make the basic materials available to the paint industry and considerable development may be expected. Another case is that of the epoxy resins, based on epichlorhydrin, which are already well-established paint materials for special purposes, but at the time of writing there is still no substantial manufacture in this country.

The kinship of plastics and paint materials and the overlap of the respective technologies is further illustrated by the polyester resins, familiar to the public in the form of plastic boats, translucent corrugated sheets, etc., where they are used in association with glass fibres. Basically the same materials can be applied as surface coatings, but the many difficulties implicit in their use in film form have not yet been fully overcome.

There is already a long history of paint use of the alkyd resins which are also polyesters though of distinctive structure. Practical work on the evaluation of alkyds has recently been supplemented at the Research Station by a more theoretical study of the kinetics of the polyesterification process. This has included consideration of the influence of the functionality of the component acids and alcohols, and of ester interchange and other side reactions on technically significant factors such as molecular weight distribution. In associated experimental work it has been found useful, in studying ester-interchange, for example, to use reactants labelled with the radioactive isotope ^{14}C. Such work may well have importance beyond the field of alkyd resins, for it may be reflected in the methods of preparation control for stand oils and the older types of natural resin varnishes.

The effects of high-energy gamma irradiation derived from radio-active scission products on organic polymers and plastics have been reported in the literature, and naturally the practical significance has been widely noted. By courtesy of the Director of the Atomic Energy Research Establishment at Harwell a variety of materials of technological interest to the paint industry have been irradiated. The products have proved of considerable interest and it is proposed to provide facilities at the Paint Research Station to continue such experiments using a cobalt source.

Studies of the behaviour of drying oils, the autoxidation and polymerization processes, the formation of films or of gels, as in linoleum manufacture, have now reached a stage where the nature of many of the reactions involved is reasonably clear. It is now possible to estimate the influence of pigments on these reactions notably on the rate and nature of film formation in relation to the physical properties of the films produced and their ultimate breakdown.

The utilization of various other media components, including the bitumens, has continued to receive attention and a close study has been made of the wide varieties of rosin now available from many parts of the world.

PIGMENTS

Rosin is an ingredient of some organic pigments, for it confers brilliance of colour, though at the cost of some tendency to oxidation during drying of such pigments, which under certain circumstances may lead to firing of the material. Investigations into this firing danger have been continued and extended to include the effect of the type of rosin on colour, bronzing and tinting strength of appropriate pigments.

On the inorganic side the study of mixed crystal systems involving lead chromate, notably lead sulphate/lead chromate, has been continued using X-ray diffraction to establish the structure of the products in relation to their pigmentary value. Some generalizations have been made concerning the ionic volume relationships necessary for mixed crystal formation and their influence in determining whether the resultant mixed crystals shall be tetragonal, orthorhombic or monoclinic. In this connexion the unstable orthorhombic crystal form of lead chromate has been isolated and examined.

Many pigments are precipitated products. Colour and pigmentary properties may in some cases be related fairly simply to particle size distribution and particle shape, but much fundamental work needs to be done on the development of crystal form and habit from the primary precipitation nuclei. Some time ago certain iron oxide pigments were examined in this way at the Research Station and recently the lead chromates have received much attention.

The established anti-corrosive functions of tannins for iron and steel surfaces have been further explored by the laboratory preparation and examination of various iron tannate compositions as pigments, and the direct use of tannin washes as pretreatments for steel before painting.

PAINTS

In the essential act of paint making, namely the incorporation of pigments into media, interfacial relationships are the dominant and directive feature. Thus the physical and chemical surface character of pigments is all-important and various adsorption and related techniques have been employed in studies of wetting and dispersion. Surface active agents which hitherto have had relatively small interest for paint manufacturers (for many paint media of themselves have high wetting propensity) have now become more important with the development of the new emulsion paint techniques. Their action on various types of pigments has been included in recent studies.

As in previous years a considerable proportion of the work of the Research Station is devoted to systematic studies of the chemical and physical changes occurring during the manufacture, storage, application and weathering of a wide range of types of paints. Particular attention is now being paid, at the instigation of the Ministry of Supply, to the mechanism of adhesion of paint films to their substrates, and the physical and chemical factors involved. It is certain that a high level of adhesion enhances the general

performance of paint films beyond mere maintenance of attachment to the surface painted.

A wide range of different research methods and tools has been developed at the Research Station over the years which will be reflected ultimately in the production of more durable paints, and certainly in the development of improved testing methods. In obtaining the maximum value from a varied and extensive programme, however, considerable care must be exercised in planning the work and in integrating the results into a considered whole. To this end and in order to obtain a compact body of information about a carefully selected range of materials, nine paints of widely used types have been selected for intensive study of the physical and chemical changes occurring after application, using a variety of research tools. Observations have been made on oxygen uptake by the drying films, solubility of the dried films in organic solvents, elastic moduli by velocity of sound measurements, other mechanical properties, water absorption at intervals during weathering, etc.

ANALYTICAL TECHNIQUES

The varied research activities demand adequate service from those departments providing infra-red and ultra-violet spectroscopy, electron microscopy, electron diffraction and X-ray analysis, colour characterization, particle size and surface area data and other analytical information. In addition, the industry is increasingly concerned to have up to date information on investigation methods.

Microchemical methods have continued to prove of value, and newer analytical techniques adapted to the special requirements and demands have included the use of ion-exchange resins and various forms of chromatography.

LIAISON AND PUBLICATIONS

The feeding of scientific knowledge into industry, leading to the improvement of industrial practice, is an operation of major importance. Of the various methods used, greatest satisfaction is achieved through personal contacts. The more senior members of the staff visit member firms, promote technical discussions and give lectures in appropriate places. There must be a limit to the time they can spare from the laboratories, but there is little doubt that the quality of presentation of the work to members, both written and verbal, has been greatly enhanced by such visits. Moreover, it is a question not only of describing the work of the Research Station, but also of presenting it in the setting of the broad knowledge of modern technology.

It is also noteworthy that visits of members to the Research Station have concurrently increased and become more concentrated in their intent.

Further, the Subject Panel committee procedure whereby representatives of member firms participate intimately in the work of the Research Station continues to broaden and to form a nucleus of personal contacts of increasing importance. The Director and members of the staff serve on numerous committees, give lectures, and participate in conferences in this country and abroad.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st July, 1951, to 30th June, 1956, a block grant of £15 000 per annum is made provided £30 000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £15 000.

The income of the Association for the last completed year was £62 763.

THE BRITISH PAPER AND BOARD INDUSTRY RESEARCH ASSOCIATION

The potential field for scientific and technological investigation into subjects of interest to the paper and board industry of the United Kingdom is extremely wide. Further, the industry is made up of organizations at widely different stages of technical development. It is clearly impossible to cover at any one time the whole range and therefore subjects under investigation are most carefully selected to cover the greatest possible field of interest generally, rather than to be of specific interest only to particular sections. The researches in progress cover fundamental studies of fibre characteristics from both physical and chemical aspects; the improvement of paper and board used in packaging by treatment to minimize the mould growth in packages; the effect of varying quantities of clay loading on the printability of the finished paper; methods of pulping imported raw materials; the mechanics of water removal from the suspension of fibres used for the production of the sheet of paper and board; methods of minimizing the polluting character of effluents discharged from mills pulping raw materials in the United Kingdom; a study of proprietary instruments designed to measure and record the moisture content of paper and board at the finishing end of the paper machine; and also an investigation into problems of production which are outside the scope of the normal mill laboratory.

In addition, the Association provides an information service to members and endeavours to get research results applied in the industry through visits of the research staff to member firms. As a further step the Association instituted during the year an *Information Bulletin* to supplement its normal technical reports. This bulletin is written in a less technical manner than the usual research report in order to stimulate the interest of laymen in the practical application of scientific and technological knowledge.

Another part of the service to members is the elucidation of their individual problems on request where these problems are outside the scope and capacity of the normal mill laboratory and its staff. An example of the value of such service is the investigation of odour in packages as described later.

Yet another feature of the service work is the facilitating of mill testing methods. An example of this is the work the Association has done in developing a rapid method for the determination on the paper or board machine of the consistency of stock being processed. It may seem that such work is of little direct value to an industry but in fact, rapid testing methods, which provide the operative with an immediate means of determining the conditions applying at a given moment without recourse to the use of a detailed laboratory analysis, are a keystone of modern industry. The following paragraphs deal with one or two selected items of general interest under investigation which emphasize the value of the work of the Association's centralized laboratories.

MILL STUDY OF MOISTURE METERS

Although the process for the production of paper is automatically controlled at the stock preparation end and the actual paper machine has a modern speed regulation system, the moisture content of the finished product varies over a relatively wide range. It is therefore essential that some record and control of this moisture is exercised, otherwise difficulties are experienced in printing due to lack of register or cockling of the sheet. These difficulties arise from the fact that paper either expands or contracts depending on whether it contains a greater or less amount of water.

There are a number of proprietary instruments on the market for measuring the moisture content at the reel continuously and there is a great need for reliable instruments. The Association has examined some seven moisture meters of both British and foreign manufacture. These instruments operate on different principles, e.g. some measure the electrical resistance of the paper and interpret it in terms of moisture, whilst others measure electrical capacity which varies with moisture content, and yet others relate the relative humidity above the sheet to the moisture in the sheet. The instruments are installed according to the manufacturers' instructions and their recorded behaviour is compared against the actual moisture content of the sheet as determined by oven drying. The investigation is carried out at a board mill and the instruments have been run in parallel for many months so as to determine not only their effectiveness as instruments but the suitability of their construction to withstand mill conditions. The results are analysed using statistical techniques, but the conclusions are set out in plain language in a report in such a way that a mill manager can decide the best moisture meter for his particular purpose. The work is being extended to trials on paper machines in contradistinction to board machines, and in this way the industry is being provided, economically and efficiently, with an assessment of the value of proprietary moisture meters in production.

CONTAMINATION OF PACKAGES

This is a problem which faces not only the printing and packaging industry but also the paper and board maker. It is obviously possible for taints to cause spoilage in foodstuffs through the inclusion of various substances in the paper or board as manufactured. Research is in progress to determine how to prevent the ingress of foreign bodies which give rise to these undesirable odours. Paper and board alone are seldom used in packaging, but are probably printed and varnished and may even be laminated and glued. There are, therefore, many potential sources of contamination. The Association has studied odour contamination and in some cases has found that the odour is due to residues in the actual pulp used for making the paper. In other cases paper flour bags were found to acquire a strong rancid smell due to considerable bacterial decomposition of the starch based adhesive used in their manufacture. In other instances, coated paper has been found to smell strongly of casein or pine oil used in manufacture as a foam preventative. The industry has been advised of methods of overcoming these difficulties which have proved quite successful.

The work on mould proofing of cardboard for non-food packaging has been continued and laboratory work has resulted in full scale trials being made with certain fungicides. These trials have proved extremely successful and the indications are that by the addition of relatively small amounts of fungicides to non-food cartons, e.g. soap cartons, spoilage of the package by mould attack can be virtually eliminated, with consequent economic advantages.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st October, 1952 to 30th September, 1957 a block grant of £10 000 per annum is made provided £30 000 of grant-earning income is received from industry, and an additional grant of £75 for each additional £100 contributed by industry up to a maximum additional grant of £12 000.

The income of the Association for the last completed year was £70 269.

THE PRINTING, PACKAGING AND ALLIED TRADES RESEARCH ASSOCIATION

During the year work has continued on a number of different research projects aimed at improving the quality of production in the printing and packaging industries. On the information side, members have made increasing use of the facilities available, both technical enquiries and library loans having shown a marked rise on last year's figures. These facts indicate that the Association is playing an important part in helping to improve efficiency in the industries served.

Printing research projects have been concerned with reducing the time taken to prepare a machine for printing (make-ready); plastic printing plates; the effects of emulsification in lithography; improving the quality and faithfulness of tone reproduction; behaviour of inks and ink-misting; ink drying; colour control on the press; work on ways and means of measuring the wear-resistance of bookcloths, unsewn binding and preventing mould attack.

In the packaging field, activities have been concerned with the strength of containers; cushioning materials; moistureproofness of packaging materials; adhesives; mould attack; cutting and creasing; and transparent wrapping materials.

PRINTING RESEARCH

Letterpress

The Association's work in the letterpress field has been mainly concerned with finding out what happens at the moment of impression between paper and type, since this has an obvious bearing on make-ready—one of the letterpress printer's major problems. Make-ready is the cause of much non-productive time in the printing industry. Linked with this work is an investigation into the efficiency of plastic plates; during the year trial runs of up to 80 000 impressions have been made on plastic plates developed and tested at PATRA. These trial runs have confirmed that type matter of good quality can be successfully printed without make-ready.

Lithography

Much of the year's work on lithography has been concerned with an investigation into the effect of moisture on the quality of the final print. Research has shown that a most important factor in deterioration of the print in lithographic printing is the presence of water droplets left on the inked image areas by the dampers. Other lithographic researches have been concerned with bi-metallic plates and desensitizers. Trade suppliers have reported keen interest in the products of PATRA research, which include *PATRALAC* (a new deep-etch lacquer), *PATRACOL 90* (a solvent which overcomes certain defects in plate-making) and the PATRA Wash-Up Solvents with their companion plastic squeeze bottles.

Photo-Mechanical Processes

In an attempt to see whether better quality tone reproduction can be achieved for photo-engraving and photo-lithography, new magenta contact screens from the U.S.A. have been tested in the laboratories. Results show that in semi-skilled hands, or in the rush of normal commercial conditions, contact screens give good results more consistently than the more generally used cross-line screens. Investigations are proceeding into the industrial applications of the new screens.

Inks

Work on printing inks has been undertaken on two main lines—the behaviour of inks on a press and ink drying. Investigations on the behaviour of inks have been concerned principally with the development of a new-type apparatus to measure the "tack" of printing inks and a precision model of an ink distribution system. With these instruments it is hoped to examine some of the current problems which printers experience with inks. Another aspect of the work has been concerned with further tests to try to minimize ink-misting—a source of considerable worry to printers, particularly those using large rotary presses.

Correct ink drying is a very important factor in the printing industry since in many instances it determines the success or otherwise of a job. Problems concerned with non-drying are among the most numerous of the day-to-day enquiries received at PATRA and work during the year has centred on the two main aspects—drying by oxidation and drying by absorption. In the former, tests have shown that acidity in the paper is the main deterrent; whilst in the latter, research on an apparatus for recording photographically the rate at which ink and varnish penetrate paper has shown that drying is affected not only by the characteristics of the paper but also by speed of application and pressure.

Colour Control

This new project, begun last year to examine the possibility of controlling colour variations electronically, has led to the development of a prototype apparatus for warning machine minders when colour changes occur on the printing run. Measurements of colour made with an optical head mounted on a printing press are taken on the printed area itself or on a margin which is subsequently trimmed off.

Bookbinding

In considering the problem of measuring the wear-resistance of bookcloths, two new wear tests for bookcloths have been examined—a flex-abrasion machine and an impactive abrasion instrument. These have been developed with the object of allowing bookbinders to choose a covering material for a particular type of book and be sure that it will have the required wearing qualities.

PACKAGING RESEARCH

Strength of Containers

One of the most important features of the year's work has been the development of an apparatus for measuring the cushioning properties of packaging materials—properties which have an obvious bearing on the cost and serviceability of packages. Development of the PATRA Shock Recorder, which aroused considerable interest when it was introduced two years ago, has been taken a stage further. A multiple version of the recorder has been designed, with which it is hoped to record the height, direction and time of the drops received by a case.

Moistureproofness of Packaging Materials

The methods previously developed for assessing the moisture vapour resistance of a complete package have been used to investigate the effect of bulk storage and overwrapping on the "shelf-life" of two typical perishable products—cigarettes and biscuits. It was found that the "shelf-life" of an unwrapped packet of 20 cigarettes was about tripled by wrapping

in moistureproof cellulose film, and that when 30 half-pound packets of biscuits were bulked together their "shelf-life" was increased between 1½ and 3 times.

Mould Attack

Laboratory experiments concerned with the problem of preventing mould growth on packages have resulted in a test for measuring the degree of infection of cartons by moulds and also for assessing the effectiveness of fungicides.

Cutting and Creasing

Progress has been made with this research project, which was started last year with the aim of improving the strength of a container at the crease by modified methods of cutting and creasing. An apparatus for measuring the size of cartons and the shape and size of creases—important factors determining the efficiency of a carton—has been developed.

INFORMATION

During the year an effort has been made to get research results applied in industry and to encourage firms to use the services which are available to them. A travelling exhibition, high-lighting various aspects of the Association's activities in the printing field, has been taken to many industrial centres, including Middlesbrough, Sunderland, Norwich, Ipswich, Edinburgh and Glasgow. These exhibitions, which were supported by conferences, were attended by well over a thousand people, both employers and employees.

Although exhibitions and publications all help to "get the story over", personal contact is more effective. In the year two Liaison Officers were appointed, following the granting of Conditional Aid funds. Their task is to visit members and discuss with them their technical problems, and to explain the services which the Association can offer.

Similarly, on the packaging side, visits are being made to members so that their day-to-day problems may be discussed and first-hand advice be given.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st April, 1953, to 31st March, 1956, a block grant of £16 000 per annum is made provided £40 000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £16 000.

The income of the Association for the last completed year was £82 508.

PRODUCTION ENGINEERING RESEARCH ASSOCIATION OF GREAT BRITAIN

The Association has continued to develop its means of encouraging the application of information by industry. Assistance in this work was provided in the form of a special grant under the Conditional Aid programme for the purpose of equipping and operating a mobile demonstration and film unit. This unit made its first public appearance at the Production Exhibition, Olympia, in July, 1954, and attracted considerable attention.

About a thousand visitors from industry attended the Open Days held during the year and, partly as a result of this, increasing use has been made

of PERA services, and new members continue to be enrolled. The training schemes and other educational activities run by the Association continue to be well attended.

Through factors outside the control of the Association, the erection of the proposed new research buildings has been delayed, but a start should be made in the near future.

METAL FORMING INVESTIGATIONS

An investigation into the relationship between area of shear and punch load when blanking various non-ferrous and ferrous materials has been completed[1].

Work has also been completed on the study of conditions required to produce a highly polished and burr free finish on the sheared edge when blanking aluminium and copper[2]. Results already applied in industry have resulted in considerable economies arising from the elimination of additional machining and finishing operations on blanked components. Tests are continuing on the blanking of brass and mild steel.

An investigation on the life of thread rolling dies when rolling screw threads in high tensile materials has recently begun.

Tests are in progress to compare the efficiency of different types of lubricant when deep drawing brass and aluminium alloy, and further progress was made in an investigation to study the effects of punch and die radius on the efficiency of deep drawing operations.

Work has started on a comparison of the life of punches manufactured from various grades of tool steel and cemented carbide when punching holes in mild steel, stainless steel, and electrical lamination steel.

A report has been issued under the title *Impact Extrusion of Copper* giving information on the relationship between wall thickness, base thickness, slug thickness, slug temperature and extrusion load. Tests are continuing into factors affecting the cold extrusion of steel. The results of the work on extrusion have already been applied in industry resulting in substantial savings in time and raw material.

Research into methods of dry cleaning hot rolled ferrous rod prior to wire drawing has been completed[5].

MACHINE TOOL INVESTIGATIONS

A general research into cylindrical grinding machines has been completed. As in previous researches of this type the aim is to indicate where immediate improvements in design and operational efficiency may be made and to provide data for specialized researches into machine tool elements. Arising out of an earlier general research, a report *Notes on Design and Use of Horizontal Milling Machines* will shortly be issued.

A field investigation into the effect of age and condition on the performance of centre lathes has been commenced. It is hoped that this investigation will provide useful information relating to machine tool usage and maintenance.

Good progress has been made in a research into the performance of rolling bearings used in machine tool spindles. The results demonstrate the significance of rolling element errors in relation to workpiece surface finish.

Tests are continuing in a research to determine the relative merits of different surface finishes, materials and lubricants for machine tool slideways. Important differences in frictional behaviour have been found between scraped and ground combinations of surfaces.

METAL CUTTING INVESTIGATIONS

The results of work[6] on cutting fluids show that there are applications where oil-less water-based fluids containing corrosion inhibitors compare favourably with soluble oil emulsions.

Tests to determine the effects of rake and flute area on tap life when tapping low carbon steel were completed. Further work including metallurgical studies to ascertain factors influencing tap failure has been continued. Results indicate that marked improvements in tap life can be obtained when tap shape and metallurgical condition are controlled.

Interim recommendations for grinding high speed steel, cast alloy and carbide tools have been issued[7]. A further investigation to determine the effect of the method of grinding on the performance of carbide tools will assist industry to select the most economic techniques.

Investigations concerned with cutting fluid applications and other factors relating to grinding efficiency have been continued.

Tests to determine the effect of point angle and relief angle on drill life when drilling cast iron have been completed and it has been shown that unconventional point shapes may give marked improvements in drill life. A research to establish cutting conditions for drilling small holes has been continued. A report entitled *Drilling Titanium Alloy Ti 150A* has been issued. The results of the investigation provide a guide to the machining characteristics of this new material and will assist in selecting cutting conditions and drill point shape.

An investigation concerned with cutting conditions for reaming is nearing completion. The results will assist in producing accurate reamed holes in low carbon steel to specified surface finishes.

Further progress has been made with an investigation to compare carbon dioxide as a metal cutting coolant with conventional cutting fluid applications.

MISCELLANEOUS INVESTIGATIONS

An investigation to determine whether the plastic replica method of surface finish evaluation is practicable for workshop purposes has continued.

Further progress was made with an operation research into the de-burring of machined components. The encouraging reception of this work indicates that industry can benefit greatly from this much needed information.

Further investigations into machine tool vibration problems have been carried out at the request of various members. In addition to the immediate assistance rendered to the firms concerned, these investigations have provided valuable data for use as a basis in more fundamental vibration researches at PERA.

A number of miscellaneous investigations into the accuracy and alignment of machine tools have also been carried out on behalf of members, as well as short-term practical investigations to assist in solving various machining problems,

INFORMATION SERVICES

The technical enquiry service is being increasingly used, not only by small and medium sized firms, but also by the larger firms which, although well equipped with technical staff in their own factories, continue to find that the most efficient way to locate information on new developments and special techniques is to contact the Association. Over 1700 requests for information and advice were received during the past twelve months, an increase of 500 over the previous year.

A heavy demand continues for copies of the monthly PERA *Bulletin* which contains about 500 abstracts per month and is circulated to over 10 000 personnel in industry.

Besides the documents mentioned in the text the reports issued to members included:—

(1) *Blanking and Piercing—Part II*
(2) *Finish Blanking of Aluminium and Copper*
(3) *Thread Rolling-Blank Diameters for Unified Screw Threads*
(4) *Lubricants for Deep Drawing Mild Steel and Nimonic '75'*
(5) *Mechanical Descaling of Wire*
(6) *Experimental Cutting Fluids*
(7) *Effect of Tool Surface Finish on Tool Life and Workpiece Surface Finish when Turning Various Materials*
(8) *Hi-jet System of Cutting Oil Application*
(9) *Dressing of Wheels for Cylindrical Grinding*
(10) *Prevention of Burrs*
(11) *Vapour Blasting*

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1952 to 31st December, 1953 a block grant of £40 000 per annum was made provided £50 000 of grant-earning income was received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £40 000.

For the period 1st January, 1954 to 31st December, 1956 the block grant is £60 000 per annum, provided £90 000 is received from industry, and the additional grant £100 for each additional £100 contributed by industry up to a maximum of £60 000.

The income of the Association for the last completed year was £119 887.

BRITISH RAYON RESEARCH ASSOCIATION

During the year the greater part of the plant and staff has been transferred to new premises at Heald Green, Wythenshawe, Manchester, although the old premises at Barton are being retained to house some sections of the technological work.

CHEMICAL STRUCTURE AND PROPERTIES OF FIBRES

The work on degradation of carbohydrates and oxycelluloses should lead to a real understanding of the tendering of rayons during washing. It has been shown how the structures of celluloses may be ascertained from the constitutions of their degradation products. As a side-issue, a convenient preparation of 2-deoxyribose from laminarin has been worked out and patented, and attempts are being made to get this substance from other vegetable sources.

In the determination of cellulose structure by hydrolytic methods, the quantity of accessible material can be found, but it is not yet possible to specify its nature. Experiments are being carried out to establish whether the slow degradation of cotton hydrocellulose occurs on the surfaces or at the ends of the micelles. The problem of ascertaining the relationship of

the pentoses in wood to the alpha-cellulose content is being examined by fractionation techniques.

The research on photo-oxidation has been extended to glycols, ethers and simple glucosides. It is hoped to arrive at an understanding of the mechanism of the photo-tendering of cellulose and a means of preventing the reaction. Flash photolysis methods are being used to examine the nature of excited dye molecules which may act as photo-sensitizers. The mechanism of the photo-oxidation of alcohol, sensitized by anthraquinone derivatives, has been worked out and a paper published in the *Proceedings of the Royal Society*. A start has been made on examining the photo-oxidation of cellulose itself.

Further data have been obtained for the absorption ratios of a large number of dyes on never-dry and reswollen viscose model filaments. It is hoped ultimately to derive a general picture of the structure of cellulose from dyeing experiments. The thermo-dynamic study of the adsorption of non-ionic dyes from aqueous media by cellulose secondary and tri-acetate has been continued and heats of association have been computed as a measure of the bond strength between dye and substrate. The values for any one dye on the two types of acetate do not differ significantly and it has been concluded that the most important properties of the dyes are their polarity and polarizability, the ability to form hydrogen bonds being relatively insignificant in governing their dyeing behaviour.

PHYSICAL STRUCTURE AND PROPERTIES OF FIBRES

It has been confirmed that the simple Amonton law does not apply to inter-fibre friction, but that the modified equation $F=\alpha R^n$ is generally applicable (F=frictional force at slip, R=normal reaction, α and n are constants). Methods have been developed for determining optically the size of the Hertz area of contact for a curved model filament pressed against a glass plate. Microscopic examinations of the surfaces of nylon in various forms have been made, and measurements of the effects of temperature and humidity changes on the torsion modulus of nylon have been nearly completed. The work on static electrification has shown that the charge and indentation of a polymer put temporarily into contact with a metal sphere are related by a simple power law, although impurities in the polymer may influence the sign of the charge.

The study of the photo-elastic behaviour of polymers is based on the concept of chains of randomly-jointed links, to which the real molecular structure is assumed to be statistically equivalent. The relation between the number of monomer units in the polymer molecule and the number of random links in the equivalent statistical chain has been calculated empirically for rubber, gutta-percha and polythene from the stress-optical coefficients and bond polarizabilities. The length of random link from rubber to polythene increases very rapidly, and may be taken as an indication of increasing chain stiffness.

Infra-red spectroscopy has been used to distinguish the crystalline modifications I, II and III of cellulose, and for examining cellulose from " resting cells ". Work with molecular models has shown that hydrogen bonding between layers of cellulose I chains is improbable. Crystallinity determinations are being made from infra-red spectra.

Refractive index measurements on viscose model filaments have been continued. It is now thought that decrease of density towards the fibre axis is caused by the presence of sub-microscopic pores formed during regeneration of the cellulose.

It has been shown that satisfactory electron diffraction patterns cannot be obtained by examining fibres in reflection. Preparation of thin sections is therefore essential for transmission experiments and a Sjöstrand microtome has been installed for this purpose.

Crystallinity and structure determinations on cellulose and cellulose acetate have been continued by X-rays. Refinements of technique have shown that bacterial cellulose has a higher crystallinity than has been hitherto accepted.

TECHNOLOGICAL RESEARCH

Staple Spinning

A complete range of cotton machinery has been installed and work has started on the blended yarn programme, to determine the best point at which to blend and the limits within which it is necessary to work if trouble is to be avoided at a later stage. Practical methods of control and test are being developed.

The causes of yarn irregularity are being systematically investigated. To aid in the work two types of instrument have been developed for the purpose of detecting periodicity in the presence of random variation in yarn weight. Instruments have also been devised to measure and record roller slip and roller vibration.

The Stains direct tow-to-yarn spinner is in operation and the properties of its yarns are being investigated.

Machinery for work on woollen blends is on order and will be delivered early in 1955.

Crepeing, Processing and Sizing

The necessary machinery has been installed to carry out cone winding, uptwisting, cabling, beaming, sizing and warping. The machines are being used to implement the blended yarn programme and to prepare materials for weaving and warp knitting.

Methods have been evolved to measure the physical properties of yarn in packages of all types and the stresses and strains to which it is subject, with a view to determining the best winding and storage conditions and developing correct mandrel and package design.

Weaving

The best British, Continental and American rayon looms have been installed, together with a number of woollen and worsted looms. Weaving trials are being carried out on automatic looms both on the Association's premises and under survey conditions in the mills. The running efficiency and the time taken to carry out standard operations are being measured over a range of fabrics.

A weaving laboratory has been equipped to study weaving faults such as thick and thin places, repping, cannage, and bright picks. Instruments have been devised to detect faults and to enable looms to be set so as to avoid them. Considerable evidence has been accumulated on the importance of accurate loom timing.

Knitting

A 28-gauge warp knitting machine has been installed. The programme of work includes the study of machine settings in relation to fabric faults. Particular attention is being paid to stopping marks and their relation to yarn types and fabric construction.

Dyeing, Printing and Finishing

A range of full-scale dyeing and finishing machinery is now installed and work has started on the blended yarn programme.

Fugitive tints have been developed employing dye-casein complexes in solutions of inorganic salts. The tints are neutral, non-migratory, and do not become fixed even under severe heat treatments. The tints are to be manufactured and sold by a firm operating under licence to the Association.

As outlined in last year's report (p. 212), the causes of weathering have been elucidated and the work is now being followed up by a detailed study of cloth storage and transport conditions, with a view to discovering at what stage weathering occurs in practice. Methods of curing suspected weathering have been tried, but a completely acceptable solution has not yet been found.

Work is being carried out on the drying of cakes and packages using novel techniques. At present wet patches due to uneven drying tend to cause yarn faults, hence some managements over-dry and then recondition. Special methods of hygrometry have been devised to allow the measurement of the water content of packages at specific points inside them.

PRODUCTIVITY AND ECONOMICS

In collaboration with the British Man-Made Fibres Federation a survey has been completed on the relative costs of producing a series of standard cloths on automatic and non-automatic looms. The conclusions for spun fabrics appear to be that automatic looms produce better quality cloth and that, quality for quality, they are cheaper to run. The work is continuing and a survey on filament yarn fabrics is now being carried out.

An investigation has been made into the effect of increasing the package size on the cost of weaving on non-automatic looms. It has been shown theoretically that a comparatively small increase in the size of the weft package would make non-automatic looms competitive with automatic looms.

The productivity section is collecting data which will enable an assessment to be made of the relative efficiency of different types of loom on specific cloths, in spite of the variation due to the yarn, the size, the weaver, etc.

MACHINERY DEVELOPMENT

Work on the Barton tow-to-top machine has continued in co-operation with the research organization of an important group of textile machinery manufacturers and a number of experimental machines have been built.

A long staple roller draw frame has been constructed and shows promise in processing 6-in. staple. An improvement has been made to the cotton draw frame which has greatly improved the regularity of the sliver produced.

A small open-width drier has been constructed on entirely novel lines and successfully tested. It gives a heat utilization of approximately 90 per cent. A prototype machine to handle full-width fabric is being designed.

LIAISON WITH MEMBERS

The work on oil stains discussed in the previous report (p. 213) has continued. Investigations have involved the examination of the mill processes and machinery, and of both loom-state and finished cloth. It has been found that in one mill 75 per cent of the stains were the result of shuttle projection.

Improvements in mill discipline reduced the incidence of irremovable stains to 5 per cent. Various modifications, for instance to the picking spindle, are being tried out with a view to reducing the trouble still further.

High-speed beaming of spun rayon warps has been under survey in two mills. It was found that low efficiencies were due to irregular yarn, faulty cone winding, and lack of care in creeling. As a result of the survey, recommendations have been made which increased the mill beaming efficiency from 30 per cent to 50 per cent.

Enquiries reaching the member service department have doubled during the last six months. In addition to this service, which consists largely of reports on faults in samples of cloth submitted and suggestions for their elimination, a considerable number of investigations in mills have been undertaken at the request of members faced with special problems.

A comprehensive report on the nature of the faults occurring in fabric submitted to the Association for examination over the past three years, has been prepared and is being used as a basis for further experimental work.

A survey has been carried out amongst the garment makers to determine which fabric faults are most likely to cause trouble to this branch of the industry.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st July, 1951 to 30th June, 1956 a block grant of £50 000 per annum is made provided £140 000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £40 000.

The income of the Association for the last completed year was £297 743.

THE RESEARCH ASSOCIATION OF BRITISH RUBBER MANUFACTURERS

During the past year the Association has completed the removal of its laboratories and headquarters from Croydon to Shawbury, near Shrewsbury, and is now enjoying the benefits of much improved facilities. Although recruitment of research staff to replace those who did not move to Shawbury has proved slow, and some vacancies still have to be filled, a good output of both fundamental and applied research has been maintained.

The programme of research, drawn up in consultation with organizations representing the various sections of the industry, has covered broadly the same topics as in recent years, but with one important addition—operational research on factory processes. Another new activity aimed at informing industry more effectively of the Association's work, is the preparation of technical manuals on subjects that have been studied extensively.

Fundamental studies on flow characteristics, which are important in the factory processing of rubber, have continued with special reference to the high rates of deformation that occur in these processes, and unexpected features have been found which may explain the behaviour of rubber during extrusion through a die ; this work is being supplemented by an extra-mural research at Manchester College of Technology on high-speed flow. Other basic investigations include the mechanism of the reinforcement of vulcanized rubber by fine-particle fillers such as carbon black, the dynamic behaviour

of vulcanized rubber under the conditions met with in engineering uses, and the causes and prevention of oxidative deterioration (ageing); important results have been achieved, some of which are indicated in more detail below. The studies on dynamic behaviour have been summarized in a paper presented at the Third Rubber Technology Conference, London, June, 1954 (Preprint No. 59).

Work of a more directly practical nature has been concerned with improving the adhesion of rubber to synthetic textiles (essential components of many rubber articles); with the properties of mixtures of natural rubber and synthetic polymers, for use as non-flam compositions or for shoe soling; with studies of raw materials, especially new types of natural and synthetic rubbers and the various grades of whiting produced from indigenous chalk deposits; and with improvement of testing apparatus and procedures. In all these subjects, progress has been made and information given to members; recent work on the rubber textile adhesion problem was reported to the Rubber Technology Conference (Preprint No. 31).

The advisory and information services, based on the Association's own research experience and its extensive library, have been maintained and continue to be a valuable aid to member firms.

REINFORCEMENT

The research on the mechanism of reinforcement was started some years ago at the request of the Committee on Industrial Productivity of the Advisory Council on Scientific Policy. At that time the United Kingdom depended on imports of carbon black, the only satisfactory reinforcing agent for such severely stressed articles as vehicle tyres. Although reinforcing carbon black is now made in this country, we are still heavily dependent on this one material, and the development of alternatives would therefore be a valuable achievement, both technically and strategically. As indicated in previous Reports, the Association began by studying what happens at the interface between the rubber matrix and the embedded filler particle, and showed that to achieve reinforcement there must be very strong bonds (e.g. chemical linkages) between rubber and filler. Moreover, the surface of a carbon black particle is not uniform, only a small part being capable of forming the requisite strong bonds. A more recent development of the theory arises from the observation that when raw rubber is masticated by working on rollers, the thread-like molecules break, leaving highly reactive broken ends. When rubber and carbon black are mixed by working on rollers, these broken ends probably attach themselves to the "active" areas on the carbon particles, thus producing the reinforcing effect. This explains why true reinforcement is never observed in mixtures made without vigorous mechanical working.

Through these researches and parallel work in other laboratories, an explanation of the phenomenon of reinforcement that has so long baffled rubber scientists is now within sight. In this development the Association has played an important part, especially by first propounding the view that it is the attachment of broken rubber molecules to filler particles that produces reinforcement.

OXIDATION AND AGEING

The fundamental investigations on deterioration or ageing of vulcanized rubber by atmospheric oxidation have dealt particularly with the powerful effect of traces of certain metals, notably copper, in aggravating this deterioration, and also with the action of "sequestering agents" intended to render

these metals harmless. These harmful metals or "poisons" are particularly troublesome in rubber-proofed fabrics for mackintoshes which are a major product of the industry, and any means of reducing the liability to deterioration would be an important advance.

From the Association's work a picture of the complex chemical reactions involved in oxidation and its prevention is gradually being built up. An important recent discovery is that a sequestering agent may render, say, copper harmless but make some other trace metal, such as iron, extremely active; a sequestering agent is thus not necessarily a panacea for all ageing troubles. Further, most existing sequestering agents, having been developed for protecting materials other than rubber, do not dissolve in rubber and so cannot effectively protect it. Finally, since copper is most troublesome in so-called "cold-cured" fabrics, in the production of which hydrochloric acid is formed, the agent must be stable to acid. Thus the ideal sequestering agent must be soluble in rubber, must be acid-stable, and must protect against all likely harmful metals—certainly against copper, manganese and iron. The Association's investigations have already led to the synthesis of substances much nearer to this ideal than any hitherto available, and still further improvements can be expected.

WHITING

In collaboration with the Research Council of the British Whiting Federation, an extensive study has been made of the types of whiting and other powdered calcium carbonates made from natural chalk and limestone. As these minerals occur abundantly in the United Kingdom, and the rubber industry uses annually some 25 000 tons of whiting valued at nearly £200 000, it is important to know how its behaviour in rubber depends on such factors as its source (North or South of England chalk), particle fineness, and whether it is wet or dry ground. The results obtained will help the rubber manufacturer to select the type of whiting best suited to his needs, as well as helping to make the best use of an important indigenous material.

The problem of metal "poisons" arises here also, since natural chalk always contains traces of manganese. The possible harmful effects of this metal have been especially sought, both by laboratory tests and by wearing trials on mackintoshes proofed with rubber containing selected whiting samples. So far no signs of harmful effects have appeared, the reason being probably that the manganese is already "sequestered" by occurring in the crystal lattice of the calcium carbonate.

OPERATIONAL RESEARCH

During the past year a start has been made with operational research, or more specifically, productivity surveys of the basic operations of masticating and mixing unvulcanized rubber. These operations were selected because they are common to most rubber factories and represent an annual expenditure of some £3 million in this country alone.

A grant of nearly £3000 has been made from Conditional Aid funds, and this has enabled a start to be made on this research project. There has been a good response from member firms to requests for permission to survey their mill room operations; indeed, some now ask the research team to visit them. It is too early to state any detailed conclusions, since the comparative productivities between one factory with another have not yet been worked out. However, the investigations have already revealed several causes of low productivity, such as excessive time required for cutting

up bales of plantation rubber (often aggravated by their having become misshapen during transit), excessive idling time of machinery, or unnecessarily long mixing times.

There can be no doubt that the results of these surveys, if taken to heart by the factory managements—and some are already taking action—will lead to an overall increase in productive efficiency.

TECHNICAL MANUALS

This project also has been made possible by a grant from Conditional Aid funds. It is intended that manuals shall be written and published on subjects that the Association has studied extensively; they will form a useful means of presenting in summarized and easily assimilable form the results of researches already communicated in numerous technical reports. The four manuals projected will deal with: principles of compounding vulcanized natural and synthetic rubbers; electrically conductive and antistatic rubbers; ebonite; chemical analysis and testing of rubbers and raw materials used in rubber manufacture. The synopses of these manuals have been prepared and the drafting of the text of three of them is well in hand; provisional arrangements for publication have also been made.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1949 to 31st December, 1953 a block grant of £15 000 per annum was made provided £25 000 of grant-earning income was received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £15 000.

For the period 1st January, 1954 to 31st December, 1955 the block grant is £17 000 per annum, provided £30 000 is received from industry, and the additional grant £100 for each additional £100 contributed by industry up to a maximum of £13 000.

For the subsequent three years the terms will be further modified.

The income of the Association for the last completed year was £66 198.

BRITISH SCIENTIFIC INSTRUMENT RESEARCH ASSOCIATION

The programme of research of the Association is mainly concerned with the basis of the techniques, the nature of the processes, and the properties of materials used in the instrument industry, and a very large proportion of the effort during the past year has been directed in these channels. Most research establishments, industrial or otherwise, devote considerable attention to the design of instruments for particular purposes and it has, therefore, been felt that, somewhat paradoxically, the actual design of instruments should not be a major activity of the Instrument Research Association. Nevertheless, in the carrying out of its own particular type of work the Association has developed and designed over the past few years some dozen or so instruments and devices which may well have a wider application. A special exhibition of these, for the benefit of the membership, will take place in the near future. Of the more normal work of the Association, during the past year certain researches which have occupied the attention of the laboratories for some considerable time have been virtually concluded and these are described below. It is impossible in the space available to describe with any adequacy the full range of projects undertaken and these items are selected as examples.

OPTICAL INTERFERENCE FILTERS

The issue of a research report on the characteristics of typical "Fabry-Perot" interference filters, with the latest improvements in the method of construction, has brought to an end the investigation on these narrow-band filters for the visible region of the spectrum. While, in view of a rapidly growing interest in the use of interference beam splitters in colour television systems, the problems of design and deposition of multi-layer films for this purpose are now being investigated in the laboratories, yet a very definite further stage has been reached in the work of the Association on high vacuum evaporation processes. This work has, over the years, introduced into the industry the techniques of the production of metallic reflectors by evaporation, the deposition of anti-reflection films on optical components, the production of beam splitters and transparent reflectors, and, more recently, the deposition of multi-layer filters and reflectors. Most of these techniques are in use throughout industry.

MEASUREMENT OF RELATIVE HUMIDITY

It was indicated a year ago that the work on ceramic humidity-sensitive elements had reached its final stage and a point had been reached at which the design of a commercial hygrometer appeared to be possible. Whilst little work has been carried out on the actual elements during the past year, a considerable number of the elements have been made in the laboratories. The testing and standardization of these elements have brought to light the need for apparatus capable of producing atmospheres of accurately known and controllable humidity. A special apparatus to meet these requirements has been devised and has been described in a research report. It is apparent from the activities of the Information Department that humidity measurements are of great interest to industry generally, and that the pursuit of this subject in the laboratories of the Association is a well worthwhile project, the results of which cannot but have a wide impact in many directions.

METHODS OF OPTICAL COMPUTING

Under the aegis of the Ministry of Supply, a project was inaugurated last year in the Mathematics Department of Manchester University, with the object of determining the part which digital computing machines could play in optical design work. It was not hoped to do more in the first year than to make intimate acquaintance with the ditigal computer at Manchester and its method of working, but, in fact, progress has been exceedingly rapid. A comprehensive scheme of "programming" for the machine has been evolved, appropriate and suitable for work in the optical field, and from the relatively short experience of the working of the machine in this field two interesting results have emerged. In the first place it is apparent that digital computing machines will, in the future, have an important role in the field of optical design. It is clear that, with suitable "programming", optical systems can be computed and the performance of the systems evaluated with extreme rapidity, and, moreover, the testing of optical systems can be carried out more comprehensively than is possible by normal computational methods. In the second place it is apparent that the digital computing machine could be a very important tool in mathematical researches into optical problems, which hitherto have been considered too laborious and complicated to undertake. It is probable that the present project will continue in this research direction.

ELECTRONICS

Three projects have been substantially concluded during the year in the Electronics Department:

General Investigation on d.c. Amplifiers

The fourth, and final, part of the report on " converter type d.c. amplifiers " has been issued, thus concluding a project in which the obtaining of information from the literature has been interspersed with experimentation in the laboratory.

Thickness Gauging

The electromagnetic method of gauging thickness of lead cable sheaths has had its first trial under works conditions. Further work has been carried out following the experience gained at this trial, and a further trial, which it is hoped will be final, will take place in the near future.

Servo-Mechanisms

A photoelectric indexing servo-mechanism has been devised by means of which a work table can be rotated from one desired stationary position to another and located accurately at each in succession. These positions are defined by the combination of a fixed indexing device—employing a single photocell—and a graduated glass circle carried on the rotating body. Locations can be made with extreme accuracy and the development has some importance in the use of optical machine tools in engineering processes.

INFORMATION DEPARTMENT

Whilst the normal activities of the Information Department continue to increase both in volume and in usefulness to the membership, the main item to report is the emergence of a new publication, *Sira Technical News*. This monthly publication is designed to present in the simplest useful form progress reports, digests of full research reports, notes on minor but interesting experimental work, and on new materials and processes. The publication has been exceedingly well received, and each article in each issue has been the subject of diligent enquiries from interested member firms.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st April, 1952 to 31st March, 1955 a block grant of £35 000 per annum is made provided £15 000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £15 000.

For the period 1st April, 1955 to 31st March, 1956 the block grant will be £35 000 per annum, provided £17 500 is received from industry, and the additional grant £100 for each additional £100 contributed by industry up to a maximum of £15 000.

The income of the Association for the last completed year was £69 771.

THE BRITISH SHIPBUILDING RESEARCH ASSOCIATION

The Association is the central research organization of firms in the shipbuilding, ship-repairing and marine engineering industries in the United Kingdom and is concerned with all aspects of ships other than turbines, both steam and gas, and gearing which are dealt with by the sister organization, Pametrada.

In April, 1954, the Association attained the tenth anniversary of its incorporation and it is appropriate, therefore, to review the growth in the magnitude of its efforts. These can well be indicated by reference to expenditure. In its first financial year the Association's expenditure was

under £6000; in the second year the total rose to nearly £40 000; and in the tenth financial year completed on the 31st March, 1954, the total was just over £200 000, which it is expected will be the level at which expenditure will stabilize. As from the 1st April, 1954, revised terms of grant aid applied and the maximum grant that can now be earned is £50 000 per annum as compared with a maximum of £75 000 for the previous quinquennium.

The Council of the Association have recently reviewed the organization and progress of the Association during the period since its incorporation. They are very satisfied with what has been achieved and the manner in which the organization has worked. The object of the Association is to provide shipbuilders and marine engineers with data and information that will enable them to produce better designs. Generally it is not the function of the Association to undertake design or development work. It is, therefore, very difficult to make any financial assessment of the value of research results so far obtained but the Council are certain that the work is greatly appreciated by the members as a vital contribution towards the building of more efficient ships and machinery.

The research programme is too extensive for reference to be made to all the items, but the nature of the work may be judged from the following examples which have already proved of value, and which are listed under the five main sections of the Association.

HYDRODYNAMICS

A comprehensive series of methodical tests, covering both propulsion and resistance, have been carried out in ship model testing tanks on a range of models of ocean-going merchant ship forms. The effects have been determined of changes in such variables as propeller diameter and position of longitudinal centre of buoyancy. These data are of great value to designers as leading to improvements in hulls, propellers and all ship/propeller combinations. The Ship Division of the National Physical Laboratory has carried out for the Association much of the model testing required for this work.

The *Lucy Ashton* trials have provided a vast amount of information over a wide range of subjects. Reliable data have been secured for the first time about the resistance of a full-size ship which can only lead to more reliable predictions of performance based on model tests. In addition results of immediate practical application were secured about the advantages accruing from seam fairing, smoothing of the hull and better qualities of paint.

SHIPS' STRUCTURES

The better knowledge of ships' structures secured from the work of the Association's structures testing establishment at Glengarnock has led to improvements in the construction of the ship and to considerable savings in steel. For example the work has resulted in reductions of scantlings, particularly with regard to the substitution of welding for riveting.

Other structures investigations that have achieved similar effects are the work on masts and derricks, weld tests, and double bottom tests.

SHIPS' MACHINERY

Work on the optimum thickness of boiler tubes produced information of value to Lloyd's Register when amending their Rules to accept thinner tubes.

Investigations into surface finish have led to changes in machine shop practice in a number of firms.

It has been shown that noise is transmitted largely through the ship's structure and is not airborne. In a recent instance it was decided, as a result of this work, not to employ a considerable amount of expensive acoustic lining in the engine room and elsewhere but to adopt other and less expensive methods. The results were completely satisfactory.

Investigations have produced data about ventilation of passenger and crew accommodation and machinery spaces which have already influenced designs in some instances.

SHIPS' PERFORMANCE

The B.S.R.A. code of procedure for the conduct of measured mile trials is now widely adopted for ship acceptance trials.

Assistance has been given in a number of instances of trouble from the descent of funnel smoke on to ships' decks.

VIBRATION

The Association has been able to help members considerably in diagnosing and eliminating instances of vibration troubles on board ships. Advances have been made in the prediction of critical frequencies and allied information.

CURRENT ACTIVITIES

During the past year the Association has proceeded vigorously with work in all sections of the research programme and research reports on many items have been circulated to members. Other work has been published through papers read before technical institutions in the industry. The workshop and laboratory at Sunderland has continued to be used for the development and manufacture of equipment for use on ship trials and as most of these trials are carried out in the shipbuilding areas in Scotland and the North of England the more heavy equipment is maintained and kept at Sunderland.

INTELLIGENCE SECTION

The Intelligence Section has continued to be a most important section of the Association's activities. The monthly *Journal of Abstracts* provides a valuable service to members in keeping them abreast of technical developments in many fields of interest to shipbuilders. The number of enquiries for information from members with problems has continued at a satisfactory level. The special library provides a service to member firms and to the staff of the Association which is complementary to the library services provided by the technical institutions in the industry.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st April, 1949 to 31st March, 1954 a block grant of £50 000 per annum was made provided £100 000 of grant-earning income was received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £25 000.

For the period 1st April, 1954 to 31st March, 1959 the block grant is £40 000 per annum, provided £120 000 is received from industry, and the additional grant £100 for each additional £300 contributed by industry up to a maximum of £10 000.

The income of the Association for the last completed year was £243 909.

COIL SPRING FEDERATION RESEARCH ORGANISATION

During the past year the Organisation has deferred any expansion of the active programme owing to the desirability of conserving resources until new work could be started in a central headquarters. The search for a suitable building or site has been continued, so far without success, but it is hoped that practical progress will become possible within the next twelve months. Meanwhile the current researches have been proceeding at Sheffield, Nottingham and Birmingham Universities, and it is intended to commence additional extramural researches of limited duration in order to fill the gap until a headquarters is available.

In addition to its advisory work, the Research Committee has carried out through its members a great deal of experimental work dealing with the determination of properties, and the preparation of materials specially needed for the researches.

Development work on testing methods has again claimed much attention, especially in connexion with the research on spring steels at Sheffield, and the method of stressing adopted in the research, which is parallel to the stressing of springs and is new in this respect, has now been established so that it can be of continuing value in future researches. For rig testing also, newly modernized equipment is completed and ready for installation. Further equipment is under consideration for fatigue tests on small springs, which are at present necessarily carried out by member firms.

Research on spring steels has revealed much new information relating to the effects of decarburization and oxidation of spring steels. Even very small amounts of decarburization have been found to exert large effects on fatigue behaviour in the absence of surface defects which can act as stress raisers. A very high carbon content is not essential in spring steel. The use of a carburizing treatment together with shot-peening has been shown to have very beneficial effects.

Research on the effects of zinc coatings have produced interesting results of practical importance. The work is being continued by a series of tests on thinner wires to confirm the general indications of the research up to the present stage.

Research on prestressing has indicated that the beneficial effect on static properties is not associated with a similar effect on fatigue behaviour except in some cases where the harmful effects of fine surface cracks appeared to have been reduced by prestressing.

Rig testing has dealt mainly with the effects of design modifications applied to heavy railway springs.

Solutions to design problems relating to spring washers and stranded springs have been investigated.

The preparation of a new specification for brass and corrosion-resistant steel has been completed, and work has continued in co-operation with B.S.I. and other bodies, on specifications for spring wires and the requirements for railway buffer springs and pressure valves.

The *Coil Spring Journal* has continued in regular publication and has included research reports and articles from current literature. Five research reports have been published during the year.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st April, 1952 to 31st March, 1957, a block grant of £5000 per annum is made provided £6000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £5000.

The income of the Organisation for the last completed year was £14 879.

THE BRITISH STEEL CASTINGS RESEARCH ASSOCIATION

The British Steel Castings Research Association was incorporated on the 5th March, 1953, upon which date it had vested in it full responsibility for all co-operative research within the steel-founding industry. This had hitherto been conducted by the Research and Development Division of the British Steel Founders' Association which came into being in October, 1949, and which, by arrangement with the British Iron and Steel Research Association, agreed, early in 1951, to take over responsibility for all commitments that had been entered into up to that date by their Steel Castings Division.

The British Steel Castings Research Association, which has been grant-aided from April, 1954, serves an industry employing some 20 000 operatives with a turnover of £25 000 000 of carbon, low alloy and high alloy steel castings. 74·5 per cent of the industry, in terms of tonnage production, supports the Research Association.

The Association, which has its headquarters and laboratories at Broomgrove Lodge, Sheffield, is to construct, as part of its first five-year programme, a fully-equipped Foundry Experimental Station, the purpose of which is to carry forward the results of its laboratory researches to a stage of practical development, where they can be applied directly on a production basis in members' foundries.

The Association's work ranges, in research and development, from the extremes of shop floor practice to fundamental investigations of a long-term character, and of some 22 projects upon which the Association has been engaged during the period under review, the following are typical.

HOT-TEARING IN STEEL CASTINGS

Hot-tearing, or local rupture of a steel casting while still at elevated temperature, due to interference with contraction by the mould, has been recognized generally as a major production difficulty, and the Association's work upon this problem has been aimed at determining the influence of moulding materials rather than of steel composition upon its incidence in the course of manufacture. During the year under review research has continued, employing test castings of increased weight and section. It had been considered that the greater heat capacity of the larger test castings would effect more rapidly the collapse of the organic bonding agents under test, and thereby reduce the relatively high degree of hot-tearing that was associated with the use of these bonds in the earlier research. This forecast was confirmed, emphasizing the importance of recognizing at all times the influence which dimensional factors can exercise upon phenomena associated with the cooling and contraction of steel in refractory foundry moulds. In consideration of these later findings, in conjunction with the Association's Moulding Materials Panel, it was concluded that prior to increasing still further the weight and section of the type of test casting in order to relate

the results more nearly to normal foundry practice—research better conducted when the Association's Experimental Station facilities become available—an investigation should be conducted to establish the deformation and collapse characteristics of various bonding agents when subjected to rapid heating to high temperatures.

SAND ADHERENCE TO STEEL CASTINGS

The investigation of metal penetration of the mould face and consequent sand "burn-on" in relation to the surface finish of steel castings which has been sponsored by the Association at Cambridge University since 1950, has continued. Definite correlation has been established between the occurrence of metal penetration and both ferrostatic pressure and the degree of compaction of the refractory sand employed in the making of the mould. Simultaneous research has continued into the phenomenon whereby sand adherence to the surface of steel castings takes place without the occurrence of metal penetration into the mould face, and it has been established in the laboratory that such adherence does occur when silica sand is maintained in contact with solid steel in the presence of oxygen, thus paralleling the mechanism of vitreous enamelling. The Association's programme of research relating to the surface finish of steel castings is essentially of a long-term character and has an important bearing both upon productivity, in reducing the time to be taken in dressing steel castings, and in industrial health by limiting the formation of siliceous dust.

ROTARY METAL SAMPLING MACHINE

A machine providing a rapid method of obtaining bath samples of steel in granulated form, and avoiding the necessity for the normal drilling operations, was developed during the year and is being adopted by an increasing number of member firms. Satisfactory development depended upon the assistance of certain members in conducting field trials, and in making comparisons with orthodox sampling procedures. Early difficulties arising from excessive oxidation of the samples were overcome by the use of oxygen-free nitrogen in the casting chamber of the sampling machine. In order to help members assess the usefulness of the device in relation to their own practice and in order to provide a demonstration of the operating procedure, the Association has issued a short instructional film, one of a series that has been prepared for conveying the results of its work to its industrial member firms.

NON-DESTRUCTIVE TESTING

The development of improved and simplified forms of non-destructive testing, and the dissemination within the industry of information to encourage the application of these techniques, has continued to form an important part of the Association's work. During the year a slide-rule calculator has been completed and made available for determining exposure conditions in radiography employing radon and the radioactive isotopes of cobalt and iridium. This exposure calculator, which is also in considerable demand from outside the steel founding industry itself and from abroad, has, as its purpose, the saving of time and the avoidance of errors in the non-destructive testing of steel castings by radiographic means. In response to widespread demand, a later edition of the calculator will incorporate, in addition, the radioisotopes caesium-137 and thulium-170. A comparison has been made of the advantages of dye-penetrant surface flaw detection methods, with the well-established chalk and paraffin test, and with the more recently developed fluorescent penetrant technique, and, arising from this work the Association

has developed a procedure and a dye-penetrant solution of high sensitivity, which can readily be prepared from commercially available materials. Working on the same principle as that of chalk and paraffin, the penetrant dye reveals the surface defects against a white background, and has of course particular application to castings for which any form of magnetic flaw detection is unsuitable. The test, as developed by the Association, has the advantage that the castings do not require immersing in a tank of liquid nor do they necessarily require heating to induce penetration of the detecting dye.

A radiological scanning technique based upon the use of a relatively low intensity radiation source and a scintillation counter, was demonstrated to member firms at an Exhibition of the Association's work, held in York in July, 1954. The technique, which requires further practical development, has important potentialities in relation to the non-destructive examination of certain types of steel casting, particularly those with heavy section and of cylindrical or plate form.

HEALTH HAZARDS FROM DUST

As part of the programme of work in this field, financed through and conducted in conjunction with the Industrial Health Committee of the British Steel Founders' Association, the Research Association's Dust Research Station in Sheffield has studied the dust flow characteristics of swing-frame grinding machines as used in steel foundries, and a device has been developed that provides a simple but effective answer to this dust control problem. The system is such that not only can it be incorporated relatively cheaply into grinding machines of this type, but it can also be fitted to existing equipment without difficulty. The system has attracted widespread interest, not only from H.M. Inspectorate of Factories and the Trade Unions, but also from the manufacturers of grinding machines, who have agreed that the improvement shall be incorporated in new equipment and at the same time made available in the form of "conversion sets" for fitting to existing units, as soon as field trials are completed and design details established. The Association has had in hand during the year the preparation of a film, following the precedent set in relation to its previous work on the stand grinder dust suppression problem, recording the development of the swing frame grinder dust control system and demonstrating it in action under varying operating conditions.

A form of "air feed mask" to provide protection from airborne dust or other atmospheric contaminants has been developed and tested in the Association's laboratories to a stage at which the formal approval of H.M. Inspectorate of Factories has been sought. The device consists of a transparent mask covering the nose and partially the mouth, an air supply being provided to the mask both for breathing purposes and to produce an air current against the entry of airborne dust to the breathing zone. The usefulness of the mask is enhanced in that it incorporates protective goggles.

During the year, research into the causes of silicosis has continued at Reading University under the supervision of Dr. P. F. Holt, and this has yielded yet further confirmation and support to the theory that the polymerization of silicic acid at critical hydrogen ion concentration is a major factor in the growth of silicotic tissue. The Holt theory, which now appears to be so adequately supported by experimental data, not only provides an explanation as to the mechanism where certain siliceous dusts are dangerous, but also explains why others, notably cement, do not give rise to silicosis. The ultimate importance of this fundamental work, with its bearing upon the

prevention or treatment of silicosis arising in steel foundries, is now a matter for assessment by the Medical Research Council, to which it has been referred.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st April, 1954, to 31st March, 1959, a block grant of £15 000 per annum is made provided £30 000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum grant of £10 000.

THE COAL TAR RESEARCH ASSOCIATION

The research programme of the Association has continued to be based on the needs of its sponsoring industry as formulated and defined by the Research Committee and the Advisory Panels.

There are four main objectives:—to increase knowledge of the physical and chemical nature of coal tar; improvement of plant design, instrumentation and analytical control methods; development of new and improved methods for obtaining commercially useful products from coal tar; maintenance and extension of outlets for pitch and creosote.

CHEMICAL AND PHYSICAL STRUCTURE OF TARS AND PITCHES

Chemical Analysis of Tars and Tar Oils

Coal tar is an extremely complex mixture whose composition is affected by a large number of factors which are unique for any carbonizing plant at any given time. The "fine" chemical structure of each individual sample of tar, therefore, is likely to vary and the chemical analysis of tars cannot be expected to do more than establish the nature and amounts of the major constituents and show the variation in the amounts of these constituents between tars produced by different methods of carbonization, and also the variation which may be expected within any one type of tar.

This information is now available for British high temperature tars following on the completion of the series of assays of representative samples. The results of these assays, including the quantitative estimation of each of the C_6–C_8 aromatic hydrocarbons and the individual phenols will be issued shortly as data sheets for the *Coal Tar Data Book* which was issued to the industry a year ago.

With the increasing shortage of high quality gas-making coal, the pattern of carbonization in Britain is likely to change in future years and tar obtained as a by-product of low temperature carbonization and complete gasification processes will replace, at least partly, the present gas-works vertical retort and horizontal retort tars. To enable the industry to plan for the future such new types of tar are, as they become available, being assayed. Two such tars—derived from complete gasification of West Midlands coal in a Lurgi pressure generator and from a low-temperature carbonization process respectively have been analysed during the past year.

As mentioned in the last Report (p. 225) it was hoped that the assays of high temperature tars would indicate certain correlations between the amounts of the major components in a tar or between the amounts of certain components and the physical characteristics of the tar. Although a number of relationships of this type have been found which hold for most of the

tars assayed, there are invariably exceptions and the original hope that it might be possible to calculate the chemical composition of a tar from its physical properties has proved unduly optimistic. Attention has, therefore, been devoted to developing standardized methods for the estimation of the commercially important components of tars, particularly methods which could be applied in works laboratories. Suitable methods for the estimation of fluorene and acenaphthene have been developed. A method devised for the estimation of diphenylene oxide is, in its present state, essentially a research tool, and this is also true of other methods devised during the year for the spectroscopic analysis of benzoles, naphthas, tar acid mixtures and tar base mixtures.

Chemical Nature of Pitch

The foregoing assay and analytical work has been concerned with components occurring in the distillate oils from tar—that is in the fraction which distils up to 360°C at atmospheric pressure. Knowledge of the chemical and physical structure of the distillation residue, pitch, is much less detailed but considerable progress on this topic can be reported. The study of pitch coking oils has been completed; in addition to the twenty-two individual components previously mentioned as major components of these oils, two further major constituents—picene and 1:12 benzperylene have been identified.

The major components in these pitch oils are of similar types to those of the tar distillate oils but have a more highly condensed ring structure. By analogy it is reasonable to postulate that similar compounds, still more highly condensed, will constitute the major components of that part of pitch which has so far resisted separation into individual constituents.

The study of the molecular weight distribution in pitches using the technique of osmosis through poly (vinyl alcohol) membranes of controlled pore size has been further developed. The results show interesting and significant differences between different types of pitch and between pitches as a class and bitumen. They provide a reasonable explanation for some of the differences in rheological properties and volatility between different bituminous binders and, of greater importance, they provide the fundamental background for the work on the modification of pitch properties.

The work on the molecular weight of pitch fractions has shown that the most complex components have a molecular weight of about 2500. To account for the physical properties it must be assumed that these relatively small molecules are strongly associated and, in fact it can be demonstrated that such association occurs even at relatively low concentrations. A knowledge of the nature and magnitude of these associative forces is, therefore, necessary for a full understanding of the structure of pitch and work on this has commenced.

UTILIZATION OF PITCH

Modification of Physical Properties of Pitch

The main factors which restrict use of coal tar pitch are its high volatility and the relatively small temperature interval between its brittle point and its softening point. Although air-blowing at high temperature reduces the temperature susceptibility of pitch, it is doubtful, in the light of our knowledge of the structure of pitch, whether any chemical treatment can modify the flow properties to widen sufficiently the temperature interval between the flow point and the brittle point. A more promising alternative approach lies in conferring on pitch a yield value at high temperatures and elastic or plastic properties at low temperatures by the addition of certain fillers and high polymers. A major part of the work on this topic during

the year has been devoted to studying the quantitative effect of such additions, and has involved a fundamental investigation of the rheological properties of pitch-polymer systems.

The effect of fillers depends on their particle size and shape and on their concentration. Non-fibrous fillers cause an increase in viscosity, a reduction in the temperature susceptibility and a useful increase in the shatter resistance but, in concentrations below 10 per cent, do not give rise to plasticity or thixotropy. Fibrous fillers, in addition to improving the temperature susceptibility and the resistance to shatter, cause marked plasticity with the production of a yield value and their addition to pitch appears a most promising method of increasing the temperature interval between flow point and brittle point.

The "volatility" of pitches and mixtures of pitch and fluxing oils is the term rather loosely applied to describe two effects of practical importance in the application of coal tar pitch. In the manufacture of road tar, tar paints, roofing felts, pitch mastics etc., coal tar pitch is fluxed with a suitable oil and the mixture applied or compounded at a temperature between 100 and 200°C. When the pitch composition is maintained at such a temperature in air it increases in viscosity and loses volatile oils. In the case of pitch of coke oven or horizontal retort origin the effect is essentially one of evaporation but with materials derived from vertical retort tar oxidation is an additionally important factor. The investigation on pitch volatility has shown that the rate of loss of oils and the rate of increase in viscosity of any pitch/oil mixture can be calculated from the properties of the pitch and the oil and it is now possible to assess the effect of modifications of the pitch and changes in the nature of the fluxing oil on these effects. One important practical result of this work is the discovery that, by suitable pretreatment of both pitch and fluxing oil, bituminous compositions can be made from coal tar whose volatility is of the same order as that of a straight run bitumen of the same viscosity.

It is thus possible to overcome, or at least minimize, the two main defects of coating compositions and adhesives based on pitch and improved compositions are now under evaluation in the laboratory. Larger quantities of these modified compositions are being produced for industrial evaluation. At the same time attention is being devoted to the measurement of the other practically important properties of pitch coating composition, e.g. adhesion to metal and water resistance, to ensure that such properties are not impaired by the modifications made.

Use of Pitch as a Binder in Coal Briquetting

A joint programme between the Association and the Central Research Establishment of the National Coal Board on the effect of the nature of the pitch binder on the strength of coal briquettes has been in progress during the year. There appears to be a good correlation between the toluene-insoluble matter content of a pitch and the strength of the aged briquettes. This correlation does not hold, however, for the strength of the briquettes immediately after pressing and before cooling to atmospheric temperature. The resistance to deformation as the briquettes cool depends not only on the nature of the pitch but also on the time of cooling and, to some extent, on the size and shape of the briquettes.

UTILIZATION OF CREOSOTE AND TAR OILS

Hydrogenation Studies

The main effort on this programme has been concerned with the catalytic refining of benzoles and naphthas. A joint programme with the National Benzole Association has involved a comparison between the hydro-refining

of six representative crude benzoles under various conditions of temperature and pressure and their refining with concentrated sulphuric acid. If the aim of the refining process is to produce motor benzole then the results show that the catalytic process offers only marginal advantage over sulphuric acid refining; if purer grades of benzole are desired catalytic refining is the more economical process.

In the refining of solvent and heavy naphthas the main objectives are water-white colour, colour stability and pleasant smell rather than low sulphur content. A process has been worked out for the catalytic refining of naphthas to achieve these desired results which, compared to normal refining by treatment with concentrated sulphuric acid, offers an increased yield of up to 30 per cent. In order to compare the economics of this process with treatment of the total crude naphtha with sulphuric acid or the other alternative, which is prefractionation followed by acid refining of selected fractions, much time has been spent in determining the optimum conditions for refining samples submitted by members and producing sufficient refined products from these for evaluation.

It has been found that hot-pressed naphthalene can be hydrogenated to give a high yield of tetrahydronaphthalene at any desired conversion up to 75 per cent. Details of a commercial plant to produce a ton a day of tetrahydronaphthalene or, alternatively, a smaller amount of tetrahydronaphthalene, together with some sulphur-free naphthalene, have been worked out for one member.

Oxidation Studies

The pilot scale fluidized oxidation plant for the production of phthalic anhydride from coal tar oils was commissioned early in the year and, after overcoming some initial difficulties, has given very encouraging results. From a coke oven naphthalene oil weight yields of up to 80 per cent of phthalic anhydride have been obtained. No evidence of catalyst disintegration or catalyst carryover with the products has been noted; control of the plant has been excellent and condensation of the phthalic anhydride has proved much easier than anticipated. It has not yet been possible to carry out a catalyst life test but so far there is no evidence of a fall-off in activity.

Concurrently with the pilot plant investigation a statistical study on the effect of catalyst composition and operational variables on the vapour phase oxidation of naphthalene to phthalic anhydride is in hand with a view to determining the optimum catalyst and the optimum conditions for its use. The results indicate that much higher space-time yields (i.e. weight of phthalic anhyride produced per unit volume of catalyst per unit time) are possible than those at present obtained in commercial practice.

SERVICE TO INDUSTRY

Corrosion and Coking of Tar Stills

The study of the factors influencing the corrosion of tar distilling equipment was concluded during this year and a full report is being prepared.

Briefly, it has been found that corrosion of mild steel is caused either by inorganic salts or by higher boiling phenolic compounds. Alkali injection controlled the effect of the former, but increased corrosion by the latter. Mechanical dehydration reduced corrosion by inorganic salts, but had no effect on the phenols. The effect of high boiling tar acids increased above 275°C and steam or vacuum distillation minimized their attack. The relatively small quantities of phenolic components could be neutralized by adding iron oxide, but the amount required was impracticably great. In

laboratory studies "Inconel" and aluminium showed good resistance respectively to inorganic and phenolic corrosion. Stainless steel resists both types of attack while unmachined cast iron is considerably more resistant than mild steel.

The study of the factors affecting coke deposition in pipe stills was also concluded during the year and the findings have been successfully applied in the industry.

Chemical Engineering Advisory Service

Although valuable background information on plant problems such as corrosion and coke formation can be obtained by research in the laboratory, such knowledge can only be satisfactorily applied to the problems arising at a particular works if the conditions prevailing at that works are taken into consideration. During the past year the Association, by virtue of a grant from Conditional Aid funds for studies designed to improve British industrial productivity, has been able to institute a valuable new service to the tar distilling industry. A mobile team of chemical engineers has been recruited who will be available to visit members' works to advise them on improving the efficiency of their operations and processes.

Determination of Chemical Engineering Data

The activities of the investigational team have greatly increased the number of samples on which data are required and considerable attention has been devoted to extending the range of instruments available and to the adaption of the present instruments for more rapid routine measurements. Particular mention may be made of the development of a new technique for the determination of the thermal conductivity of pitch at temperatures at which it is semi-fluid and also of a simplified method for determining flash vaporization equilibria.

The effect of composition and molecular weight on the specific heats of tar oils and the correlation of specific heats of tar oils and tar oil vapours have been studied and expressions have been derived which may enable specific heats of tar oils in the liquid and vapour states to be calculated from their boiling ranges and tar acid contents.

LIBRARY AND INTELLIGENCE SERVICES

The first instalment of the *Coal Tar Data Book* was circulated to the industry in September, 1953. This first section covers the properties of the major components in coal tar and further sections, dealing with the properties of tar, tar oils and pitches, and with general chemical engineering data, will be issued as they are compiled.

Two issues of *Review of Coal Tar Technology* based on the 1600 abstracts made during the year, were printed and circulated. Information of commercial interest to the industry was also abstracted and circulated to the industry through the Association of Tar Distillers as a three monthly bulletin.

The quarterly *News Bulletin* has been replaced by a more ambitious printed publication entitled *Coal Tar Science* designed particularly to interest the commercial and managerial sides of the industry in the work of the Association.

CONFERENCE

The Fourth Annual Tar Conference was held in Leeds on 3rd and 4th November, 1953; 120 delegates attended to discuss seven papers dealing with different aspects of the production and utilization of creosote. Most

of the members attending the Conference availed themselves of the opportunity to visit the laboratories during the "Open Days" and discuss their problems with the Association's staff.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st April, 1953 to 31st March, 1958 a block grant of £12 000 per annum is made provided £45 000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £200 contributed by industry up to a maximum additional grant of £12 000.

The income of the Association for the last completed year was £90 855.

BRITISH WELDING RESEARCH ASSOCIATION

During the year the research activities of the Association have continued to grow and alternative accommodation for the researches now carried on at the headquarters laboratories has become necessary. It has therefore been decided to transfer the metallurgical researches to Abington and to erect there a new laboratory building as soon as plans can be completed.

The progress of some of the current investigations is briefly reviewed in the following sections but special attention should be drawn to two new projects which have been commenced during the year. The first concerns the arc welding of copper, and the second is a co-operative investigation of the possibility of health risks from basic-coated low-hydrogen electrodes for welding steel. The work on brittle fracture, too, has continued to flourish, and has excited considerable attention.

During the year the Association's rights in five patents have been assigned to the National Research Development Corporation, under the agreement outlined in the previous report (p. 229). A special grant has been made from F.O.A. funds for the purchase from the U.S.A. of a Sciaky three-phase spot welding machine and a Baldwin-Tate-Emery 400 000 lb. Universal testing machine. These machines, which could not otherwise have been obtained, are most valuable additions to the research facilities.

Present figures for membership of the Association are 282 ordinary members and 30 associate members; comparative figures for the same time last year being 260 and 27 respectively.

The usefulness of the Association's advisory service is evidenced by the growing number of requests for assistance, and of visits to the laboratories by members' representatives.

Twenty-three special reports have been prepared, covering a very wide range of subjects dealing with members' industrial problems. In addition to this, thirty-four confidential reports have been issued to members during the year, covering progress on the main lines of work. A similar number of papers has been published in various journals, and thirteen lectures have been given to professional and technical societies by members of the staff.

At the end of 1953 separate publication ceased of the Association's publication *Welding Research*, and of the *Transactions of the Institute of Welding*, with the launching of the new *British Welding Journal*.

SPECIAL RESEARCHES

Arc Welding of Copper

At the first meeting of the committee an initial programme of co-operative work was agreed, to examine the effect of hydrogen in the parent plate material on weldability, and it was also decided to prepare a résumé on the attitude of the industry to their various problems in the light of the newly-available materials and methods.

FERROUS METALS

Higher Strength Weldable Structural Steels

About half of the original series of 40 experimental steels have been tested with low-hydrogen electrodes, and shown to be appreciably less susceptible to cracking than when rutile electrodes are used, thus rendering available steels having an 0·3 per cent proof stress of up to 35 tons/sq in., as compared with 25 tons/sq. in. for the best acceptable alloy completely weldable with rutile electrodes.

Preliminary tests have shown, in the case of two of the selected steels, that there is great advantage in quenching and tempering; the materials have good tensile properties, satisfactory impact strength and excellent weldability.

Test specimens containing the same amount of hydrogen as the heat-affected zone, and which have been through the same thermal cycle, are found to fracture in a brittle manner similarly to the hardened zone material. Tests on specimens artificially charged with hydrogen for dilatation experiments show that the end-of-transformation temperature is depressed.

It has been established that when using low-hydrogen electrodes there is a critical end-of-transformation temperature of 245°C, and with figures below this value it is impossible to weld without hardened zone cracking. Previous work had given a figure of 290°C for rutile electrodes.

Constitution of Weld Metal

Two furnaces have been made, one for testing the influence of hydrogen, and the other, using argon and high-frequency heating, for studying high-temperature equilibria. Several experimental runs have been made using variously shaped specimens.

Experiments with crack-testing machines have disclosed some unexpected results caused by variation in rate of straining.

Non-metallic inclusions in weld metal have been analysed for several classes of electrode, including one experimental type. For the first time, ferrotitanate has been identified in weld metal. Increase of arc length has been found generally to cause more slag inclusions. The effect of arc length on inherent (not slag) inclusions was examined, but was found to be insignificant. A titanium target has been used for the first time in micro-radiographic inspection of inclusions.

Cracking in Welded Gas Mains

Some cracking has been obtained using a synthetic mixture of hydrogen sulphide, ammonia and hydrocyanic acid which might account for corrosion cracking in gas plant.

Oxygen Cutting

A major difficulty in investigating the fundamentals of oxygen cutting is the need to separate the heat contributions from the iron/oxygen combustion and from the pre-heating flame. Experimental work previously carried out

has investigated the former only. More recent work has been directed towards the measurement of the pre-heating flame contribution. Some aspects of the cutting of cast iron are also being examined.

LIGHT ALLOYS

Fusion Welding of Light Alloys

Cracking experienced in the welding of H.10 bridge deck units with aluminium electrodes containing 5 per cent silicon has been explained in terms of weld composition, and in particular the effect of joint design and the dilution of the weld by the parent plate to produce a crack-sensitive composition.

Apparatus for hydrogen estimation is working, particularly for pure aluminium specimens and Al-Mg alloys. The results will be correlated with porosity, and for this purpose a porosity code has been established and has given good results.

Welding of Heat-Treatable Light Alloys

Some special filler alloys have been drawn to wire, and, by their use, welds of high strength have been produced. Original work on dilution effects is giving valuable information, and has shown that joint design is an important factor affecting weld composition by modifying the extent of dilution.

ENGINEERING

Load-Carrying Capacity of Frame Structures

A review of stanchion design has been prepared. The electronic computing machine at the Mathematical Laboratory, Cambridge, has been used to obtain extensive data on the behaviour of stanchions bent about the minor axis. A tentative design method for stanchions bent about the major axis has been completed, and a start made on a further series of trials to test its adequacy. A series of tests to determine minimum weld sizes for rigid joints has been completed, and good correlation obtained with a theoretical treatment.

Behaviour of Welded Structures under Dynamic Loading

S/N curves for a pulsating tension load cycle have been determined for plain and welded plates 4 inches wide by $\frac{1}{2}$ in. and $1\frac{1}{4}$ in. thick.

Alternating bend (minor axis) tests have been completed on some thin gauge box sections, and further work will be devoted to investigating their behaviour under alternating torsion.

Testing of Welded Pipes and Pressure Vessels

The pressure vessel previously tested has been fitted with six new nozzles of different kinds to examine the effect of reinforcement.

An equal branch welded connexion, reinforced with a collar, has been analysed when subjected to four different loading conditions. A similar connexion with "triform" reinforcement is under test.

Difficulty was experienced in obtaining a butt weld between the bend and the tangents which did not fail before the bend, but this difficulty has now been overcome, and both pulsating pressure and bending fatigue tests have been completed and S/N curves plotted. Ancillary equipment for tests under combined bending and internal pressure has been made.

Residual Stresses and Brittle Failure

The work on the efficacy of various stress-relieving treatments on impact strength has been completed. A range of specimens has been tested with a rail testing tup hammer, and the results reported to the committee. Cooling tests on a restrained weld did not produce brittle fracture—contrary to an earlier experiment where there was less control of the cooling rate.

Docherty's classic experiments on " size effect ", in which, with successively smaller notched specimens, failure suddenly changes from brittle to ductile, have been repeated, and can be explained. The velocity of propagating cracks has been calculated from theory (for the first time) and corresponds with the facts. A design has been prepared for tests on the brittle fracture of wide plates.

RESISTANCE WELDING

Projection, Spot and Stud Welding

Work is in hand to produce satisfactory recommendations for projection welding of sheet thicker than 14 S.W.G., and thinner than 20 S.W.G., to extend the previous work.

A code of practice for projection welding has been published, and in addition a revised code of practice issued on the technique for spot welding low-carbon steel. Experimental and theoretical work has continued on thermal effects associated with spot welding of ferrous materials.

A new committee has been set up on the testing of resistance welds. The tests to be compared have been agreed upon, and cover shear, tension, torsion, hardness and micrographic examination.

A final report is to be published on the investigation on the spot welding of high-strength aluminium alloys.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st April, 1949, to 31st March, 1954, a block grant of £20 000 per annum was made provided £20 000 of grant-earning income was received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £20 000.

For the period 1st April, 1954, to 31st March, 1956, the block grant is £40 000 per annum, provided £40 000 is received from industry, and the additional grant £100 for each additional £100 contributed by industry up to a maximum of £10 000.

For the subsequent three years the terms will be further modified.

The income of the Association for the last completed year was £113 369.

RESEARCH COUNCIL OF THE BRITISH WHITING FEDERATION

During the year it was decided that the basis of the industrial contribution should be increased by 25 per cent, and it was further decided to purchase premises which had been brought to the notice of the Council and which would give additional facilities for further laboratory work and particularly for the installation of pilot plants. The Council has also approved the admission of the National Association of Putty Manufacturers as an associate member of the Council. Up to the end of the period covered by this report

the Council had not completed discussions with other industries using chalk as a raw material, but collaboration with the research organization set up by those industries is envisaged, whilst the possibilities and the problems connected with even closer association in the field of research are being further explored.

Attention has recently been concentrated upon the improvement of processes of manufacture to reduce costs and to make possible production of finer or more closely controlled grades of whiting. This work has involved investigations at the works of a number of members and has included measurements of fuel efficiencies in drying processes. A mobile pilot plant of a new type for classifying whiting has also been operated at the works of several members, with successful results.

Progress with the investigation on the use of whiting in linseed oil putty has given further insight into the factors affecting quality. The amount of oil, the mixing conditions and the quality of the whiting are found to be important. Methods of test suitable for routine control of quality of putty have been devised.

The co-operative work carried out with the Research Association of British Rubber Manufacturers on the use of whiting and other calcium carbonate fillers in rubber has been described in a joint report; the results and conclusions from this co-operative work are of considerable value in showing the properties required. Some work has been done on the use of whitings in particular types of paint, and attention given to the possibilities of increased use in this and other fields.

Although much of the work on standardization of test methods, and on examination of the range of properties of whitings, has been completed, research into improvements of methods and into special properties continues. A machine for automatic sieve testing on fine sieves, and recording of the results, for use in routine control has been devised and built. Another investigation has been concerned with the applicability for measuring specific surface of whiting of a semi-automatic apparatus, devised in the cement industry.

Further work has been done on the compilation of a bibliography on Particle Size of which two sections have already been issued. A further section bringing the entries up-to-date is nearing completion and is expected to be available during 1955.

Papers on a number of items of work have been published, and other work has been described in some 17 papers and confidential reports which have been furnished to members. The reports have been discussed in detail with individual members, as well as at meetings of the Council and of its Technical Committee.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1953 to 31st December, 1955 a block grant of £4000 per annum is made provided £7500 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £4000.

The income of the Research Council for the last completed year was £13 797.

WOOL INDUSTRIES RESEARCH ASSOCIATION

The Council and the Research Control Committee have carefully considered how much of the Association's effort should be devoted to research on the blending of man-made and other fibres with wool. Hitherto the Association has confined its work primarily to the processing of wool, and in this way it has been able to give the members the service they required. But as circumstances are today, the industry is tending to use more and more man-made fibres in conjunction with wool, so that the previous policy of the Association means that members may not get the service that they should expect. There are, however, innumerable economic and technical problems associated with blending, and if the Association were to concern itself with all of them, research on wool would be jeopardized. The Research Control Committee has, therefore, recommended that although the future policy of the Association should make more provision for research into the blending of man-made fibres with wool, the programme should be guided by the interests of the members and the wool producers.

A grant of £5000 has been made to the Association from funds made available as Conditional Aid by the U.S.A. This is being used to investigate the relative merits of automatic and non-automatic looms in the woollen and worsted industries, taking into account such problems as the need for improved yarns with automatic looms and the effect of these looms on the mending costs for fabrics. The project will continue for two years. A work study engineer has been engaged to manage the project and on its conclusion he will join the staff of the Work Study Centre which has been set up by the Wool (and Allied) Textile Employers' Council. This arrangement should ensure that the investigation will not only provide the Association and its members with knowledge that is required for research and other purposes, but will also provide for close co-operation between the Centre and the Association.

PROCESS RESEARCH

Much background work done by the Association came to light at the Textile Recorder Machinery Exhibition which was held in Manchester during October, 1953. One exhibitor had on show a new drawing system for the worsted process, known as the Raper Drawing System. This incorporates automatic control of the levelness of slivers, or autolevelling, as the worsted top is extended to form roving preparatory to the spinning process. The inventor brought his original autoleveller machines to the Association some five years ago. Drawing office and workshop facilities were provided for the design and production of new models, and the staff of the Association assisted by applying their considerable knowledge of sliver measurement and sliver drafting to experimental trials with the machines. With their co-operation, further autolevelling units were built in the Association's workshop, and were given extended trials in members' mills. Prototypes for the drawing system were also built in the Association's workshop, after which commercial development was taken up by the company exhibiting the plant. This exhibit has been described as a highlight of the Machinery Exhibition, and the number of firm orders which have been placed by British spinners for this new device has been very satisfactory. Arrangements have been made with this machinery manufacturer to use commercial models of the new units in the Association's pilot worsted drawing and spinning plant, which was mentioned in last year's Report (p. 236).

An automatic controller for the woollen card also has been designed in the Association's laboratories in co-operation with a member firm. A development contract was placed with a firm of electronic engineers to make a prototype of this unit which would be suitable for commercial production. The prototype has now undergone trials successfully and two firms are making the controller in quantity. The device controls the weight per unit area of the web coming from the cards so that the woollen slubbings and yarns are maintained at the desired weight per unit length. A recorder, which is incorporated in the automatic controller, can be bought separately and has proved a valuable device for tuning up the woollen card. In this form it can be used either in mills or for research purposes.

During the year a raw wool scouring plant was installed and the Association is now able to follow the full top-making process. Little research has hitherto been done on top-making because of lack of facilities and the cost of the wool involved. There now seems good prospect of obtaining results of considerable value to the industry in this field.

At the other end of cloth making, much work has been done on the effect of high temperature dyeing on wool fibres. This is of importance, not only because of improved dyeing methods that can be obtained for wool by the use of high pressures and temperatures, but also because of the importance of dyeing man-made fibres, either for use with wool or when blended with wool. Considerable guidance has already been given to members on the conditions that wool will withstand in this new process.

FUNDAMENTAL RESEARCH

A chromatographic method of analysis has been developed for lanthionine, which is one of the more important products obtained on wool hydrolysis. So far its quantitative estimation has proved difficult and because of this much speculation has arisen about the form of sulphur in the wool molecule. The quantitative work now being undertaken should throw light on this problem. Chromatographic methods are also being developed for the analysis of scouring liquors, and on the more fundamental side, the analysis of wool grease and of oils used in spinning has been considerably advanced by this method, coupled with infra-red absorption spectra techniques.

A fundamental study of the setting of individual fibres and the reactions of these set fibres to changes in relative humidity, has shown that the fibre becomes stiffer both to bending and to twist when steamed, and becomes more pliable on drying. This might seem to conflict with published results, which show that the torsional rigidity of fibres decreases very rapidly with increasing regain. The published results refer, however, to dynamic measurements of rigidity whereas in the present experiments the rigidity has been measured by equilibrium methods. The equilibrium torsional rigidity of the fibre material does decrease with increasing regain, but the compensating effect of radial swelling is so great as to outweigh this, and a net increase in stiffness is obtained.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st October, 1953, to 30th September, 1956, a block grant of £40 000 per annum is made provided £100 000 of grant-earning income is received from industry, and an additional grant of £100 for each additional £100 contributed by industry up to a maximum additional grant of £30 000.

The income of the Association for the last completed year was £205 267.

OTHER GRANT-AIDED ORGANIZATIONS

ASLIB

After four years of rapid development, it was essential that the year should be primarily a period of consolidation. Even so, membership rose from 1550 to nearly 1700, the greatest increase continuing to be in industrial concerns, and gross income rose by about £5000.

The pronounced upward trend in the use made of Aslib's services continued. The number of enquiries dealt with by the Information Department rose to about 16 000 (cf. 3521 in 1951) and 11 organizations employed Aslib consultants in establishing or re-organizing information sections. Over 12 000 translations of scientific papers were recorded in the Commonwealth Index of Translations and the Panel of Translators contains the names of 135 persons qualified by both linguistic and subject knowledge. The number of papers photocopied or microfilmed for member organizations was again double that recorded in the previous year.

One notable achievement was the publication of the first issue of an annual *Index to Theses Accepted for Higher Degrees in the Universities of Great Britain and Ireland.* This work, undertaken with the generous co-operation of the universities concerned, was instrumental in making information generally available—for the first time in this country—about academic theses recently completed in all subject fields. The bulk of the work of collecting information for the forthcoming revised edition of the *Aslib Directory to Sources of Specialised Information* (1928) was also completed during this period and publication of this edition is expected in 1955. The work of the seven specialist groups—covering aeronautics, chemistry, economics, engineering, food and agriculture, fuel and power and textiles—developed satisfactorily. In particular, the Aeronautical Group worked closely with the Documentation Committee of the Advisory Group for Aeronautical Research and Development of N.A.T.O.

Aslib's recent expansion has been such that the new premises taken over in December, 1949, are no longer adequate for its needs. In common with many similar organizations, therefore, Aslib faces once more the urgent problem of finding additional office accommodation.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1952, to 31st December, 1953, a block grant of £5000 per annum was made provided £5000 of grant-earning income was received and an additional grant of £100 for each additional £100 of grant-earning income up to a maximum additional grant of £1000.

For the period 1st January, 1954, to 31st December, 1958, the block grant is £5000 per annum, provided £7500 of grant-earning income is received, and the additional grant £50 for each additional £100 received up to a maximum of £2000.

The income of the Association for the last completed year was £24 972.

COMMONWEALTH MYCOLOGICAL INSTITUTE

The work on the culture collection of fungi kept at the institute continues to expand. Nearly 1900 strains are now maintained, and during the year about 1400 cultures were issued to the public. Industrial concerns show an increasing interest, demanding fungi for a great variety of syntheses, assays, and other purposes.

The Catalogue, publication of which was recorded last year, has been welcomed by firms, and is undoubtedly partly responsible for the increased demand for cultures. Two supplements were issued during the year, on January 1st and July 1st; further supplements are expected to appear annually on those dates.

On October 1st, 1953, a second mycologist was appointed for duty with the collection. A new laboratory block is in the course of erection, and is expected to be ready for occupation in the summer of 1955. These additional facilities will enable development of the collection and its services to proceed more quickly.

Many technical enquiries, by telephone and letter, are received from the research departments of firms who use cultures. Enquirers are invited to send representatives of their scientific staffs to Kew, and a large number of chemists and technicians have visited the Institute, where advice is given and difficulties can be cleared up in consultation with the mycologists.

The grant for the maintenance and expansion of the collection at the present time is £2000 per annum.

APPENDIX I

Throughout this Appendix [1] against a member's name shows that he retired and [2] that he was appointed during the year 1953–54.

A. ASSESSORS TO THE ADVISORY COUNCIL

Department	*Assessor*
Admiralty	C.R.N.S.S. (W. R. J. Cook, Esq., C.B.)
Ministry of Agriculture and Fisheries	A. B. Bartlett, Esq.
Agricultural Research Council ...	Sir William Slater, K.B.E., D.Sc., F.R.I.C.
Air Ministry	[1]Air Vice-Marshal Sir Claude Pelly, K.C.B., C.B.E., M.C. [2]Air Vice-Marshal G. W. Tuttle, C.B., O.B.E., D.F.C.
Colonial Office	W. B. L. Monson, Esq., C.M.G.
Commonwealth Relations Office ...	J. P. Gibson, Esq., C.B.E.
Development Commission	E. H. E. Havelock, Esq., C.B., C.B.E.
Ministry of Education	H. J. Shelley, Esq., O.B.E.
Ministry of Food	Norman C. Wright, Esq., D.Sc., F.R.I.C.
Ministry of Fuel and Power ...	[1]Sir Harold Roxbee Cox, Ph.D., M.I.Mech.E., F.R.Ae.S. [2]K. T. Spencer, Esq., C.B.E., M.C., A.M.I.C.E., F.R.Ae.S.
Home Office	[1]Sir Edward Paris, C.B., D.Sc., F.Inst.P. [2]R. H. Purcell, Esq., Ph.D., F.R.I.C.
Ministry of Housing and Local Government	H. Symon, Esq., C.B.
Ministry of Labour and National Service	Dame Mary Smieton, D.B.E.
Ministry of Materials	[1]R. F. Bretherton, Esq., C.B.
Medical Research Council	Sir Harold Himsworth, K.C.B., M.D., F.R.C.P.
Post Office	Sir Gordon Radley, C.B.E., Ph.D., M.I.E.E.
Scottish Office	[1]H. R. Smith, Esq., C.B. [2]W. Lewis, Esq.
Ministry of Supply	O. H. Wansbrough-Jones, Esq., C.B., O.B.E., Ph.D.
Board of Trade	R. M. Nowell, Esq., C.B.
Ministry of Transport and Civil Aviation	[1]F. C. Hampden, Esq. [2]A. W. Wray, Esq., O.B.E.
University Grants Committee ...	[1]Sir Arthur Trueman, K.B.E., D.Sc., F.R.S. [2]K. A. H. Murray, Esq., Ph.D.

B. COMMITTEES OF THE ADVISORY COUNCIL

(i) Industrial Grants Committee

Sir Henry Hinchliffe, D.L., J.P. (*Chairman*)
Sir Wallace Akers, C.B.E., D.Sc., D.C.L., F.R.I.C., F.R.S.
Sir Hugh Beaver, M.I.C.E., M.I.Chem.E.
J. Crawford, Esq., J.P.
Professor R. S. Edwards, B. Com.
Professor T. R. C. Fox, M.I.Mech.E., M.I.Chem.E.
The Rt. Hon. the Earl of Halsbury, F.R.I.C., F.Inst.P.
W. L. Heywood, Esq., O.B.E.
Sir Philip Johnson
A. H. Wilson, Esq., F.R.S.

Assessors

Board of Trade ... ... S. A. ff. Dakin, Esq.
Ministry of Supply ... ... D. W. Mitchell, Esq., C.B.E.

(ii) Scientific Grants Committee

A. H. Wilson, Esq., F.R.S. (*Chairman*)
Professor T. R. C. Fox, M.I.Mech.E., M.I.Chem.E.
The Rt. Hon. the Earl of Halsbury, F.R.I.C., F.Inst.P.
Willis Jackson, Esq., D.Sc., D.Phil., M.I.E.E., F.Inst.P., F.R.S.
Professor R. V. Jones, C.B., C.B.E., D.Phil., F.Inst.P., F.R.A.S., F.R.S.E.
Professor Sir Eric Rideal, M.B.E., D.Sc., F.R.I.C., F.R.S.
Professor F. S. Spring, D.Sc., F.R.S.
Sir George Thomson, D.Sc., LL.D., F.R.S.
[2]Professor G. C. Varley, Ph.D.

Assessors

The Secretaries of the Royal Society
The Chairman of the University Grants Committee

(iii) Nuclear Physics Committee

Sir John Cockcroft, K.C.B., C.B.E., D.Sc., LL.D., M.I.E.E., F.R.S. (*Chairman*)
Professor P. M. S. Blackett, F.R.S.
Professor Sir Lawrence Bragg, O.B.E., M.C., D.Sc., LL.D., F.R.S.
Sir David Brunt, Sc.D., Sec.R.S.
Professor P. I. Dee, C.B.E., F.R.S.
[2]Professor P. B. Moon, Ph.D., F.R.S.
Professor N. F. Mott, D.Sc., F.R.S.
[2]K. A. H. Murray, Esq., Ph.D.
Professor Sir Francis Simon, C.B.E., F.R.S.
[2]Professor H. W. B. Skinner, Ph.D., F.R.S.
Sir George Thomson, D.Sc., LL.D., F.R.S.
[1]Sir Arthur Trueman, K.B.E., D.Sc., F.R.S.
The Chairman of the Scientific Grants Committee

C. RESEARCH BOARDS* OF THE DEPARTMENT

Building Research Board

Chairman: [1]W. K. Wallace, Esq., C.B.E., M.I.C.E., M.I.Struct.E.
[2]Sir Herbert Manzoni, C.B.E., M.I.C.E.

[1]Professor H. V. A. Briscoe, D.Sc., A.R.C.S., D.I.C., F.R.I.C., F.Inst.F.
[2]Professor A. L. Banks, M.D., F.R.C.P., D.P.H.
D. N. Chester, Esq., C.B.E.
[2]G. G. J. Davis, Esq.
[2]Professor D. H. Everett, M.B.E., D.Phil.
N. S. Farrow, Esq., M.B.E.
Sir Luke Fawcett, O.B.E.
H. J. B. Harding, Esq., M.I.C.E., F.C.G.I., D.I.C.
[1]A. C. Hartley, Esq., C.B.E., M.I.C.E., M.I.Mech.E.
[1]T. M. Herbert, Esq., M.I.Mech.E.
E. R. Hole, Esq., M.I.Struct.E.
L. C. Howitt, Esq., F.R.I.B.A., M.T.P.I.
L. W. Hutson, Esq., O.B.E., F.R.I.B.A., F.R.I.A.S.
Miss J. G. Ledeboer, F.R.I.B.A., F.I.L.A.
[1]Professor J. M. Mackintosh, M.D., LL.D., F.R.C.P.
Professor J. A. L. Matheson, M.B.E., Ph.D., M.I.C.E., M.I.Struct.E.
[2]L. Scott White, Esq., O.B.E., M.I.C.E., M.I.Struct.E., M.Am.Soc.C.E.
[2]R. M. Wynne-Edwards, Esq., O.B.E., D.S.O., M.C., M.I.C.E.

Director of Building Research: F. M. Lea, Esq., C.B.E., D.Sc., F.R.I.C., Hon.A.R.I.B.A.

Assessors

Admiralty	D. H. Little, Esq., A.M.I.C.E.
Ministry of Agriculture and Fisheries	[2]F. W. Holder, Esq., A.R.I.B.A.
Department of Agriculture for Scotland	D. S. Macphail, Esq., A.R.I.B.A., M.S.A.
Air Ministry	G. J. Biggs, Esq., M.B.E., F.I.A.A.
Colonial Office	S. J. W. Gooch, Esq., C.B.E., M.I.C.E.
Ministry of Education	S. A. W. Johnson-Marshall, Esq., C.B.E., A.R.I.B.A.
Ministry of Fuel and Power ...	F. C. Lant, Esq., O.B.E., A.M.I.H.V.E., M.Inst.F.
Ministry of Housing and Local Government	J. H. Forshaw, Esq., C.B., M.C., F.R.I.B.A., M.T.P.I. G. M. McNaughton, Esq., C.B., M.I.C.E., M.I.Mech.E. S. F. Wilkinson, Esq., C.B.
Department of Health for Scotland	R. Scott Morton, Esq., A.R.I.B.A., A.M.T.P.I.
Ministry of Labour and National Service	H. Eccles, Esq., M.B.E., M.C., A.M.I.C.E.
Ministry of Supply	D. G. T. Colebrook, Esq., A.Inst.P., F.I.M.
War Office	Major-General D. C. T. Swan, C.B.E.
Ministry of Works	Sir Charles Mole, M.V.O., O.B.E., F.R.I.B.A. [1]A. J. Filer, Esq., C.B. [2]M. W. Bennitt, Esq.

*Membership of the Committees of the Research Boards is given in the Annual Reports of the Boards.

Chemistry Research Board

Chairman: Professor E. L. Hirst, D.Sc., LL.D., F.R.I.C., F.R.S.

J. W. Barrett, Esq., Ph.D., F.R.I.C., A.R.C.S., A.I.Chem.E.
Professor C. E. H. Bawn, Ph.D., F.R.S.
R. P. Bell, Esq., F.R.S.
Professor H. V. A. Briscoe, D.Sc., A.R.C.S., D.I.C., F.R.I.C.
A. H. Cook, Esq., D.Sc., F.R.I.C., F.R.S.
[1]Professor E. G. Cox, D.Sc., F.Inst.P., F.R.S.
H. W. Cremer, Esq., C.B.E., F.R.I.C., M.I.Chem.E., M.Inst.F.
[2]W. Davies, Esq., Ph.D., A.I.M.M.
Professor R. D. Haworth, D.Sc., F.R.I.C., F.R.S.
[2]J. Davidson Pratt, Esq., O.B.E., M.I.Chem.E., F.R.I.C.
[2]Professor J. M. Robertson, D.Sc., F.R.I.C., F.Inst.P., F.R.S.E., F.R.S.
[1]S. Robson, Esq., D.I.C., F.R.I.C.
[1]B. Topley, Esq.
R. M. Winter, Esq., F.R.I.C.
D. D. Woods, Esq., Ph.D., F.R.S.

Director, Chemical Research Laboratory: D. D. Pratt, Esq., O.B.E., Ph.D.

Assessors

Admiralty	W. R. J. Cook, Esq., C.B.
Ministry of Supply	[1]C. S. Bryant, Esq., F.R.I.C.
	[2]C. H. Johnson, Esq., D.Sc., A.R.I.C.
Board of Trade	J. F. Hirst, Esq., F.R.I.C.
War Office	Major S. Elliott, O.B.E., T.D., A.R.I.C.

Fire Research Board

(D.S.I.R. and Fire Offices' Committee)

Chairman: Sir George Burt, M.I.C.E., F.I.O.B.

H. Bedford, Esq., M.I.Mech.E., M.I.Mar.E.
[2]John Brown, Esq.
E. C. T. Carden, Esq.
[1]Professor T. P. Hilditch, D.Sc., F.R.I.C., F.R.S.
A. B. Hunter, Esq., A.F.R.Ae.S.
[2]J. L. Martin, Esq., Ph.D., F.R.I.B.A.
[1]R. B. Shepheard, Esq., C.B.E.
C. F. Trustam, Esq.
W. H. Tuckey, Esq., O.B.E.
[1]Professor B. R. Ward, F.R.I.B.A.
F. Webster, Esq., M.C., M.I.C.E., Hon.M.E.I.(Canada)

Director of Fire Research: S. H. Clarke, Esq., M.Sc.

Assessors

Admiralty	Cdr. W. Walmsley, R.N. (Retd.), O.B.E. O. V. Richards, Esq., Ph.D., A.R.I.C. Cdr. (E.) A. G. B. Norman, R.N.
Ministry of Agriculture and Fisheries	A. Thorpe, Esq., F.R.I.B.A.
Air Ministry	E. J. C. Williams, Esq.
Fire Services	Martin Chadwick, Esq., O.B.E.
Ministry of Fuel and Power ...	[1]P. D. Edmondson, Esq. [2]K. T. Spencer, Esq., C.B.E., M.C., A.M.I.C.E., F.R.Ae.S.
Home Office	[1]Sir Edward Paris, K.C.B., D.Sc., F.Inst.P. [2]R. H. Purcell, Esq., Ph.D., F.R.I.C. H. M. Smith, Esq., C.B.E., L.I.F.E.
Ministry of Housing and Local Government	A. E. Hickinbotham, Esq.
Ministry of Labour and National Service	H. Eccles, Esq., M.B.E., M.C.
Ministry of Materials	[2]E. J. Cowles, Esq., O.B.E.
Medical Research Council	J. P. Bull, Esq., M.D.
Ordnance Board	Group-Captain G. P. Woodhouse
Scottish Home Department ...	A. D. Wilson, Esq.
Ministry of Supply	P. W. Cooper, Esq. E. L. Hill, Esq.
Board of Trade	J. Wright, Esq.
Ministry of Transport and Civil Aviation	J. A. Brooker, Esq., M.B.E. F. J. Colvill, Esq., M.I.Mech.E., M.I.Mar.E., M.I.N.A.
War Office	[2]Major L. S. McLean, R.A.S.C.
Ministry of Works	M. A. Hall, Esq., F.I.A.S., F.C.I.I.

Food Investigation Board

Chairman: [1]Professor Sir Frank Engledow, C.M.G., F.R.S.
[2]R. Holroyd, Esq., Ph.D.

Professor W. T. Astbury, Sc.D., F.Inst.P., F.R.S.
Professor E. H. F. Baldwin, Ph.D.
[2]F. H. Banfield, Esq., Ph.D., F.R.I.C.
Professor G. E. Briggs, F.R.S.
[1]H. J. Channon, Esq., C.M.G., D.Sc., F.R.I.C.
[1]P. V. Danckwerts, Esq., G.C., M.B.E.
Professor A. C. Frazer, M.D., D.Sc., F.R.C.P.
[2]E. F. Gale, Esq., Sc.D., F.R.S.
[2]Professor A. W. Scott, Ph.D., A.R.T.C., M.I.Mech.E.
[1]Professor E. T. C. Spooner, M.D., M.R.C.S., L.R.C.P.
G. C. Wilson, Esq., O.B.E.
[1]Professor C. M. Yonge, C.B.E., D.Sc., F.R.S.

Director of Food Investigation: F. Kidd, Esq., C.B.E., D.Sc., F.R.S.

Assessors

Ministry of Agriculture and Fisheries	J. A. K. Christie, Esq. R. A. Hughes, Esq.
Agricultural Research Council ...	W. G. Alexander, Esq., O.B.E.
Department of Agriculture for Scotland	W. H. Senior, Esq., F.R.S.E.
Australia	[1]J. E. Cummins, Esq., F.R.I.C. [2]W. Ives, Esq.
Canada	D. A. Bruce Marshall, Esq.
Colonial Office	D. Rhind, Esq., O.B.E., F.L.S.
Ministry of Education	A. Urie, Esq., Ph.D., A.R.T.C., F.R.I.C.
Ministry of Food	H. R. Barnell, Esq., Ph.D. N. C. Wright, Esq., D.Sc., F.R.I.C. W. A. Letham, Esq., M.C., M.D., D.P.H., D.T.M.
Ministry of Health	H. E. Magee, Esq., M.B., D.Sc., M.R.C.P.
India	S. Krishna, Esq., D.Sc., F.R.I.C., F.N.I.
Ireland	J. W. Dulanty, Esq., C.B., C.B.E., LL.D.
Medical Research Council	L. J. Harris, Esq., Sc.D., F.R.I.C.
New Zealand	[1]E. Marsden, Esq., C.M.G., C.B.E., M.C., D.Sc., F.R.S. [2]V. Armstrong, Esq., Ph.D., D.I.C.
Scottish Home Department ...	[1]T. F. S. Hetherington, Esq. [2]C. E. Lucas, Esq., D.Sc., F.R.S.E.
South Africa	[2]A. M. Schady, Esq.
Federation of Rhodesia and Nyasaland	J. E. C. Coventry, Esq.
War Office	H. G. Smith, Esq., Ph.D., F.R.I.C.

Forest Products Research Board

Chairman: R. G. Bennett, Esq., C.B.

Professor W. T. Astbury, Sc.D., F.Inst.P., F.R.S.
David Booth, Esq., F.R.I.B.A., F.S.I.A.
H. A. Collinson, Esq., F.R.I.C.
A. H. Gosling, Esq., C.B., F.R.S.E. (Forestry Commission)
[1]Professor R. D. Haworth, D.Sc., F.R.I.C., F.R.S.
Sir Edward Monkhouse, C.B.E.
[2]Professor M. Stacey, D.Sc., F.R.S.
[1]Professor J. Walton, Sc.D., D.Sc.
Paul Williams, Esq.

Director of Forest Products Research: F. Y. Henderson, Esq., C.B.E. D.Sc., D.I.C.

Assessors

Admiralty	O. T. Whitehead, Esq.
Colonial Office	R. H. Kirby, Esq., Ph.D.
Ministry of Materials	[2]J. C. Rea Price
Ministry of Supply	E. L. Hill, Esq. W. Hardy, Esq.
Board of Trade	R. A. Jones, Esq.
Ministry of Works	W. Abnett, Esq.

Fuel Research Board

Chairman: Professor Sir Cyril Hinshelwood, Sc.D., F.R.S.

F. M. Birks, Esq., C.B.E., M.I.C.E., M.I.Mech.E., M.Inst.Gas E.
[1]A. T. Bowden, Esq., Ph.D., M.I.Mech.E.
[1]Sir Walter Drummond, M.I.C.E., M.I.Mech.E.
[2]Sir Charles Ellis, Ph.D., F.R.S.
Professor T. R. C. Fox, M.I.Mech.E., M.I.Chem.E.
Professor F. H. Garner, O.B.E., Ph.D., F.R.I.C., M.I.Mech.E., M.I.Chem.E.
Sir John Hacking, M.I.E.E.
[2]H. F. H. Jones, Esq., M.B.E., M.Inst.Gas E., A.M.I.C.E.
Professor H. W. Melville, D.Sc., F.R.I.C., F.R.S.
Professor J. Small, D.Sc., M.I.C.E., M.I.Mech.E.
Sir Ernest Smith, C.B.E., D.Sc., F.R.I.C.
[1]O. G. Sutton, Esq., C.B.E., D.Sc., F.R.S.
A. H. Wilson, Esq., F.R.S.

Director of Fuel Research: A. Parker, Esq., C.B.E., D.Sc., F.R.I.C., M.I.Chem.E.

Assessors

Admiralty	... Vice-Admiral (E.) F. T. Mason, C.B.
Ministry of Fuel and Power	... [1]Sir Harold Roxbee Cox, Ph.D., M.I.Mech.E., F.R.Ae.S.
	[2]Engineer Rear-Admiral Sir Sydney Frew, K.B.E., C.B., M.Inst.F., M.I.Mar.E.
Ministry of Supply	... F. G. Willson, Esq., B.E.M., A.R.I.C.
Board of Trade	... J. F. Hirst, Esq., F.R.I.C.

Geological Survey Board

Chairman: [1]Sir Arthur Trueman, K.B.E., D.Sc., M.I.Min.E., F.G.S., F.R.S.
[2]Sir Walter Drummond, M.I.C.E., M.I.Mech.E.

[1]E. H. Browne, Esq., C.B.E., M.I.Min.E.
[2]J. B. Dennison, Esq., A.R.S.M., M.I.M.M.
Alexander Fleck, Esq., D.Sc., F.G.S., F.R.I.C.
[1]Professor L. Hawkes, D.Sc., F.G.S., F.R.S.
Professor W. B. R. King, O.B.E., M.C., Sc.D., F.G.S., F.R.S.
G. M. Lees, Esq., M.C., D.F.C., Ph.D., F.G.S., F.R.S.
Professor T. C. Phemister, D.Sc., F.G.S., F.R.S.E.
[2]Professor H. H. Read, D.Sc., A.R.C.S., F.R.S.
[1]Professor W. F. Whittard, D.Sc., A.R.C.S., D.I.C., F.G.S.

Director of the Geological Survey and Museum of Practical Geology: W. J. Pugh, Esq., O.B.E., D.Sc., M.I.Min.E., F.G.S., F.R.S.

Assessors

Ministry of Agriculture and Fisheries	W. Morley Davies, Esq., F.R.I.C.
Agricultural Research Council ...	A. Muir, Esq., Ph.D.
Colonial Office	F. Dixey, Esq., C.M.G., O.B.E., D.Sc., F.G.S., M.I.M.M.
Ministry of Fuel and Power ...	R. N. Quirk, Esq.
	C. Forrester, Esq., Ph.D., F.R.I.C., A.M.I.Chem.E., F.R.S.E.

Ministry of Housing and Local Government	G. M. McNaughton, Esq., C.B., M.I.C.E., M.I.Mech.E.
Ministry of Materials	[1]R. F. Bretherton, Esq., C.B.
Ministry of Supply	W. K. Ward, Esq.
Board of Trade	[2]J. A. R. Pimlott, Esq., C.B.
Government of Northern Ireland ...	[1]W. Rigby Foster, Esq.
	[2]A. A. Farrell, Esq., M.I.C.A.
Scottish Office	[1]H. R. Smith, Esq., C.B.
	[2]W. Lewis, Esq.

Hydraulics Research Board

Chairman: W. P. Shepherd-Barron, Esq., M.C., T.D., M.I.C.E., M.I.Mech.E.

[1]C. H. Dobbie, Esq., M.I.C.E.
A. T. Doodson, Esq., D.Sc., F.R.S.
W. E. Doran, Esq., O.B.E., M.I.C.E.
[1]J. Duvivier, Esq., M.I.C.E., M.I.Struct.E., M.Cons.E.
Colonel R. H. Edwards, M.I.C.E.
W. H. Haile, Esq., O.B.E., M.I.C.E.
A. C. Hartley, Esq., C.B.E., M.I.C.E., M.I.Mech.E.
Sir Harold Hartley, K.C.V.O., C.B.E., M.C., D.Sc., F.R.S.
Brigadier C. G. Hawes, C.I.E., M.C., M.I.C.E.
[2]A. S. Quartermaine, Esq., C.B.E., M.C., M.I.C.E.
Professor Sir Geoffrey Taylor, F.R.S.
W. K. Wallace, Esq., C.B.E., M.I.C.E., M.I.Struct.E.
[2]F. E. Wentworth-Sheilds, Esq., O.B.E., M.I.C.E.
[2]G. A. Wilson, Esq., M.I.C.E., M.I.Mech.E.

Director of Hydraulics Research: Sir Claude Inglis, C.I.E., M.I.C.E., M.Am.Soc.C.E., F.R.S.

Assessors

Admiralty	Cdr. W. I. Farquharson, O.B.E., R.N. (Retd.)
	B. J. Vickars, Esq., A.M.I.C.E.
Ministry of Agriculture and Fisheries	E. A. G. Johnson, Esq., C.B.E., M.I.C.E., M.I.W.E., A.M.I.Mun.E.
Colonial Office	A. G. Robinson, Esq., M.I.C.E.
Crown Agents for Oversea Governments and Administrations	S. J. W. Gooch, Esq., C.B.E., M.I.C.E.
Ministry of Fuel and Power ...	K. T. Spencer, Esq., C.B.E., M.C., A.M.I.C.E., F.R.Ae.S.
Ministry of Housing and Local Government	G. M. McNaughton, Esq., C.B., M.I.C.E., M.I.Mech.E.
Scottish Office	F. W. Waddell, Esq., M.I.C.E., M.I.W.E.
Ministry of Transport and Civil Aviation	R. E. O'Malley, Esq., A.M.I.C.E.
War Office	Brigadier C. D. Reed, M.I.C.E.
Ministry of Works	C. L. Champion, Esq., M.I.C.E., M.I.Mech.E., A.M.I.E.E.

Mechanical Engineering Research Board

Chairman: Sir Andrew McCance, D.Sc., LL.D., A.R.S.M., M.I.Mech.E., F.R.S.

D. S. Anderson, Esq., Ph.D., A.R.T.C., M.I.Mech.E.
F. W. Archer, Esq.
E. Bruce Ball, Esq., C.B.E., M.I.Mech.E.
W. F. Cartwright, Esq., M.I.Mech.E.
D. Clayton, Esq., D.Sc., M.I.Mech.E., F.Inst.Pet.
N. Elce, Esq., M.I.Mech.E., M.I.E.E.
[2]Professor E. Giffen, D.Sc.
[1]A. C. Hartley, Esq., C.B.E., F.C.G.I., M.I.C.E., M.I.Mech.E.
H. E. Merritt, Esq., M.B.E., D.Sc., M.I.Mech.E.
Professor J. L. M. Morrison, D.Sc., M.I.Mech.E.
[2]D. A. Oliver, Esq., C.B.E., F.Inst.P., F.I.M.
Sir David Pye, C.B., Sc.D., M.I.Mech.E., F.R.Ae.S., F.R.S.
[1]Professor O. A. Saunders, D.Sc., M.I.Mech.E., F.Inst.P.
Sir Richard Southwell, D.Sc., LL.D., M.I.Mech.E., F.R.Ae.S., F.I.Ae.S., F.R.S.

Director of Mechanical Engineering Research: D. G. Sopwith, Esq., D.Sc., M.I.Mech.E.

Assessors

Admiralty	Colonel A. V. Kerrison
Crown Agents for the Oversea Governments and Administrations	J. W. Norris, Esq., C.B.E., A.C.G.I., A.M.I.C.E., A.M.I.Mech.E.
Ministry of Fuel and Power ...	R. G. Voysey, Esq., A.C.G.I., A.M.I.Mech.E.
Scottish Office	[1]H. R. Smith, Esq., C.B. [2]W. Lewis, Esq.
Ministry of Supply	D. H. Chaddock, Esq., M.I.Mech.E.
Board of Trade	S. A. ff. Dakin, Esq.
Ministry of Transport and Civil Aviation	F. J. Colvill, Esq., C.B.E., M.I.Mech.E., M.I.Mar.E., M.I.N.A.
Ministry of Works	[1]P. T. Fletcher, Esq., M.I.C.E., M.I.Mech.E., M.I.E.E. [2]A. B. Mann, Esq., O.B.E., M.I.Mech.E., A.M.I.C.E.

Executive Committee of the National Physical Laboratory

Chairman: Sir Ben Lockspeiser, K.C.B., F.R.S.

E. D. Adrian, Esq., O.M., M.D., President R.S.
Sir Thomas Merton, D.Sc., Treasurer R.S.
Sir David Brunt, Sc.D., Secretary R.S.
T. E. Allibone, Esq., D.Sc., M.I.E.E., F.Inst.P., F.R.S.
Professor H. Wright Baker, D.Sc., M.I.Mech.E.
F. P. Bowden, Esq., Sc.D., F.R.S.
Sir Charles Darwin, K.B.E., M.C., Sc.D., F.R.S.
Sir Arthur Gouge, M.I.Mech.E., F.R.Ae.S.
T. G. N. Haldane, Esq., M.I.E.E.
Sir Charles Lillicrap, K.C.B., M.B.E., M.I.N.A.
[1]Professor N. F. Mott, D.Sc., F.R.S.
Sir David Pye, C.B., Sc.D., M.I.Mech.E., F.R.Ae.S., F.R.S.
Sir William Stanier, D.Sc., M.I.Mech.E., F.R.S.
[2]R. Stoneley, Esq., Sc.D., F.R.S.
C. Sykes, Esq., D.Sc., F.Inst.P., F.R.S.
Professor J. H. C. Whitehead, F.R.S.

Director of the National Physical Laboratory: Sir Edward Bullard, Sc.D., F.R.S.

Assessors

Admiralty	W. R. J. Cook, Esq., C.B.
Ministry of Supply	Brigadier G. H. Hinds, O.B.E.
	E. T. Jones, Esq., O.B.E., A.F.R.Ae.S

Pest Infestation Research Board

Chairman: F. R. Horne, Esq., N.D.A., N.D.D.

[1]W. J. Arrol, Esq., Ph.D., D.I.C.
[2]F. H. Banfield, Esq., Ph.D., F.R.I.C.
J. M. Barnes, Esq., M.B.
[1]W. H. Cashmore, Esq., N.D.A.
[2]J. W. Corran, Esq., Ph.D., F.R.I.C.
W. McA. Gracie, Esq., M.B.E., M.Inst.T.
W. J. Hall, Esq., C.M.G., M.C., D.Sc.
[1]T. Moran, Esq., C.B.E., D.Sc., N.D.D.
[2]A. B. P. Page, Esq., Ph.D.
Professor A. D. Peacock, D.Sc.
[1]O. W. Richards, Esq., D.Sc.
N. D. Riley, Esq., C.B.E.
[2]R. Spence, Esq., C.B., D.Sc., F.R.I.C.

Director of Pest Infestation Research: G. V. B. Herford, Esq., O.B.E.

Assessors

Agricultural Research Council ...	[1]R. A. E. Galley, Esq., Ph.D., D.I.C., A.R.C.S., F.R.I.C.
	[2]G. G. Samuel, Esq.
Ministry of Agriculture and Fisheries	I. Thomas, Esq., Ph.D.
	[1]J. W. Evans, Esq., D.Sc.
Department of Agriculture for Scotland	D. W. Williams, Esq., Ph.D.

Australia	[1]N. M. Tulloh, Esq.
Canada	Lt.-Colonel J. G. Robertson, B.S.A.
Colonial Office	[1]G. A. C. Herklots, Esq., Ph.D., F.L.S.
	[2]R. A. E. Galley, Esq., Ph.D., D.I.C., A.R.C.S., F.R.I.C.
	[2]D. Rhind, Esq., O.B.E.
Ministry of Food	H. R. Barnell, Esq., Ph.D.
Ministry of Health	[1]J. R. Nicholls, Esq., D.Sc., F.R.I.C.
	[2]H. M. Elliott, Esq., M.B., D.P.H.
India	[2]S. Krishna, Esq., D.Sc., F.R.I.C., F.N.I.
	[1]Lt.-Colonel C. L. Pasricha
Ministry of Materials	[2]E. J. Cowles, Esq., O.B.E.
New Zealand	[1]E. Marsden, Esq., C.M.G., C.B.E., M.C., D.Sc., F.R.S.
	[2]V. Armstrong, Esq., Ph.D., D.I.C.
Federation of Rhodesia and Nyasaland	J. E. C. Coventry, Esq.
Board of Trade	R. A. Jones, Esq.
War Office	H. G. Smith, Esq., Ph.D., F.R.I.C.

Radio Research Board

Chairman: Sir Noel Ashbridge, M.I.C.E., M.I.E.E., F.I.R.E.

F. S. Barton, Esq., C.B.E., F.Inst.P., M.I.E.E., F.I.R.E. (Ministry of Supply)
Captain C. D. Bonham-Carter, R.N. (Admiralty)
[1]T. E. Goldup, Esq., M.I.E.E.
[1]Air Commodore V. G. A. Hatcher, O.B.E., A.F.C. (Air Ministry)
[2]O. W. Humphreys, Esq., M.I.E.E.
[1]Willis Jackson, Esq., D.Sc., D.Phil., M.I.E.E., F.Inst.P., F.I.R.E., F.R.S.
Professor F. Llewellyn Jones, D.Phil., F.Inst.P.
Professor R. V. Jones, C.B., C.B.E., D.Phil., F.Inst.P., F.R.A.S., F.R.S.E.
E. C. S. Megaw, Esq., M.B.E., D.Sc., M.I.E.E. (Admiralty)
Colonel J. H. E. Panton, O.B.E. (War Office)
Sir Gordon Radley, C.B.E., Ph.D., M.I.E.E. (Post Office)
[2]Air Commodore G. H. Raadle, A.M.I.E.E. (Air Ministry)
[2]J. A. Ratcliffe, Esq., O.B.E., M.I.E.E., F.R.S.
J. A. Smale, Esq., C.B.E., A.F.C., M.I.E.E.
C. E. Strong, Esq., O.B.E., M.I.E.E., F.I.R.E.
[2]O. G. Sutton, Esq., C.B.E., D.Sc., F.R.S. (Air Ministry)
[1]Captain K. McN. Walter, R.N. (Admiralty)
[1]Sir Robert Watson-Watt, C.B., LL.D., M.I.E.E., F.I.R.E., F.R.S.
[2]R. T. B. Wynn, Esq., C.B.E., M.I.E.E.

Director of Radio Research: R. L. Smith-Rose, Esq., C.B.E., D.Sc., M.I.E.E., F.C.G.I., F.I.R.E.

Road Research Board

Chairman: [1]Sir Frank E. Smith, G.C.B., G.B.E., D.Sc., LL.D., F.R.S.
[2]E. John Powell, Esq., M.I.C.E., M.I.Mun.E.

[2]J. F. A. Baker, Esq., M.I.C.E., M.I.Mun.E., A.M.Inst.T.
Colonel G. T. Bennett, O.B.E., M.I.C.E.
C. E. Boast, Esq., O.B.E., M.C., M.I.C.E., M.I.Mun.E., F.R.I.C.S., M.I.W.E.
C. T. Brunner, Esq., M.Inst.T., F.Inst.P.
P. G. Stone Clark, Esq., M.I.Mech.E., M.Inst.T.
H. Dalton, Esq., C.B.E.
[2]R. L. Fitt, Esq., M.I.C.E.
A. Floyd, Esq., C.B.E., M.I.C.E., M.I.Mun.E.
A. Fogg, Esq., M.I.Mech.E.
[1]E. B. Hugh-Jones, Esq., C.B., M.C., M.I.C.E.
J. W. Laing, Esq., C.B.E., F.I.O.B.
S. Mehew, Esq., O.B.E., M.I.C.E., M.I.Mun.E., A.M.T.P.I.
J. Robertson, Esq., O.B.E., M.I.C.E., M.I.Mun. E.

Director of Road Research: W. H. Glanville, Esq., C.B., C.B.E., D.Sc., M.I.C.E.

Assessors

Admiralty	[1]J. H. Siddons, Esq., M.I.C.E. [2]F. B. Pickles, Esq., A.M.I.C.E.
Air Ministry	[1]W/Cdr. M. J. Scott, M.Inst.T. [2]W/Cdr. W. Higgs, O.B.E. C. E. Docker, Esq., A.C.G.I., D.I.C.
Colonial Office	S. J. W. Gooch, Esq., C.B.E., M.I.C.E.
Ministry of Education	*J. B. M. Hay, Esq., M.C., M.I.C.E. [2]J. R. N. Booth, Esq.
Home Office	[2]Miss J. J. Nunn
Ministry of Housing and Local Government	R. S. Colquhoun, Esq., A.M.I.C.E., A.M.T.P.I.
Medical Research Council	E. Farmer, Esq.
Ministry of Supply	Sir Donald Bailey, O.B.E., D.Eng., A.M.I.C.E., M.I.Struct.E.
Ministry of Transport and Civil Aviation	G. V. Hole, Esq. [1]R. J. Samuel, Esq., C.B.E., M.I.C.E. W. F. Adams, Esq., A.M.I.C.E., A.M.Inst.T. [2]G. H. Hargreaves, Esq., M.C., M.I.C.E.
War Office	Brigadier C. D. Reed, M.I.C.E.
Ministry of Works	[1]R. B. Unwin, Esq., A.M.I.C.E. [2]E. A. Oliver, Esq., A.M.I.C.E., A.M.I.Struct.E.

*Died 24th January, 1954

Water Pollution Research Board

Chairman: Professor D. M. Newitt, M.C., D.Sc., M.I.Chem.E., F.R.S.

[2]H. W. Cremer, Esq., C.B.E., F.R.I.C., M.I.Chem.E.
[2]J. S. Evans, Esq.
H. W. Harvey, Esq., Sc.D., F.R.S.
S. H. Jenkins, Esq., D.Sc., F.R.I.C.
L. W. F. Millis, Esq., O.B.E.
C. J. Regan, Esq., F.R.I.C.
Professor C. M. Yonge, C.B.E., D.Sc., F.R.S.

Director of Water Pollution Research: B. A. Southgate, Esq., C.B.E., D.Sc., F.R.I.C.

Assessors

Ministry of Agriculture and Fisheries	F. T. K. Pentelow, Esq.
Colonial Office	S. J. W. Gooch, Esq., C.B.E., M.I.C.E.
Development Commission	Professor W. H. Pearsall, D.Sc., F.R.S.
Government Laboratory	J. Longwell, Esq., D.Sc., F.R.I.C.
Ministry of Housing and Local Government	A. Key, Esq., D.Sc. T. C. Coote, Esq., M.B.E., M.T.P.I.
Department of Health for Scotland	J. B. Dempster, Esq., M.I.C.E.
Government of Northern Ireland ...	A. J. Howard, Esq., F.R.I.C.
Medical Research Council	Professor J. C. Cruickshank, M.D.
Scottish Home Department (Fisheries Division)	P. R. C. Macfarlane, Esq., B.Sc.
Ministry of Supply	R. E. Johnstone, Esq., M.I.Chem.E., F.R.I.C.
Board of Trade	[1]S. R. Raffan, Esq., [2]D. Caplan, Esq.
Ministry of Transport and Civil Aviation	R. E. O'Malley, Esq., A.M.I.C.E.
Ministry of Works	E. H. Williams, Esq., F.R.I.C.

D. COMMITTEES ON HUMAN FACTORS IN INDUSTRY

(Joint Committees of D.S.I.R. and Medical Research Council)

Committee on Human Relations in Industry

Chairman: A. B. Waring, Esq.

J. Foster Beaver, Esq., J.P.
J. O. Blair-Cunynghame, Esq., O.B.E.
A. D. Bonham-Carter, Esq.
E. Fletcher, Esq.
Miss Beryl Foyle
[2]F. Hayday, Esq.
Professor A. J. Lewis, M.D., F.R.C.P.
J. N. Morris, Esq., M.R.C.P., D.C.H., D.P.H.
Professor R. W. Russell, Ph.D.
Miss B. N. Seear
Professor T. S. Simey, M.A.
Sir Reginald Verdon Smith
A. T. M. Wilson, Esq., M.D.

Assessor

Ministry of Labour and National Service: A. M. Morgan, Esq.

Committee on Individual Efficiency in Industry

Chairman: Sir Frederic Bartlett, C.B.E., F.R.S.

J. O. Blair-Cunynghame, Esq., O.B.E.
Professor J. V. Connolly
J. Crawford, Esq., J.P.
Professor J. Drever
C. B. Frisby, Esq., Ph.D.
L. V. Green
Professor Esther M. Killick, D.Sc., M.B., M.R.C.P.
Professor W. E. Le Gros Clark, M.D., D.Sc., LL.D., F.R.C.S., F.R.S.
N. G. McCulloch, Esq., C.B.E.
Professor R. W. Russell, Ph.D.
L. Wright, Esq.
Miss Nora Wynne

Assessor

Ministry of Labour and National Service: Sir George Barnett

APPENDIX II

SUMMARY OF THE EXPENDITURE OF THE DEPARTMENT DURING THE YEAR ENDED 31ST MARCH 1954

Organization	Gross*	Receipts	Net
	£	£	£
Headquarters, Administration, etc.	220,790	411	220,379
Headquarters, Overseas Liaison	92,314	21,969	70,345
National Physical Laboratory	831,019	317,970	513,049
Building Research	444,729	33,135	411,594
Chemical Research Laboratory	171,374	47,021	124,353
Fire Research	69,049	43,694	25,355
Food Investigation...	296,420	4,302	292,118
Forest Products Research	105,764	4,512	101,252
Fuel Research	268,535	21,551	246,984
Geological Survey and Museum	257,674	46,942	210,732
Hydraulics	67,622	6,060	61,562
Mechanical Engineering	327,692	13,285	314,407
Pest Infestation	62,311	3,554	58,757
Radio Research	98,976†	4,579	94,397
Road Research	327,293	21,761	305,532
Water Pollution	62,739	66	62,673
Research Contracts	7,293	4,704	2,589
Miscellaneous Programmes	23,710	2,774	20,936
Grants for Research:			
Annual Grants to Research Associations ...	1,254,088	1,775	1,252,313
Special Grants to Research Associations ...	1,839	—	1,839
Grants to Students, etc....	295,419	133	295,286
Grants for Special Researches	412,431	60	412,371
American Aid—Provision of Technical Equipment	115,283	1,167	114,116
American Aid—Promotion of Productivity ...	8,432	9,512	*1,080*‡
Contributions to European Nuclear Research ...	42,483	—	42,483
TOTALS	5,865,279	610,937§	5,254,342

* Includes the cost of work for "Boards and Committees" at other Stations of the Department.

† The increase over 1952–53 results mainly from the full year cost of staff transferred from National Physical Laboratory on 1st October, 1952.

‡ Represents charges for salaries under Headquarters, Administration, etc.

1953–54

§This may be classified:—

		£
A.	RECEIPTS FROM INDUSTRY:	
	National Physical Laboratory	125,029
	Other Stations	86,114
B.	RECEIPTS FROM OTHER SOURCES:	
	Payment by other Government Departments for services rendered ...	329,754
	Sales and Miscellaneous Receipts	40,211
	Payment by Government of Northern Ireland for survey work ...	7,860
	Contributions from Commonwealth Countries towards cost of Overseas Liaison	21,969
		610,937

APPENDIX III

A. ESTABLISHMENTS OF THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

Establishment	Address	Telephone No.
HEADQUARTERS OFFICE ...	Charles House, 5–11, Regent Street, London, S.W.1.	Whitehall 9788
Overseas Liaison	Africa House, Kingsway, W.C.2 ...	Holborn 3422
Technical Information and Documents Unit.	Cunard Building, 15, Regent Street, S.W.1.	Whitehall 9788
Scottish Branch Office ...	20, Walker Street, Edinburgh, 3 ...	Edinburgh 34994
Welsh Branch Office ...	c/o Welsh Board of Health, Cathay's Park, Cardiff.	Cardiff 28066 Ext. 216
BUILDING RESEARCH STATION	Bucknalls Lane, Garston, near Watford, Herts.	Garston 2246
Building Operations Research Unit.	Montagu Mansions, Crawford Street, London, W.1.	Welbeck 4420
Building Operations Research Unit.	Thatched Barn, Barnet-by-Pass, Barnet, Herts.	Elstree 3211
Scottish Branch	Thorntonhall, Glasgow	Busby 1171
CHEMICAL RESEARCH LABORATORY	Coleshill Road, Teddington, Middlesex	Molesey 1380
FIRE RESEARCH STATION ...	Boreham Wood, Elstree, Herts ...	Elstree 1341 or Elstree 1797
Statistical Unit	Cunard Building, 15, Regent Street, London, S.W.1.	Whitehall 9788
FOOD INVESTIGATION		
Director	20A, Regent Street, Cambridge ...	Cambridge 55604
Low Temperature Research Station.	Downing Street, Cambridge	Cambridge 4477
Smithfield Laboratory ...	91–93, Charterhouse Street, E.C.1 ...	Clerkenwell 8150
Torry Research Station ...	Aberdeen	Aberdeen 24258
Humber Laboratory ...	Wassand Street, Kingston-upon-Hull, Yorks.	Hull Central 38283
Ditton Laboratory ...	East Malling, Maidstone, Kent ...	West Malling 3441
Covent Garden Laboratory	Inveresk House, 346, Strand, W.C.2...	Temple Bar 6156
FOREST PRODUCTS RESEARCH LABORATORY	Princes Risborough, Aylesbury, Bucks	Princes Risborough 101
FUEL RESEARCH STATION ...	River Way, Blackwall Lane, East Greenwich, London, S.E.10.	Greenwich 3065
Scottish Branch	Thorntonhall, Glasgow	Busby 1171
GEOLOGICAL SURVEY AND MUSEUM	Exhibition Road, South Kensington, S.W.7.	Kensington 9441
Head Office and Museum, Scotland	"Southpark", 19, Grange Terrace, Edinburgh, 9.	Edinburgh 45203
Branch Offices:—		
Northumberland and Durham District.	33, Eskdale Terrace, Newcastle-on-Tyne, 2.	Newcastle-on-Tyne 81-0318
Lancashire District ...	102, High Street, Manchester, 13 ...	Rusholme 6760
Northern Ireland	20, College Gardens, Belfast, N. Ireland	Belfast 28041

Establishment	Address	Telephone No.
HYDRAULICS RESEARCH STATION	Howbery Park, Wallingford, Berks ...	Wallingford 2381
Research Sub-Station ...	Tidal Basin, Tilbury Docks, Essex ...	Tilbury 3439
MECHANICAL ENGINEERING RESEARCH LABORATORY	East Kilbride, Glasgow	East Kilbride 20222
NATIONAL PHYSICAL LABORATORY	Teddington, Middlesex	Molesey 1380
Taxi-meter Testing Station	Newnham Terrace, Hercules Road, Lambeth S.E.1.	Waterloo 7589
PEST INFESTATION RESEARCH LABORATORY	London Road, Slough, Bucks... ...	Slough 21295
RADIO RESEARCH STATION ...	Ditton Park, Slough, Bucks	Slough 20391
ROAD RESEARCH		
Road Research Laboratory	Harmondsworth, West Drayton, Middlesex.	Colnbrook 116
Road Safety Division ...	Langley Hall, near Slough, Bucks ...	Langley 360
Scottish Branch	Thorntonhall, Glasgow	Busby 1171
WATER POLLUTION RESEARCH		
Water Pollution Research Laboratory.	Elder Way, Stevenage, Herts	Stevenage 820

B. DEPARTMENT'S REPRESENTATIVES ABROAD

H. J. Hadow, B.Sc.: United Kingdom Scientific Mission (North America),
1907 K Street, N.W.,
Washington 6, D.C.,
U.S.A.

A. C. Copisarow, B.Sc., M.I.R.E., F.G.S.: Scientific Attache,
British Embassy,
35, Rue du Fauborg St. Honoré,
Paris 8e,
France.
(Covers France, Belgium, Holland and Luxembourg)

R. G. Silversides, M.Sc.: Scientific Attache,
British Embassy,
Stockholm,
Sweden.
(Covers Norway, Sweden and Denmark)

K. H. Lauder: Scientific Adviser,
United Kingdom Scientific Research Organization,
19, Karl-Finkelnburg Strasse,
Bad Godesberg,
22c Rhineland,
Germany.

APPENDIX IV

LIST OF RESEARCH ASSOCIATIONS AND OTHER GRANT-AIDED ORGANIZATIONS

Name (1)	Address (2)	Chairman and Director of Research (3)
British Baking Industries Research Association	*Laboratories and Office:* Baking Industries Research Station, Chorleywood, Herts. Tel. No.: Chorleywood 900.	R. T. Colgate, Esq., D.Sc., F.R.I.C. J. B. M. Coppock, Esq., Ph.D., F.R.I.C., M.R.San.I.
British Boot, Shoe and Allied Trades Research Association	*Laboratories and Office:* Satra House, Rockingham Road, Kettering, Northants. Tel. No.: Kettering 3151.	W. A. Royce, Esq., F.B.S.I. H. Bradley, Esq., C.B.E., B.Sc., D.I.C., A.R.C.S., F.B.S.I.
British Cast Iron Research Association ...	*Laboratories and Office:* Bordesley Hall, Alvechurch, Birmingham. Tel. No.: Redditch 716. *Scottish Laboratory:* Blantyre Industrial Estate, Glasgow. Tel. No.: Blantyre 486.	J. J. Sheehan, Esq., B.Sc., A.R.C.Sc.I. J. G. Pearce, Esq., O.B.E., Dr.-Ing.(h.c.), M.Sc., M.I.Mech.E., M.I.E.E., F.I.M., F.Inst.P., M.I.Brit.F.
British Ceramic Research Association ...	*Laboratories:* (i) Queen's Road, Penkhull, Stoke-on-Trent. Tel. No.: Stoke-on-Trent 44045. (ii) Mellor Laboratories, Shelton, Stoke-on-Trent. Tel. No.: Stoke-on-Trent 29641. *Office:* Queen's Road, Penkhull, Stoke-on-Trent. Tel. No.: Stoke-on-Trent 44045.	G. N. Hodson, Esq. A. T. Green, Esq., O.B.E., D.Sc., F.R.I.C., F.Inst.P., M.I.Chem.E., Hon.M.Inst.Gas E.
British Coal Utilisation Research Association	*Research Station and Registered Office:* Randalls Road, Leatherhead, Surrey. Tel. No.: Leatherhead 4411.	Sir Charles Ellis, F.R.S. D. T. A. Townend, Esq., C.B.E., D.Sc., Ph.D., D.I.C., F.R.I.C., Hon.M.Inst.Gas E, M.Inst.Min.E., F.Inst.F.

Name (1)	Address (2)	Chairman and Director of Research (3)
British Coke Research Association	*Laboratories:* (i) Midland Coke Research Station, Lynwood, Clarkehouse Road, Sheffield, 10. Tel. No.: Sheffield 63396. (ii) Northern Coke Research Committee, King's College, Newcastle-upon-Tyne. Tel. No.: Newcastle 23401. *Office:* 74, Grosvenor Street, London, W.1. Tel. No.: Mayfair 9736.	L. O'Connor, Esq. G. W. Lee, Esq., M.Sc., F.R.I.C., F.Inst.F.
British Cotton Industry Research Association	*Laboratories and Office:* Shirley Institute, Didsbury, Manchester. Tel. No.: Didsbury 2401–3 and 5281–2.	N. G. McCulloch, Esq., C.B.E. F. C. Toy, Esq., C.B.E., D.Sc., F.Inst.P.
(1) Cutlery Research Council	*Office:* Light Trades House, Melbourne Avenue, Sheffield, 10. Tel. No.: Sheffield 63084.	D. A. Palmer, Esq. C. N. Kington, Esq., M.B.E., B.Sc., A.M.I.Mech.E., A.M.I.E.E.
British Electrical and Allied Industries Research Association	*Laboratories:* (i) 5, Wadsworth Road, Greenford, Middlesex. Tel. No.: Perivale 9511. (ii) E.R.A. Field Station, Shinfield Green, near Reading, Berks. Tel. No.: Reading 81269. *Office:* Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Tel. No.: Leatherhead 3423.	C. T. Melling, Esq., M.Sc.Tech., M.I.E.E., M.I.Mech.E., M.Inst.F., F.I.I.A. S. Whitehead, Esq., M.A., D.Sc., M.I.E.E., F.Inst.P.
British Hat and Allied Feltmakers Research Association	*Laboratories and Office:* Stanley House, Manchester Road, Fairfield, Droylsden, Manchester. Tel. No.: Droylsden 2235–6.	J. Begley, Esq., F.I.L. T. Barr, Esq., Ph.D., B.Sc., F.R.I.C.
Research Association of British Flour-Millers	*Laboratories:* Cereals Research Station, Old London Road, St. Albans, Herts. Tel. No.: St. Albans 6121. *Office:* 21, Arlington Street, London, S.W.1. Tel. No.: Hyde Park 2521.	L. Hector Read, Esq. T. Moran, Esq., C.B.E., D.Sc., Ph.D.

British Food Manufacturing Industries Research Association	*Laboratories and Office:* Randalls Road, Leatherhead, Surrey. Tel. No.: Leatherhead 4124.	E. E. Wells, Esq. F. H. Banfield, Esq., M.Sc., Ph.D., F.R.I.C.
Fruit and Vegetable Canning and Quick Freezing Research Association	*Laboratories and Office:* Chipping Campden, Gloucestershire. Tel. No.: Campden 319.	R. B. Inglis, Esq. F. Hirst, Esq., O.B.E., M.Sc., A.R.C.Sc.
(1)Research Committee of the Furniture Development Council	*Laboratories:* Redhill Aerodrome, South Nutfield, Surrey. Tel. No.: Nutfield Ridge 2245 and 2376. *Technical Information Service and Office:* 11, Adelphi Terrace, Robert Street, London, W.C.2. Tel. No.: Trafalgar 4935-6.	Sir David Waley, K.C.M.G., C.B., M.C. J. C. Pritchard, Esq.
British Gelatine and Glue Research Association	*Laboratories:* 2A, Dalmeny Avenue, Holloway, London, N.7. Tel. No.: North 4971. *Office:* Sardinia House, 52, Lincoln's Inn Fields, London, W.C.2. Tel. No.: Holborn 2662.	S. G. Hudson, Esq. A. G. Ward, Esq., M.A., F.Inst.P.
Hosiery and Allied Trades Research Association	*Laboratories and Office:* 4, First Avenue, Sherwood Rise, Nottingham. Tel. No.: Nottingham 63311.	S. F. Peshall, Esq., C.B.E., M.C., M.A. D. Starkie, Esq., M.Sc., Ph.D.
British Hydromechanics Research Association	*Laboratories and Office:* Eastern Industrial Estate, Harlow, Essex. Tel. No.: Harlow 2366-8.	A. Ivanoff, Esq., Ph.D., M.Sc., M.Inst.Pet. L. E. Prosser, Esq., B.Sc.(Eng.), M.I.Mech.E.
British Internal Combustion Engine Research Association	*Laboratories and Office:* 111-112, Buckingham Avenue, Trading Estate, Slough, Bucks. Tel. No.: Slough 20295-6.	C. G. Tangye, Esq., M.I.Mech.E. Eng. Rear-Adm. D. J. Hoare, C.B., M.I.Mech.E.

Name (1)	Address (2)	Chairman and Director of Research (3)
British Iron and Steel Research Association	*Laboratories:* (i) 140 Battersea Park Road, London, S.W.11 (Physics, Chemistry, Corrosion and Plant Engineering). Tel. No.: Macaulay 5511. (ii) Hoyle Street, Sheffield, 3 (Mechanical Working Steel Making and Metallurgy). Tel. No.: Sheffield 28941. (iii) Sketty Hall, Singleton Park, Swansea (Surfaces of Metals, Metallic Coatings). Tel. No.: Swansea 88868. (iv) High Street, Normanby, Middlesbrough, Yorks. (Iron Making). Tel. No.: Normanby 203. *Office:* 11, Park Lane, London, W.1. Tel. No.: Grosvenor 4751.	Captain H. Leighton-Davies, C.B.E. Sir Charles Goodeve, O.B.E., D.Sc., F.R.S.
British Jute Trade Research Association ...	*Laboratories and Office:* Kinnoull Road, Kingsway West, Dundee, Scotland. Tel. No.: Dundee 86781–2.	W. F. Keay, Esq. H. Corteen, Esq., M.Sc., F.Inst.P., F.T.I.
Lace Research Association	*Laboratories and Office:* Glaisdale Drive West, Bilborough, Nottingham. Tel. No.: Nottingham 74544.	J. G. McMecking, Esq., O.B.E., J.P., F.I.I.A. J. C. MacCallum, Esq., B.Sc.
British Launderers' Research Association ...	*Laboratories and Office:* The Laboratories, Hill View Gardens, Hendon, N.W.4. Tel. No.: Hendon 7846.	C. E. Fry, Esq., A.M.I.E.E. F. C. Harwood, Esq., B.Sc., F.R.I.C., M.I.Chem.E., F.T.I.
British Leather Manufacturers' Research Association	*Laboratories and Office:* Milton Park, Egham, Surrey. Tel. No.: Egham 3086–7.	H. A. Densham, Esq., O.B.E. H. Phillips, Esq., D.Sc., F.R.I.C.

Linen Industry Research Association ...	*Laboratories and Office:* The Research Institute, Lambeg, Lisburn, Co. Antrim, N. Ireland. Tel. No.: Lisburn 2255–6.	H. B. McCance, Esq. A. J. Turner, Esq., C.B.E., M.A., D.Sc., F.T.I.
Parsons and Marine Engineering Turbine Research and Development Association	*Laboratories and Office:* PAMETRADA Research Station, Wallsend-on-Tyne. Tel. No.: Wallsend 6–4061.	Sir Philip B. Johnson. T. W. F. Brown, Esq., D.Sc., S.M., A.R.T.C., M.I.Mech.E., M.I.N.A., F.Inst.P.
Motor Industry Research Association ...	*Laboratories and Proving Ground:* Lindley, near Nuneaton, Warwickshire. Tel. No.: Nuneaton 3664.	M. C. Wilks, Esq. A. Fogg, Esq., M.Sc., M.I.Mech.E.
British Non-Ferrous Metals Research Association	*Laboratories and Office:* Euston Street, London, N.W.1. Tel. No.: Euston 6411.	Lt.-Col. The Hon. R. M. Preston, D.S.O. G. L. Bailey, Esq., C.B.E., M.Sc.
Research Association of British Paint, Colour and Varnish Manufacturers	*Laboratories and Office:* The Paint Research Station, Waldegrave Road, Teddington, Middlesex. Tel. No.: Molesey 4427–9.	Professor H. V. A. Briscoe, D.Sc., A.R.C.S., D.I.C., F.R.I.C. L. A. Jordan, Esq., C.B.E., D.Sc., A.R.C.Sc., F.R.I.C.
British Paper and Board Industry Research Association	*Laboratories and Office:* St. Winifred's Laboratories, Welcomes Road, Kenley, Surrey. Tel. No.: Uplands 6401–3.	C. V. Oliver, Esq. N. R. Hood, Esq., Ph.D., B.Sc., F.R.I.C., M.I.Mech.E., M.I.Chem.E., F.R.S.A., Fel.Univ.L'pool.
Printing, Packaging and Allied Trades Research Association	*Laboratories and Office:* Patra House, Randalls Road, Leatherhead, Surrey. Tel. No.: Leatherhead 4041–5.	E. Harrison, Esq. G. L. Riddell, Esq., PhD., F.R.I.C.
Production Engineering Research Association of Great Britain	*Laboratories and Office:* Staveley Lodge, Melton Mowbray, Leicestershire. Tel. No.: Melton Mowbray 535.	Sir Lionel Kearns, C.B.E., B.A., M.I.Prod.E. D. F. Galloway, Esq., Ph.D., B.Sc., Wh.Sc., M.I.Mech.E., M.I.Prod.E., M.Inst.Pet., M.I.I.A., A.M.I.E.E.

Name (1)	Address (2)	Chairman and Director of Research (3)
British Rayon Research Association ...	*Laboratories:* (i) Heald Green Laboratories, Wythenshawe, Manchester. Tel. No.: Gatley 4285. (ii) Barton Dock Road, Urmston, Manchester. Tel. No.: Urmston 2233. *Office:* Bridgewater House, 58, Whitworth Street, Manchester, 1. Tel. No.: Manchester-Central 3777.	Sir William Palmer, K.B.E., C.B. J. Wilson, Esq., M.C., M.Sc., F.R.I.C.
Research Association of British Rubber Manufacturers	*Laboratories and Office:* Shawbury, Shrewsbury, Shropshire. Tel. No.: Shawbury 383.	H. Rogers, Esq., F.I.R.I. J. R. Scott, Esq., Ph.D., M.Sc., F.R.I.C., F.Inst.P.
British Scientific Instrument Research Association	*Laboratories:* SIRA, Southill, Elmstead Woods, Chislehurst, Kent. Tel. No.: Imperial 2237. *Office:* 20, Queen Anne Street, London, W.1. Tel. No.: Langham 4251.	J. E. C. Bailey, Esq., C.B.E. A. J. Philpot, Esq., C.B.E., M.A., B.Sc., F.Inst.P.
British Shipbuilding Research Association...	*Office:* 5, Chesterfield Gardens, Curzon Street, London, W.1. Tel. No.: Grosvenor 8891.	C. Connell, Esq. S. L. Smith, Esq., C.B.E., D.Sc., F.C.G.I., M.I.C.E., M.Inst.Mar.E., M.I.Mech.E., M.I.N.A.
(1)Coil Spring Federation Research Organisation	*Office:* 40, Grosvenor Gardens, London, S.W.1. Tel. No.: Sloane 0925 and 6218.	R. Salter Bache, Esq., J.P. R. Genders, Esq., M.B.E., D.Met., F.R.I.C., F.I.M.
British Steel Castings Research Association	*Office:* Broomgrove Lodge, Broomgrove Rd., Sheffield 10. Tel. No.: Sheffield 63046-9. *Dust Research Station:* Imperial Steel Works, Vulcan Rd., Sheffield 9. Tel. No.: Sheffield 41054.	C. H. Kain, Esq., A.M.I.Mech.E., F.I.M. J. F. B. Jackson, Esq., B.Sc., F.R.I.C., F.I.M.
Coal Tar Research Association	*Laboratories and Office:* Oxford Road, Gomersal, near Leeds. Tel. No.: Cleckheaton 1087.	R. B. Robinson, Esq. D. McNeil, Esq., B.Sc., Ph.D., F.R.I.C.

British Welding Research Association ...	*Metallurgical Laboratory and Office:* 29, Park Crescent, London, W.1. Tel. No.: Langham 7485–9. *Engineering Research Station:* Abington Hall, near Cambridge. Tel. No.: Linton 375.	Sir Charles S. Lillicrap, K.C.B., M.B.E., R.C.N.C., M.I.N.A. H. G. Taylor, Esq., D.Sc.(Eng.), D.I.C., F.Inst.P., M.I.E.E.
(1)Research Council of the British Whiting Federation	*Laboratories:* 245, Ampthill Road, Bedford. Tel. No.: Bedford 66917. *Office:* 12, Buckingham Street, Strand, London, W.C.2. Tel. No.: Trafalgar 1973–4.	G. F. Holdcroft, Esq. G. E. Bessey, Esq., M.Sc., F.R.I.C.
Wool Industries Research Association ...	*Laboratories and Office:* Torridon, Headingley, Leeds, 6. Tel. No.: 5–1047–9.	J. Foster Beaver, Esq., J.P. A. B. D. Cassie, Esq., D.Sc., Ph.D., M.A., F.Inst.P.

(1) Recognized by the Department as the co-operative research organization for this industry.

OTHER GRANT-AIDED BODIES

Association of Special Libraries and Information Bureaux (Aslib)	*Office:* 4, Palace Gate, Kensington, London, W.8.	A. B. Agard Evans, M.Sc. L. Wilson, Esq., M.A.
Commonwealth Mycological Institute ...	*Laboratories and Office:* The Mycological Institute, Ferry Lane, Kew, Surrey.	*Director:* S. Wiltshire, Esq., M.A., D.Sc.

APPENDIX V

A. MAINTENANCE ALLOWANCES FOR POSTGRADUATE TRAINING IN RESEARCH, SENIOR RESEARCH AWARDS, AND GRANTS FOR SPECIAL RESEARCHES

Explanatory Note.—Maintenance Allowances for postgraduate training in research and Senior Research Awards are normally made for two years, with possible extension to three years. Grants for Special Researches are made for various periods fixed beforehand according to the circumstances.

The cost of these grants during the year 1953–54 is shown in Appendix II.

TABLE 1

PARTICULARS OF APPLICATIONS RECEIVED IN RESPECT OF THE ACADEMIC YEAR 1953–54 (COMPARED WITH SIMILAR DETAILS FOR EARLIER YEARS)

	Maintenance Allowances			Senior Research Awards			Grants for Special Researches		
	1951–52	1952–53	1953–54	1951–52	1952–53	1953–54	1951–52	1952–53	1953–54
A.—Applications granted	384	413	415	9	7	4	38	41	26
B.—Applications refused	556	420	523	16	18	24	35	36	21
C.—Applications withdrawn or referred elsewhere	105	132	79	8	10	6	2	—	4

TABLE 2

PARTICULARS OF THE TOTAL NUMBER OF GRANTS HELD IN THE ACADEMIC YEAR 1953–54 AS COMPARED WITH PREVIOUS YEARS

	1951–52			1952–53			1953–54		
	Continued from 1950–51	New in 1951–52	Total	Continued from 1951–52	New in 1952–53	Total	Continued from 1952–53	New in 1953–54	Total
1.—Maintenance Allowances	539	384	923	563	413	976	594	415	1,009
2.—Senior Research Awards	4	9	13	7	7	14	7	4	11
3.—Grants for Special Researches	53	38	91	29	41	70	32	26	58

TABLE 3

DISTRIBUTION OF GRANTS HELD IN VARIOUS BRANCHES OF SCIENCE

	Maintenance Allowances			Senior Research Awards			Grants for Special Researches		
	1951–52	1952–53	1953–54	1951–52	1952–53	1953–54	1951–52	1952–53	1953–54
Chemistry	390	419	427	5	3	3	26	20	17
Physics	276	283	300	6	8	6	40	32	25
Mathematics and Astronomy	48	50	38	—	—	—	4	4	4
Biology	73	78	97	—	—	1	6	6	4
Geology and Mineralogy	38	41	32	—	—	—	—	—	3
Metallurgy	27	26	16	—	—	—	1	2	1
Engineering	71	79	99	2	3	1	14	6	4
Totals	923	976	1009	13	14	11	91	70	58

B. AFTER CAREERS OF RESEARCH STUDENTS WHOSE MAINTENANCE ALLOWANCES ENDED DURING THE SESSION 1952–53

TABLE 4

Public Service	89	Unaided Research	5
Industry	53	Research Assistantships	20
University Posts	30	Overseas Posts	26
Schools and Technical Colleges	4	Miscellaneous (including National Service)	37
Scholarships (home and overseas)	74	Untraced	42
Senior Research Awards (D.S.I.R.)	2		
		Total	382

C. STUDENTS AWARDED MAINTENANCE ALLOWANCES FOR POSTGRADUATE TRAINING IN RESEARCH BEGINNING IN 1954

TABLE 5

ABERDEEN UNIVERSITY

Subject	*Student*	*Subject*	*Student*
Chemistry:	A. MacLeod	Physics:	D. Greig
			J. P. Llewellyn

QUEEN'S UNIVERSITY—BELFAST

Geology:	J. A. Weir

BIRMINGHAM UNIVERSITY

Botany:	M. E. Davies	EngineeringProduction:	E. Page
Chemistry:	P. J. Boddy	Geology:	H. C. Squirrell
	P. Brown	Applied Biochemistry:	D. Walker
	P. M. Grant	Mathematical	M. H. Boon
	B. N. Preston	Physics:	J. Randles
	N. D. Scott	Metallurgy:	J. R. Kench
	J. B. Smith	Physics:	B. B. Culwick
	J. M. Webber		M. Derrick
	K. S. Whiteley		P. J. Duke
Chemical	V. G. Jenson		P. S. Fisher
Engineering:	R. B. Keey		J. E. Gore
	J. J. Lane		R. Leach
Engineering:	K. D. Oughton		

BRISTOL UNIVERSITY

Chemistry:	A. J. Banister	Geology:	P. R. Evans
	D. Davidson	Mathematics:	L. T. Jones
	A. J. Floyd	Physics:	R. W. Bown
	P. G. Fox		R. F. Followell
	R. M. O'Keeffe		R. R. Hillier
	D. W. Thomas		G. M. Jarman
	J. M. Tiplady		G. W. T. White
Engineering:	G. J. Franklin	Zoology:	R. H. Stobbart

CAMBRIDGE UNIVERSITY

Botany:	D. A. Hopwood	Mathematics:	J. Goldstone
Chemistry:	R. Bonnett		Miss A. C. Hawk
	R. S. Coffey		J. Higgins
	A. J. Duke		J. G. Laski
	E. A. V. Ebsworth		D. Monk
	C. H. S. Hitchcock		D. Morgan
	L. C. Johnson		C. St. J. A. Nash-Williams
	F. J. Lipscomb		A. J. Willson
	R. J. Marklow	Metallurgy:	D. J. Arrowsmith
	J. N. Murrell		J. A. Coiley
	A. H. Neilson	Physics:	I. R. Gibbons
	H. G. Scott		I. D. Howard
	D. W. A. Sharp		R. Jackson
	M. S. Spencer		I. C. T. Nisbet
	I. O. Sutherland		W. R. Phillips
	C. M. B. Tylor		H. Rishbeth
Engineering:	J. F. Barrett		M. G. Rusbridge
	A. N. Schofield		S. Simons
	C. P. Wroth		J. M. Soper
Geodesy and			M. J. Whelan
Geophysics:	A. R. Smith		R. W. Whitworth
Geology:	V. S. Colter		D. J. H. Wort
	R. P. S. Jefferies	Zoology:	A. P. M. Lockwood
Mathematics:	B. J. Birch		A. L. Panchen
	J. M. Campbell		R. H. Pottage

DURHAM UNIVERSITY—DURHAM COLLEGES

Subject	*Student*	*Subject*	*Student*
Botany:	S. R. J. Woodell	Geology:	M. J. Gallagher
Chemistry:	F. Cuthbertson	Physics:	B. K. Ridley

DURHAM UNIVERSITY—KING'S COLLEGE, NEWCASTLE UPON TYNE

Botany:	R. F. Lyndon	Engineering:	T. Ginty
Chemistry:	T. N. Bell		J. F. Meredith
	B. Carss	Mathematics:	W. S. Blackburn
	A. R. Sanderson	Physics:	J. Eve

EDINBURGH UNIVERSITY

Chemistry:	A. W. Arbuckle	Chemistry:	R. S. Williams
	A. G. Cairns-Smith	Physics:	L. W. Barr
	J. W. Falconer		D. C. Dryburgh
	I. D. Fleming		S. W. Peat

UNIVERSITY COLLEGE—EXETER

Chemistry:	K. G. Lewis	Physics:	W. C. Clark
Mathematics:	P. G. Barnett		

GLASGOW UNIVERSITY

Chemistry:	R. F. Bryan	Geology:	W. G. E. Caldwell
	M. D. Coutts	Physics:	P. Carmichael
	Miss A. W. P. Jarvie		W. R. Hogg
	N. J. McCorkindale		I. M. H. Preston
	I. C. McNeill		D. Sinclair
	J. K. Sutherland	Physiology:	A. B. Cairnie
	A. Wylie	Zoology:	Miss E. M. Cawthra

HULL UNIVERSITY

Chemistry:	J. G. Mather	Physics:	B. J. Goldsmith

LEEDS UNIVERSITY

Botany:	J. Cronshaw	Engineering:	J. D. Brunton
Chemistry:	C. R. Allen		D. G. Edwards
	K. Allison	Metallurgy:	R. M. Douthwaite
	I. T. Harrison	Mining:	F. Jackson
	J. Howard	Physics:	A. C. Chapman
	I. G. Laing		M. Fox
	P. A. Warsop		N. H. Saunders

UNIVERSITY COLLEGE—LEICESTER

Botany:	J. A. Sargent

LIVERPOOL UNIVERSITY

Chemistry:	H. C. Fielding	Engineering:	M. J. Stedman
	T. Francis	Mathematics:	E. W. Wallace
	G. Pass	Physics:	J. F. Barry
	N. H. Rees		C. Broude
	E. B. Smith		D. N. Edwards
	J. H. Taylor		S. Hinds
	D. Verdin		A. M. Wetherell
Engineering:	W. A. Smith	Zoology:	M. P. Thomas

BEDFORD COLLEGE—LONDON

Chemistry:	Miss P. M. Everitt

BIRKBECK COLLEGE—LONDON

Subject	*Student*	*Subject*	*Student*
Botany:	L. G. Willoughby	Physics:	J. P. Cleave
Chemistry:	P. J. May	Psychology:	E. A. J. Little
	J. C. Orr		

IMPERIAL COLLEGE—LONDON

Aeronautics:	A. J. Taylor-Russell	Geology:	C. H. James
Chemistry:	K. H. Ansell		M. J. Rickard
	W. V. Barnes		B. Scott
	M. J. Bennett	Mathematics:	H. G. Pinsent
	Miss P. M. Brown	Metallurgy:	G. P. Jones
	A. L. Bull		J. R. Stubbles
	I. S. Fox	Meteorology:	W. T. Roach
	G. Lowe	Physics:	D. J. Blundell
	W. I. Stuart		M. Gadsden
	D. M. Wells		A. Goodings
Chemical Engineering:	P. Levine		B. W. Petley
	R. D. Evered		G. Wexler
	A. E. Mitson		C. B. Wheeler
Engineering:	C. G. Lennox		P. H. White
	M. Redwood	Plant Physiology:	E. J. Guthrie
Geology:	P. Clifford		T. Reynolds

KINGS COLLEGE—LONDON

Chemistry:	D. M. Adams	Mathematics:	J. Brindley
	A. F. Chaplin		J. G. T. Jones
	K. S. Ennor	Physics:	Miss I. M. Hoppett
	J. K. Hambling		L. D. Isaacs
	T. M. Moyneham		S. B. Wright
	D. Walmsley		I. J. Zucker
Engineering:	J. N. Hutchinson	Zoology:	J. C. Perryman

QUEEN MARY COLLEGE—LONDON

Chemistry:	T. Mole	Mathematics:	J. F. Bowers
	R. J. Sampson	Physics:	P. Gray
	D. S. Urch		R. E. Turner
Engineering:	A. E. D. Heylen	Zoology:	D. A. Dorsett
	C. G. Plane		Miss D. M. Duval

ROYAL HOLLOWAY COLLEGE—LONDON

Chemistry:	Miss M. A. Place	Physics:	Miss J. B. Ramage

UNIVERSITY COLLEGE—LONDON

Botany:	D. H. Bone	Mathematics:	G. M. L. Gladwell
	Miss J. K. Wright		I. C. Pull
Chemistry:	J. D. Backhurst	Physics:	A. C. Butcher
	S. J. Bass		G. R. Davies
	P. E. Francis		P. I. P. Kalmus
	B. L. Silver		K. Smith
	A. J. Rhind-Tutt		J. B. Thompson
Chemical Engineering:	E. J. Roberts	Statistics:	D. J. Bartholomew
Geology:	C. A. Sizer	Zoology:	A. W. C. Blackler

BATTERSEA POLYTECHNIC—LONDON

Chemistry:	R. H. Jones	Chemical Engineering:	P. S. Houston

CHELSEA POLYTECHNIC—LONDON

Subject	*Student*	*Subject*	*Student*
Biology:	A. L. Bartlet	Chemistry:	W. A. Cramp

LONDON SCHOOL OF ECONOMICS

Industry:	K. Grossfield

SIR JOHN CASS COLLEGE—LONDON

Chemistry:	K. C. Bass

MANCHESTER UNIVERSITY

Chemistry:	H. V. Carter	Mathematics:	Miss D. M. Agar
	J. D. Cocker		G. Barratt
	D. W. Dicker		J. C. Howarth
	B. F. Gray	Metallurgy:	P. Cotterill
	G. Hughes	Physics:	Miss V. M. Bradley
	B. Nicholls		V. J. Emery
	J. B. Taylor		J. V. Evans
	W. B. Turner		P. Y. Millns
	T. I. Wrigley		B. W. Powell
Engineering:	P. J. Lawrenson		B. Rowson
	G. T. Roberts		A. W. Sharp
	B. N. Sharp		H. Steiner
	P. Wolstenholme		C. D. Watkins
			H. E. Wrigley

NORTH STAFFORDSHIRE UNIVERSITY COLLEGE

Chemistry:	H. D. Law	Mathematics:	J. S. Lowndes

NOTTINGHAM UNIVERSITY

Chemistry:	J. W. Gramshaw	Physics:	G. S. Barlow
	R. M. Powrie		M. M. Newmann
	G. Read		D. J. Sansom
	K. Wade		

OXFORD UNIVERSITY

Biochemistry:	Miss H. M. Hallaway	Mathematics:	R. J. R. Hayward
Botany:	D. H. Jennings	Physics:	J. Butler
	Miss M. E. Marker		C. A. Caine
Chemistry:	K. N. Bascombe		L. J. Challis
	D. A. Blackadder		D. C. Champeney
	R. A. Care		L. A. Edelstein
	R. M. Haines		R. A. Kamper
	J. W. Lewis		J. N. Lyness
	D. C. Nonhebel		H. Morton
	J. Robbins		M. F. Partridge
	H. L. Roberts		A. D. Petford
	I. W. Scott		R. G. Scurlock
	F. J. Smith		R. T. Taylor
	D. N. Waters		A. G. Warner
	D. Watt	Psychology:	D. H. Drazin
	J. D. Wilson	Zoology:	Q. Bone
	J. Winternitz		M. G. Hardy
	C. R. Worthing		D. Nichols
Geology and Mineralogy:	E. I. Hamilton		

READING UNIVERSITY

Chemistry:	R. S. W. Braithwaite	Physics:	S. D. Smith

ST. ANDREWS UNIVERSITY

Subject	*Student*	*Subject*	*Student*
Chemistry:	Miss F. G. Smith	Physiology and	
	J. S. Sneezum	Biochemistry:	J. F. Mitchell
Physics:	N. B. Johnson	Zoology:	C. K. Goddard
	K. J. H. Mackay		

SHEFFIELD UNIVERSITY

Botany:	H. J. Hudson	Fuel Technology:	A. G. Raper
Chemistry:	C. I. Ayres	Metallurgy:	G. Greetham
	K. Jewers	Mining:	D. R. Bridger
	B. J. Kirkbride		C. Fairhurst
	A. F. Turner	Physics:	K. E. Banyard
	M. J. G. Williams		P. Rogers
Engineering:	J. Allison	Zoology:	Miss M. Dinsley

SOUTHAMPTON UNIVERSITY

Botany:	W. F. T. Hartill	Engineering:	J. White
Chemistry:	A. G. McKenna	Mathematics:	C. J. Hall
	A. W. White	Zoology:	S. K. Eltringham

UNIVERSITY COLLEGE OF WALES, ABERYSTWYTH

Botany:	K. W. Jones	Physics:	G. T. Williams
	D. L. Thomas	Zoology:	H. H. Williams
Chemistry:	G. R. Nash		

UNIVERSITY COLLEGE OF NORTH WALES, BANGOR

Chemistry:	J. M. Evans	Physics:	D. Griffiths
			D. G. Hughes

UNIVERSITY COLLEGE OF SOUTH WALES, CARDIFF

Chemistry:	J. L. Cotter
	G. L. Mattok

UNIVERSITY COLLEGE, SWANSEA

Botany:	D. A. Griffiths	Mathematics:	R. H. Thomas
Chemistry:	J. M. Thomas	Metallurgy:	E. R. Hayward
	C. A. Wellington	Physics:	D. M. Parkyn

ROYAL TECHNICAL COLLEGE, GLASGOW

Technical Chemistry:	E. Jones	Technical Chemistry:	A. C. K. Smith
	W. Lawrie		

MANCHESTER COLLEGE OF TECHNOLOGY

Chemistry:	G. H. Cowan	Chemistry:	Miss S. Hollingshead
	J. P. Critchley	Physics:	B. D. Dunkerley
	G. F. Hewitt		A. Menarry

ROYAL TECHNICAL COLLEGE, SALFORD

Chemistry:	P. A. Lowe

COLLEGE OF AERONAUTICS, CRANFIELD

Engineering:	W. A. J. Davie
	N. C. Soper

APPENDIX VI

A. GRANTS FOR SPECIAL RESEARCHES IN PROGRESS ON 1ST OCTOBER, 1953

Investigator	Subject	Grant	Period covered
		£	
	ABERDEEN UNIVERSITY		
Professor R. V. Jones	Study of some electrical and optical properties of semi-conductors	3,000	2 years from 1st October, 1953
	BIRMINGHAM UNIVERSITY		
Professor P. B. Moon	Construction of a 1,000 MeV proton synchrotron for nuclear physics research and experimental work with 60 in. cyclotron.	231,500	Originally 6½ years from 1st April, 1946: extended to 31st March, 1955.
Professor P.B. Moon	Running expenditure on nuclear physics research	196,100	5 years from 1st August, 1952
Professor R. E. Peierls	High-energy meson reactions	750	2 years from 1st October, 1953
Professor M. Stacey	Chemistry of the organic compounds of fluorine	2,500	1¼ years from 1st October, 1952
	BRISTOL UNIVERSITY		
Professor A. R. Collar	Design, construction and operation of a shock tube for the study of boundary layer phenomena in high-speed flow.	185	1 year from 1st January, 1953
Dr. F. C. Frank	Examination of crystal surfaces	1,600	2 years from 1st October, 1952
Dr. L. C. Jackson	Investigation of the helium film	1,600	2 years from 1st October, 1952
Professor N. F. Mott	Mechanical properties of silver halides	500	1 year from 1st October, 1953
Professor C. F. Powell	High-altitude balloon flights	3,300	2 years from 1st October, 1952
	CAMBRIDGE UNIVERSITY		
Dr. J. Barker	Studies in plant metabolism	6,400	3 years from 1st October, 1953
Dr. F. P. Bowden	Application of reflexion electron microscopy to the study of the structure and structural changes in solid surfaces.	900	2 years from 1st October, 1953
Dr. F. P. Bowden	Surface properties of solids in particular the friction, surface structure, surface deformation of non-metallic solids.	800	2 years from 1st October, 1952
Professor Sir Lawrence Bragg and Professor O. R. Frisch.	Running expenditure on nuclear physics research	65,500	5 years from 1st August, 1952
Professor Sir Lawrence Bragg and Professor O. R. Frisch.	Construction of 300–400 MeV linear electron accelerator	160,000	5⅛ years from 1st June, 1952*

* Discontinued, February, 1954.

Investigator	Subject	Grant	Period covered
		£	
	CAMBRIDGE UNIVERSITY—(*continued*)		
Dr. V. Cochran	(1) X-ray investigation of the stereochemistry of nucleotide ... (2) X-ray study of the hydrogen bond	1,100	2 years from 1st October, 1952
Dr. V. E. Cosslett	Attainment of sub-microscopic resolution with an X-ray microscope and its applications in biology.	3,100	2 years from 1st October, 1953
Professor H. J. Emeleus	Synthesis and reactions of organo-metallic and organo-metalliod compounds containing fluorcarbon radical.	1,250	3 years from 1st October, 1952
Mr. W. B. Harland	Gravity surveys and density determinations in Great Britain ...	300	1 year from 1st October, 1953
Dr. C. F. A. Pantin	The elementary nervous system	700	2 years from 1st October, 1952
Dr. G. Porter	Free radical studies by the method of flash photolysis and spectroscopy.	1,200	2 years from 1st October, 1952
Mr. J. A. Ratcliffe	Investigation of sources of radio waves in the galaxy	33,900	5 years from 1st October, 1949
Dr. S. K. Runcorn	Investigations on the ore minerals in relation to the magnetization of rocks.	475	3 years from 1st October, 1953
Dr. S. K. Runcorn	Palaeomagnetic investigations	1,140	3 years from 1st January, 1952
Dr. S. K. Runcorn	Geomagnetism	2,000	2 years from 1st October, 1952
Dr. M. V. Wilkes	The calculation of Fourier synthesis by the electronic digital computer.	1,225	2 years from 1st October, 1952
	DURHAM COLLEGES		
Professor F. A. Paneth	Application of radio-active tracer methods to physico-chemical problems.	100	1 year from 1st October, 1953
	KING'S COLLEGE, NEWCASTLE		
Dr. K. H. Jack	The structural chemistry and the physical metallurgy of iron-carbon nitrogen alloys and of other binary and ternary interstitial alloy systems.	508	3 years from 1st October, 1951
	EDINBURGH UNIVERSITY		
Sir Edward Appleton	The study of ionspheric world morphology	500	2 years from 1st October 1952
Sir Edward Appleton	(1) The elucidation of electron recombination problems at low pressure. (2) The elucidation of the geometric distortion anomaly of the F_2 layer.	1,000	1 year from 1st October, 1953

	GLASGOW UNIVERSITY		
Professor P. I. Dee	Construction of a 300 MeV electron synchroton and other high-energy equipment for nuclear physics research.	354,700	8 years from 1st April, 1947
Professor P. I. Dee	Running expenditure on nuclear physics research	72,500	5 years from 1st August, 1952
Professor J. M. Robertson	Bond-length variations in organic molecules	1,600	4 years from 1st December, 1951
	LEEDS UNIVERSITY		
Professor F. G. Cox	Development of computing techniques for X-ray analysis and other branches of physics and chemistry.	3,800	4 years from 1st December, 1949
Professor E. G. Cox	Crystallographic computations on the Manchester University electronic computer *inter alia* for molecular electron densities.	1,500	3 years from 1st October, 1953
Professor F. S. Dainton	Entropy of high polymers	2,000	3 years from 1st October, 1952
Dr. R. D. Preston	Biophysical investigations in plants	4,350	2 years from 1st October, 1952
	LIVERPOOL UNIVERSITY		
Professor H. Fröhlich	Theoretical investigations of nuclear processes at medium and high energies.	3,600	3 years from 1st October, 1953
Professor H. W. B. Skinner	Construction of a 400 MeV proton synchro-cyclotron and other high-energy equipment for nuclear physics research.	617,500	9 years from 1st April, 1946
Professor H. W. B. Skinner	Running expenditure on nuclear physics research	209,500	5 years from 1st August, 1952
	UNIVERSITY COLLEGE, LONDON		
Professor A. V. Hill	Mechanics and thermodynamics of living material...	1,150	2 years from 1st October, 1952
Professor H. S. W. Massey	Interaction of high-energy cosmic ray particles in argon in an attempt to observe V particles produced in the gas of a high-pressure cloud chamber operated at mountain altitude.	3,577	3 years from 1st October, 1953
Professor H. S. W. Massey	Nuclear and electronic collisions of electrons and positrons in the energy range of 200 keV to 20 MeV.	3,325	3 years from 1st October, 1951
	KING'S COLLEGE, LONDON		
Dr. F. C. Champion	Examination of nuclear processes by ionization chamber, electrical counter, cloud chamber, and photographic emulsion techniques.	1,600	8 years from 1st November, 1946
	IMPERIAL COLLEGE, LONDON		
Professor P. M. S. Blackett	(1) V-particles ... ... (2) Time variation and direction of arrival of extensive showers of energy up to 10^{17}ev. (3) Palaeomagnetism	5,000	1 year from 1st October, 1954 (see p. 260).
Dr. E. C. Cherry	Research in psycho-acoustics	2,000	2 years from 1st October, 1953
Dr. Willis Jackson	Electrical machine and power-network analysis	8,000	3 years from 1st October, 1953

Investigator	Subject	Grant	Period covered
		£	
	IMPERIAL COLLEGE, LONDON—(*continued*)		
Dr. J. Lamb	Ultrasonic investigations on liquids and gases over the frequency range 10^4 to 10^9 cycles per second.	4,000	3 years from 1st October, 1953
Dr. F. D. Richardson	Compilation of physico-chemical and especially thermodynamic data on metallurgical processes.	1,450	3 years from 1st October, 1951
Dr. K. D. Tocher	The development of a pilot-model parallel-working computer ...	3,000	2 years from 1st October, 1953
Professor D. Williams	Fundamental research on the principles and processes of geo-chemical dispersion in rocks, soils, etc., as applied to mineral exploration.	1,000	2 years from 1st October, 1953
	QUEEN MARY COLLEGE, LONDON		
Dr. W. J. Hickinbottom	Synthesis and reactions of branched chain hydro-carbons... ...	500	2 years from 1st August, 1952
Dr. G. O. Jones	Investigations at low temperatures	5,000	3 years from 1st October, 1952
	THE LISTER INSTITUTE OF PREVENTIVE MEDICINE, LONDON		
Dr. J. Baddiley	The chemistry of nucleotide coenzymes	1,450	2 years from 1st October, 1953
	MANCHESTER UNIVERSITY		
Professor A. C. B. Lovell	Radio astronomy	230,000	4 years from 1st April, 1952
Professor A. C. B. Lovell and Professor N. F. Mott	Simultaneous photographic and radio-echo studies of meteors ...	1,742	2 years from 1st October, 1953
	OXFORD UNIVERSITY		
Lord Cherwell	Construction of a 140 MeV electron synchrotron and other high-energy equipment for nuclear physics research.	191,000	Originally 6½ years from 1st April, 1946; extended to 31st March, 1955.
Lord Cherwell	Running expenditure on nuclear physics research	197,100	5 years from 1st August, 1952
Dr. A. Long	Intensities in the Raman effect, bond polarizabilities and bond character; a theoretical and experimental study.	500	3 years from 1st April, 1951
	ST. ANDREWS UNIVERSITY		
Professor E. Finlay-Freundlich ...	Design of a mounting for a Schmidt telescope	800	1 year from 1st October, 1953
Professor E. Finlay-Freundlich ...	Extension of the classical theory of celestial mechanics to the dynamics of star systems.	1,350	3 years from 1st January, 1952
	UNIVERSITY COLLEGE, DUNDEE		
Professor D. H. Everett...	Thermodynamic properties of solutions; the design and construction of a high-precision adiabatic calorimeter.	1,500	3 years from 1st October, 1951

	SOUTHAMPTON UNIVERSITY		
Professor H. A. Jahn	Binding of ρ-shell nuclei	450	1 year from 1st October, 1953
	UNIVERSITY COLLEGE, NORTH STAFFORDSHIRE		
Dr. P. H. Plesch...	Studies on the chemistry and kinetics of cationic polymerization	1,000	2 years from 1st June, 1952
	UNIVERSITY COLLEGE OF WALES, ABERYSTWYTH		
Professor T. A. Stephenson	Distribution of algae and animals on the British coasts between tidemarks.	(1) 1,125 (2) 200	2 years from 1st October, 1952 2 years from 1st December, 1952
	UNIVERSITY COLLEGE OF THE SOUTH WEST, EXETER		
Dr. S. J. Gregg	The strength of brittle solids	1,900	3 years from 1st May, 1952
Dr. L. H. Long	Valance-state energies of chemically combined atoms	1,425	3 years from 1st October, 1951
Professor H. O. W. Richardson ...	(1) Studies in the beta-ray and gamma-ray spectra of nuclei by magnetic spectrometry. (2) Studies in the angular correlation of gamma-rays and beta-rays.	2,108	1 year from 1st October, 1953
	TECHNICAL COLLEGE, BRADFORD		
Mr. K. L. Butcher	Energy changes accompanying the solution of non-electrolytes ...	175	2 years from 1st October, 1952

B. GRANTS FOR SPECIAL RESEARCHES AUTHORISED DURING THE YEAR ENDED 30TH SEPTEMBER, 1954

	BIRMINGHAM UNIVERSITY		
Professor P. B. Moon	Running expenditure on nuclear physics research (supplementary grants).	26,500	Remainder of the 5 years from 1st August, 1952.
	CAMBRIDGE UNIVERSITY		
Dr. J. Barker	Studies in plant metabolism	442	2 years from 1st October, 1954
Mr. B. C. Browne	Geophysical investigations	850	1 year from 1st October, 1954
Professor J. Gray	Mechanism of navigation in birds	1,550	1¾ years from 1st January, 1954
Dr. C. F. A. Pantin	The elementary nervous system	700	2 years from 1st October, 1954
Mr. J. A. Ratcliffe	Analysis of records from ionospheric observations...	8,100	3 years from 1st October, 1954
Professor R. O. Redman	Construction of Balcock solar magnetograph	4,000	3 years from 1st October, 1954
Dr. S. K. Runcorn	Palaeomagnetism	6,300	3 years from 1st October, 1954
Mr. M. Ryle	Radio astronomy	11,550	3 years from 1st October, 1954
	EDINBURGH UNIVERSITY		
Sir Edward Appleton	The interpretation of ionospheric data	1,000	1 year from 1st October, 1954
	GLASGOW UNIVERSITY		
Professor P. I. Dee	Running expenditure on nuclear physics research (supplementary grant).	20,000	Remainder of the 5 years from 1st August, 1952.

Investigator	Subject	Grant	Period covered
		£	
	LIVERPOOL UNIVERSITY		
Professor H. W. B. Skinner	Running expenditure on nuclear physics research (supplementary grant).	20,000	Remainder of the 5 years from 1st August, 1952.
	UNIVERSITY COLLEGE, LONDON		
Professor A. V. Hill	Mechanics and thermodynamics of living material...	650	1 year from 1st October, 1954
Professor H. S. W. Massey	(1) The scattering of positrons by electrons...	3,732	2 years from 1st October, 1954
	(2) Interaction of high-energy cosmic ray particles in argon in an attempt to observe V-particles produced in the gas of a high-pressure cloud-chamber operated at mountain altitude.		
	(3) The scattering of high-energy nucleons by atomic nuclei		
	IMPERIAL COLLEGE, LONDON		
Dr. A. R. Bothroyd	Transit circuit applications	2,209	2 years from 1st October, 1954
Professor P. M. S. Blackett	(1) V-particles	22,667	$2\frac{1}{6}$ years from 1st October, 1954 (see p. 257).
	(2) Time variation and direction of arrival of extensive showers of energy up to 10^{17}ev.		
	(3) Palaeomagnetism (extension of grant)		
Professor P. M. S. Blackett	Continental drift by rock magnetic studies in India, Africa, etc. ...	12,000	3 years from 1st October, 1954
Professor Sir Alfred Egerton	Investigation of the ignition delays of pre-heated gases	1,100	2 years from 1st July, 1954
Professor P. A. Sheppard	Physical and chemical properties of water	14,250	3 years from 1st October, 1954
Professor D. Williams, Dr. J. S. Webb, Dr. A. J. E. Welch.	Geochemical technique of mineral exploration	12,000	3 years from 1st October, 1954
	ROYAL HOLLOWAY COLLEGE, LONDON		
Professor S. Tolansky	Study of surface microtopography of diamonds and other crystals and fine machine finished metal bearing surfaces.	4,500	1 year from 1st October, 1954
	BATTERSEA POLYTECHNIC, LONDON		
Mr. L. W. Derry	Effect of galvanic coupling on the corrosion fatigue properties of high-tensile aluminium alloys.	3,000	3 years from 1st October, 1954
	SIR JOHN CASS COLLEGE, LONDON		
Dr. A. J. Lindsey	The composition of the organic constituents of town air	550	1 year from 1st October, 1954

	INSTITUTE OF ARCHAEOLOGY, LONDON		
Professor F. E. Zeuner	Radiocarbon dating	2,000	15th September, 1954, to 30th September, 1957.
	MANCHESTER COLLEGE OF TECHNOLOGY		
Mr. C. Adamson	Basic design and pilot equipment for a universal electrical power-system simulator.	1,000	1 year from 1st January, 1954
Dr. H. Lipson	Electronic development of diffraction spectroscope	360	1 year from 1st October, 1954
Dr. P. W. Rowe	Sheet-pile walls at failure	1,440	3 years from 1st October, 1954
	ST. ANDREWS UNIVERSITY		
Professor E. Finlay-Freundlich ...	Design of a mounting for a 37-in. Schmidt-Cassegrain telescope in St. Andrews.	700	1 year from 1st October, 1954
	SOUTHAMPTON UNIVERSITY		
Professor J. E. G. Raymont	Conditions of the large-scale culture and harvesting of marine phytoplankton.	800	2 years from 1st October, 1954

APPENDIX VII

(A) LIST OF DEPARTMENTAL PUBLICATIONS ISSUED DURING THE YEAR

(Note: Publications issued by H.M. Stationery Office are obtainable from the addresses given on the back cover of this publication)

Prices in brackets include postage

HEADQUARTERS

PUBLISHED BY H.M. STATIONERY OFFICE

Report of the Department of Scientific and Industrial Research for 1952–53 (Cmd. 9083) 8*s.* 0*d.* (8*s.* 4*d.*)

Cathodic Protection of Pipelines and Storage Tanks, by V. A. Pritula (Translated from Russian) 10*s.* 0*d.* (10*s.* 4*d.*)

The B.C.S.O. Review of Science in the U.S.A. for the year ending June, 1953 2*s.* 0*d.* (2*s.* 1½*d.*)

Notes on Grants awarded by D.S.I.R. to Research Workers and Students (Revised 1954) 6*d.* (7½*d.*)

Human Relations in Industry, March, 1953 to March, 1954. First Report of a Joint Committee of D.S.I.R. and the Medical Research Council (Chairman A. B. Waring, Esq.) 1*s.* 0*d.* (1*s.* 1½*d.*)

Scientific Research in British Universities, 1953–54 10*s.* 0*d.* (10*s.* 7*d.*)

Selenium: A Short Review of its Production and Utilization with Reference to the Current Shortage, by R. Ashton, E. G. Hill and D. Neville-Jones 1*s.* 6*d.* (1*s.* 7½*d.*)

PUBLISHED IN JOURNALS

GASS, J. R. The Human Element in the Application of Science, *Impact Sci. Soc., Paris*, 1954, 5 (2), 93—112

HILL, E. G. The Work of the T.I.D.U. *Aslib Proc.*, 6 (2), 94–100

HINGSTON, W. G. The Department of Scientific and Industrial Research. *Progress*, 1954, 43 (241), 236–240

HOGBEN, B. Science and Industrial Waste. Part II. *Bull. Industr. Recovery Advisory Councils*, 1954, 4 (7), 2–4

HOGBEN, B. and THOROGOOD, A. L. Research Reduces Waste. *Bull. Industr. Recovery Advisory Councils*, 1953, 4 (8), 2–3

KING, A. Industry and the Need for Research. *Vickers Overseas News*, Winter, 1953–4

KING, A. Organization of Science in the United Kingdom. *Teknillisen Kemian Aikakansilchti*, Winter 1953 (Special British Number)

KING, A. The Influence of Science in Industrial Productivity. *Teknillisen Kemian Aikakansilchti*, Winter, 1953

KING, A. Chemistry and International Life. *Teknillisen Kemian Aikakansilchti*, 11, Vussikerta 9, May, 1954

KING, A. The Story of E.P.A. *The Manager*, 1954, 22 (9), 588–592

KING, A. Management and Technological Innovation. *The Manager*, 1954, 22 (9), 588–592

KING, A. Science et Orientation Nouvelle de l'Industrie. La Nef: Cahier No. 6 "La Science et l'Homme" June, 1954

KING, A. Governments and Science. Memorial du Progrés Scientifique et Technique, 1954. Comité Permanent d'Organisation du Congrés Internationaux du Progrés Scientifique et Technique

KNOX, J. Organizing for Applied Research in the Civilian Field. *Impact Sci. Soc., Paris*, 1954, 5 (3), 174–190

LOCKSPEISER, SIR BEN. Manufactures. *J. R. Soc. Arts*, 1954, 102 (4923), 406–421

LOCKSPEISER, SIR BEN. Science and our Industrial Future. *Research*, 1954, 7 (6), 236–241

NEVILLE-JONES, D. Photosynthesis and Algal Culture. *Impact Sci. Soc., Paris*, 1954, **5** (2), 93–112
RUDD, E. The Collection of Data from Firms. *Nature, Lond.*, 1954, **174**, 500
STANSFIELD, R. G. Empirical Research in Industry. *Nature, Lond.*, 1953, **172**, 897
THOROGOOD, A. L. Science and Salvage. *Bull. Industr. Recovery Advisory Councils*, 1954, **4** (11), 2–3
THOROGOOD, A. L. Bricks from Pulverised Fuel Ash. Summary of Paper. *Bull. Industr. Recovery Advisory Councils*, 1953, **4** (9), 5–6
URQUHART, D. J. Facts and Faith. *J. Documentation*, 1954, **10** (3), 123–126

OTHER PUBLICATIONS

Unanswered Questions No. 10 *(Unpriced)*
Research at Your Service *(Unpriced)*
Using New Ideas *(Unpriced)*
What Science Means to Industry, by Sir Ben Lockspeiser. (Address given at the Apprentices Conference organized by an Industrial Welfare Society, September, at 1954) *(Unpriced)*

BUILDING RESEARCH

PUBLISHED BY H.M. STATIONERY OFFICE

Annual Report of the Building Research Board, and the Director of Building Research—
Building Research, 1952 3*s.* 6*d.* (3*s.* 8*d.*)
Building Research, 1953 3*s.* 6*d.* (3*s.* 8*d.*)

Building Science Abstracts. Published monthly 3*s.* 6*d.* (3*s.* 7½*d.*)
Annual Subscription rate (including Index No.) Including postage £2 4*s.*
Vol. XXIII, 1950, Name and Subject Indexes
Vol. XXVI Nos. 3–12, March–Dec., 1953
Vol. XXVII Nos. 1–8, Jan.–Aug., 1954
Vol. XXVI 1953, Name and Subject Indexes

National Building Studies
RESEARCH PAPERS
No. 18. Part VI. Fire Resistance of Reinforced Concrete Columns 3*s.* 0*d.* (3*s.* 2*d.*)
No. 19. Dynamic Stresses in Cast Iron Girder-Bridges 3*s.* 0*d.* (3*s.* 2*d.*)
SPECIAL REPORTS
No. 21. 2nd Report: Productivity in Home Building 1*s.* 9*d.* (1*s.* 10½*d.*)
No. 23. A Study of Concreting methods on Housing Sites by K. G. H. Fryer, and J. F. Eden 2*s.* 6*d.* (2*s.* 7½*d.*)

Building Research Station Digests. Published monthly 3*d.* (4½*d.*)
Annual Subscription rate (Including postage) 3*s.* 6*d.*
No. 58. Wall and Ceiling Surfaces and Condensation
No. 59. Use of Hardwoods in Building
No. 60. Condensation in Domestic Chimneys
No. 61. Index to Building Research Station Digests Nos. 1 to 60
No. 62. Review of Enquiries, 1953
No. 63. Questions and Answers
No. 64. Painting Metals in Buildings
No. 65. Floor Finishes Based on Polyvinyl Chloride (P.V.C.) and Polyvinyl Acetate (P.V.A.)
No. 66. Questions and Answers
No. 67. Miscellany
No. 68. Damp-Proof Courses
No. 69. Avoiding Defects in Internal Plastering
No. 36. Sound Absorbent Treatment *(Revised)*

PUBLISHED IN JOURNALS

ALLEN, W. A. Heating and Ventilating in American Factories. *J. Instn Heat. Vent. Engrs*, 1954, **21** (221), 393–401
ALLEN, W. A. United States can Teach a Lesson in Adaptability. *Manchester Guardian*, 5th April, 1954, p. 8
ALLEN, W. A. and MILLS, E. D. Building Materials and Techniques. *J. R. Inst. Brit. Archit.*, 1954, **61** (8), 302–320: Discussion, 320–327

ATKINSON, G. A. Building Techniques Overseas—I. *Prefabrication*, 1954, **1** (9), 7–13
ATKINSON, G. A. Building Techniques Overseas.—II. *Prefabrication*, 1954, **1** (10), 7–12
ATKINSON, G. A. Low-cost Housing in Asia; the Importance of Experimental Research and of International Collaboration. *Nirman*, 1954, **2** (1), 41–48
ATKINSON, G. A. Housing in British Colonial Territories: a Review of Recent Developments. *Builder, Lond.*, 1954, **187** (5826), 630–631
ATKINSON, G. A. Tropical Architecture and Building Standards. *Conference on Architecture*, 1953, *Proceedings, London*, 1954, pp. 41–61
BARON, D. K. Research and Building in Scotland To-Day. *J. Instn. Munic. Engrs.*, 1953, **80** (5), 281–288
BATESON, R. G. A Sensitive Floor for Examining the Movement of Traffic. *J. sci. Instrum.*, 1954, **31** (9), 336–337
BROUGHTON, H. F. Economy in Building. *Builder, Lond.*, 1954, **186** (5788), 171–172, 181–182
BROUGHTON, H. F. Economy in Building. *J. R. Inst. Brit. Archit.* 1954, **61** (4), 149–152; discussion, 153–154
BROUGHTON, H. F. and REINERS, W. J. Sub-contracting in House-building. *Builder, Lond.*, 1953, **185** (5779), 790–791
BROUGHTON, H. F. and REINERS, W. J. Incentive Schemes in House-building. *Builder, Lond.*, 1953, **185** (5778), 758–759.
BUTTERWORTH, B. Pulverized Fuel Ash in Brickmaking. *Brit. Clayw.*, 1953, **62** (740), 277–281
BUTTERWORTH, B. Properties of Clay Building Materials. *Brit. Ceram. Soc.*, Jubilee Volume, 1953, 824–877
BUTTERWORTH, B. Lessons of the Visit to France. *Claycraft*, 1954, **27** (8), 400–405
BUTTERWORTH, B. Bricks made with Pulverized Fuel Ash. *Trans. Brit. Ceram. Soc.*, 1954, **53** (5), 293–313
BUTTERWORTH, B. Contributions to the Study of Efflorescence. Part 8. The Camerman Theory. *Trans. Brit. Ceram. Soc.*, 1954, **53** (9), 563–602; discussion, 602–607
CLARKE, N. W. B. Measuring Loads in Wires: two Simple Devices to Ensure Accuracy in Prestressing. *Engineering, Lond.*, 1954, **177** (4613), 812–815
COLLINS, B. G. An Instrument for Recording the Frequency of Hourly Wind Speeds. *Met. Mag., Lond.*, 1954, **83** (986), 232–234
COLLINS, J. B. and HOPKINSON, R. G. Flicker-Discomfort in Relation to the Lighting of Buildings. *Trans. Illum. Engng Soc.*, 1954, **19** (5), 135–158; Discussion, 158–167
COOLING, L. F. and MARSLAND, A. Soil Mechanics Studies of Some Failures in the Sea Defence Banks of Essex and Kent. *Instn Civ. Engrs Proc. of Conference on East Coast Floods, held December*, 1953, published 1954, pp. 58–73
COOPER, H. G. Multi-storey Flats with Climbing Shuttering; the Hochhaus, Hamburg, Germany, *Architect, Lond.*, 1954, **206** (15), 434–439
DANTER, E. Temperature Gradients in Factories. *J. Instn Heat. Vent. Engrs*, 1954, **21** (221), 381–393
DAY, A. H. Dampness and Condensation in Dwelling Houses. *Munic. J., Lond.*, 1954, **62** (3213), 2219, and *Plumb. and Decor.*, 1954, **76** (909), 36, 38, 62
DICK, J. B. Roof Condensation in an Air-conditioned Factory. *J. Instn Heat. Vent. Engrs*, 1954, **21** (221), 371–380
DUFTON, A. F. Some Hygrometric Data. New Delineated. *J. Instn Heat. Vent. Engrs*, 1953, **21** (220), 349–351
ELDRIDGE, H. J. Common Defects in Buildings. *Parthenon*, 1954, **28** (1), 5–12
GIBSON, R. E. (HENKEL, D. J.) Influence of Duration of Tests at Constant Rate of Strain on Measured " Drained " Strength. *Géotechnique, Lond*, 1954, **4** (1), 6–15
HOPKINSON, R. G. Application of Glare Studies. *Tidskrift för Ljuskultur*, 1953, **25** (4), 95–97
HOPKINSON, R. G. Flicker-Discomfort in Relation to the Lighting of Buildings. *Tidskrift för Ljuskultur*, 1954, **26**, 29–33
HOPKINSON, R. G. Measurements of Sky Luminance Distribution at Stockholm. *J. Opt. Soc. Amer.* 1954, **44** (6), 455–9; *Tidskrift för Ljuskultur*, 1954, **26**, 48–50
HOPKINSON, R. G. Reflected Daylight. *Archit. (Build.) J.*, 1954, **120** (3101), 173–177
HOPKINSON, R. G. Calculation of the Indirect Daylight Component for Roof-lights. *Archit. (Build.) J.*, 1954, **120** (3107), 355–356
HOPKINSON, R. G., LONGMORE, J. and PETHERBRIDGE, P. An Empirical Formula for the Computation of the Indirect Component of Daylight Factor. *Trans. Illum. Engng Soc.*, 1954, **19** (7), 201–219
HOPKINSON, R. G., and PETHERBRIDGE, P. Two Supplementary Studies on Glare. *Trans. Illum. Engng Soc.*, 1954, **19** (7), 220–224
HOPKINSON, R. G., and PETHERBRIDGE, P. The Natural Lighting of Buildings in Sunny Climates by Sunlight reflected from the Ground and from opposing Facades. *Report of the Proceedings of the Conference on Tropical Architecture, London*, 1953, pp. 63–70
JONES, F. E. Alkali-aggregate Interaction in Concrete. *Chem. & Ind. (Rev.)*, 1953 (52), 1375–1382

KINNIBURGH, W. and MACTAGGART, J. A Photographic Method for the Spacial Reconstructions and Analysis or Motions. *Time and Motion Study*, 1954, 3 (1), 11-19.
KINNIBURGH, W. and MACTAGGART, J. Snap Observations Helps Time Study in Building. *Manager*, March, 1954, 179–182
LONGMORE, J. and HOPKINSON, R. G. A Simple Daylight Factor Meter. *J. sci. Instrum.*, 1954, 31 (6), 214–217
MACK, G. W. The Priming of Plasters. *Paint*, 1954, 24 (2), 54–56
MACK, G. W. Economical Maintenance of Iron and Steel. *Munic. J., Lond.*, 1954, 62 (3191), 861, 863
MACK, G. W. Distempering. *Munic. J., Lond.*, 62 (3201), 1439, 1445
MACK, G. W. Why Paint fails. *Munic. J., Lond.*, 1954, 62 (3210), 1995–1997
MACK, G. W. Emulsion paints. *Munic. J., Lond.*, 1954, 62 (3205) 1693–1695
MASON, P. A Compression Instrument for Use with Pastes. *J. sci. Instrum.*, 1953, 30 (11), 418–421
MATTHEWS, W. R. A Lifting Device for Handling Bricks. *Contract J.*, 1953, 151 (3881), 627–628
MATTHEWS, W. R. Lifting Device for Handling Bricks by Crane on Building Sites. *British Constructional Engineer*, 1954, 4 (4), 36–37
NASH, G. D. Condensation in Buildings. *Archit. (Build.) J.*, 1954, 119 (3072), 49–54
NEWBERRY, C. W. A Squat Gauge for Measurement of Static and Transient Compressive Loads, Particularly Where the Axis of Loading may be Variable or Uncertain. *Engineering, Lond.*, 1954, 177 (5498) 339–341
NEWMAN, A. J. and TEYCHENNE, D. C. A Classification of Natural Sands and their Use in Concrete Mix Design. *Cement, Lime and Grav.*, 1954, 28 (12), 588–604
PARKER, T. W. From Pozzolan to Polyethylene. *Building Materials Digest*, 1954, 14 (1), 14–16, 14 (2), 53–54
PARKER, T. W. Research on Materials, Components and Elements of Structures. *International Council for Building Research Studies and Documentation (CIB)* 1953 *Proceedings*, pp. 61–68
PARKER, T. W. (and P. ARCTANDER). International Collaboration in Research. Future Plans. *International Council for Building Research Studies and Documentation (CIB)* 1953 *Proceedings*, pp. 46–48
PARKIN, P. H. and STACY, E. F. Recent Research on Sound Insulation in Houses and Flats. *J. R. Inst. Brit. Archit.*, 1954, 61 (9), 372–376
PARKIN, P. H. and PURKIS, H. S. Noise Levels Underneath some Civilian Aircraft Shortly After Take Off. *Acustica*, 1954, 4 (4), 439–440
PENMAN, A. D. M. Shear Characteristics of a Saturated Silt, Measured in Triaxial Compression. *Géotechnique, Lond.*, 1953, 3 (8), 312–328
PENMAN, A. D. M. House Foundations on Shrinkable Clay. *Association of Rural District Council Surveyors Journal*, 1954 (14), 25–28
PETHERBRIDGE, P. and LONGMORE, J. Solid Angles Applied to Visual Comfort Problems. *Light and Ltg*, 1954, 47 (6), 173–177
PICKLES, A. T. Research on the Efficiency of Buildings; Heating and Ventilation, Lighting, Sound Insulation and Acoustics. *International Council for Building Research Studies and Documentation (CIB)* 1953, *Proceedings*, pp. 84–88
PIPPARD, N. S. and BUCKLE, W. G. Prefabrication in Traditional House-building. *Prefabrication*, 1954, 1 (7), 15–18
SIMONS, R. A. Discussion on Model Building Byelaws. *J. R. Inst. Brit. Archit.*, 1954, 61 (9), 361–366
STONE, P. A. and REINERS, W. J. Organization and Efficiency of the House-building Industry in England and Wales. *Journal of Industrial Economics*, 1954, 2 (2), 118–134
THOMAS, F. G. Code of Practice for Load-bearing Walls (C.P.111). *Builder, Lond.*, 1954, 186 (5791), 308
WHITAKER, T. Improvement of Workability by the Use of Concrete Plasticisers. *Civ. Engng, Lond.*, 1954, 49 (577), 721–722
WISE, A. F. E. Design Factors for One-pipe Drainage. *J. R. Sanit. Inst.*, 1954, 74 (4), 231–241
WISE, A. F. E. and CROFT, J. Investigation of Single-stack Drainage for Multi-storey Flats. *J. R. Sanit. Inst.*, 1954, 74 (9), 797–826
WOOD, R. H. A Derivation of Maximum Stanchion Moments in Multi-Storey Frames by Means of Nomograms. *Structr. Engr*, 1953, 31 (11), 316–328
WOOD, R. H. Discussion of "Some Recent Foundation Research and its Application to Design", by G. G. Meyerhof. *Structr. Engr*, 1954, 32 (5), 156–157
WOODHOUSE, W. M. Building and Housing in the West Indies. *Prefabrication*, 1954, 1 (10), 13–18

ISSUED GRATIS

Building Research Station. Its History, Organization and Work (Revised Edition) May, 1954

CHEMICAL RESEARCH

PUBLISHED BY H.M. STATIONERY OFFICE

Annual Report of the Chemistry Research Board, and the Director of the Chemical Research Laboratory—
Chemistry Research, 1953 2*s.* 6*d.* (2*s.* 8*d.*)

PUBLISHED IN JOURNALS

ANDON, R. J. L., COX, J. D. and HERINGTON, E. F. G. The Thermodynamic Properties of Dilute Solutions of Pyridine Bases in Water. *Disc. Faraday Soc.*, 1953, **15**, 168

BARBER, C. R., HANDLEY, R. and HERINGTON, E. F. G. The Preparation and Use of Cells for the Realization of the Triple Point of Water. *Brit. J. appl. Phys.*, 1954, **5**, 41

BIDDISCOMBE, D. P., COULSON, E. A., HANDLEY, R. and HERINGTON, E. F. G. The Preparation and Physical Properties of Pure Pyridine and Some Methyl Homologues. *J. Chem. Soc.*, 1954, 1957

BRASHER, Miss D. M. and KINGSBURY, A. H. Electrical Measurements in the Study of Immersed Paint Coatings on Metal. I. Comparison between Capacitance and Gravimetric Methods of Estimating Water-Uptake. *J. appl. Chem.*, 1954, **4**, 62

BURSTALL, F. H., FORREST, Mrs. P. J., KEMBER, N. F. and WELLS, R. A. Ion-Exchange Process for the Recovery of Gold from Cyanide Solution. *Industr. Engng Chem.*, 1953, **45**, 1648

BUTLIN, K. R. and POSTGATE, J. R. Microbiological Formation of Sulphide and Sulphur. *6th Int. Congr. Microbiol., Rome*, 1953, 126

BUTLIN, K. R. and POSTGATE, J. R. Economic Importance of Autotrophic Microorganisms. *Autotrophic Micro-organisms* (Ed. Fry, B. A., and Piel, J. L.), 1954, 271

CONWAY, D. E., GREEN, T. H. G. and REICHENBERG, D. Kinetics of Sodium-Hydrogen Exchange of Monofunctional Cationic Exchange Resin containing Carboxyl Groups. *Trans. Faraday Soc.*, 1954, **50**, 511

COX, J. D., CHALLONER, A. R. and MEETHAM, A. R. The Heats of Combustion of Pyridine and certain of its Derivatives. *J. Chem. Soc.*, 1954, 265

EVANS, R. F., HERINGTON, E. F. G. and KYNASTON, W. The Determination of the Thermodynamic Dissociation Constants of the Pyridine-monocarboxylic acids by Ultra-violet Photoelectric Spectrophotometry. *Trans. Faraday Soc.*, 1953, **49**, 1284

FARRER, T. W. A Suggested Method of Evaluating the Porosity of Coatings on Ferrous Metals. *Chem. & Ind.* (Rev.), 1954, 77

GROSSMAN, J. P. and POSTGATE, J. R. The Estimation of Sulphate-Reducing Bacteria. *Proc. Soc. appl. Bact.*, 1953, **16**, 1

HALES, J. L., JONES, J. I. and LINDSEY, A. S. The Mechanism of the Kilbe-Schmitt Reaction. *Chem. & Ind.* (Rev.), 1954, 49

HERINGTON, E. F. G., DENHAM, A. B. and MALDEN, P. J. The Freezing Point of Pure Naphthalene. *J. chem. Soc.*, 1954, 2643

HEWETSON, C. E. C. and MURCH, Mrs. E. H. A Scheme for Circulating Periodicals. *Aslib Proc.*, 1953, **5** (2), 131

HOOKWAY, H. T. and TOWNSEND, R. Osmotic Measurements with Poly(vinyl alcohol) Membranes. *13th Int. Congr. Pure and appl. Chem., Stockholm*, 1953 (Abstract only)

HUNT, E. C. and WELLS, R. A. The Absorpiometric Estimation of Niobium and Tantalum with Pyrogallol. *Analyst*, 1954, **79**, 345

HUNT, E. C. and WELLS, R. A. Inorganic Chromatography. Part XV. A Rapid Chromatographic Method for the Determination of Niobium in Low Grade Samples. *Analyst*, 1954, **79**, 351

KNIVETT, V. A. Phosphorylation coupled with Anaerobic Breakdown of Citrulline. *Biochem. J.*, 1954, **56**, 602

KNIVETT, V. A. The Effect of Arsenate on Bacterial Citrulline Breakdown. *Biochem. J.*, 1954, **56**, 606

LEWIS, J. A. and OVERTON, K. C. Automatic Recording of Ion Concentration in Flowing Solution by a Polarographic Method. *Analyst*, 1954, **79**, 293

MERCER, R. A. and WELLS, R. A. Inorganic Chromatography on Cellulose. Part XIV. A Shortened Chromatographic Method for the Determination of Niobium and Tantalum in Minerals and Ores. *Analyst*, 1954, **79**, 339

PEPPER, K. W., PAISLEY, H. M. and YOUNG, M. A. Properties of Ion-Exchange Resins in Relation to their Structure. Part VI. Anion-Exchange Resins obtained from Styrene-divinyl Benzene Co-polymers. *J. chem. Soc.*, 1953, 4097

PEPPER, K. W. and REICHENBERG, D. The Influence of the Degree of Crosslinking on Certain Fundamental Properties of Cation-Exchange Resins of the Sulphonated Polystyrene Type. *Z. Elektrochem.*, 1953, **57**, 183

POSTGATE, J. R. On the Nutrition of *Desulphovibrio desulphuricans*—a correction. *J. gen. Microbiol.*, 1953, **9**, 440

REICHENBERG, D. Applications of Ion-Exchange Resins. *Research, Lond.*, 1953, 6, 302
SANYAL, B. and PRESTON, R. St. J. Note on the Anomalous Behaviour of Ammonium Chloride Particles on the Corrosion of Steel in Humid Atmospheres. *Chem. & Ind.* (Rev.), 1953, 995
SANYAL, B. and PRESTON, R. St. J. Corrosion Inhibitive Compositions as Temporary Protectives of Steel against Atmospheric Corrosion. *J. appl. Chem.*, 1953, 3, 366
STROUD, E. G. and RHOADES-BROWN, J. E. Note on the Protection of Mild Steel by Films of Lanolin. *J. appl. Chem.*, 1953, 3, 287
THOMAS, S. L. S. and TURNER, H. S. Synthesis of Isotopically Labelled Organic Compounds. *Quart. Rev. chem. Soc., Lond.*, 1953, 7 (4), 407
VERNON, W. H. J. Corrosion: A Field for Action. *Chem. & Ind.* (Rev.), 1953, 982
WELLS, R. A. Inorganic Chromatography. *Quart. Rev. chem. Soc., Lond.*, 1953, 7 (203), 307
WORMELL, F. Corrosion Inhibitors in Neutral Aqueous Solutions. *Chem. & Ind., (Rev.)*, 1953, 556
WORMELL, F., NURSE, T. J. and ISON, H. C. K. Corrosion of Mild Steel Moving Rapidly in Salt Solutions and Neutral Waters. *J. appl. Chem.*, 1953, 3, 275

FIRE RESEARCH

PUBLISHED BY H.M. STATIONERY OFFICE

Annual Report of the Fire Research Board, and the Director of Fire Research—
Fire Research, 1953 2*s.* 6*d.* (2*s.* 8*d.*)
Bulletin
No. 1. Fire and the Atomic Bomb, by D. I. Lawson 2*s.* 6*d.* (2*s.* 7½*d.*)
Special Report
No. 2. Heat Transfer by Radiation, by J. H. McGuire 1*s.* 6*d.* (1*s.* 7½*d.*)
National Building Studies
SPECIAL REPORT
No. 22. Fire Hazard of Internal Linings, by D. Hird and C. F. Fischl 1*s.* 3*d.* (1*s.* 4½*d.*)

PUBLISHED IN JOURNALS

Western Red Cedar Shingle Roofs. *Fire Prot. Assoc. J.*, 1954 (26), 249–254
ASHTON, L. A. Comparative Tests on Prestressed and Reinforced Concrete Floors during and after Fires. *Civil Engng, Lond.*, 1953, **48** (569), 1035–1038
ASHTON, L. A. Prestressed Concrete and High Temperatures. *Fire Prot. Assoc. J.*, 1954 (25), 203–209
ASHTON, L. A. and BIGMORE, R. H. The Fire-Resistance of No-Fines Concrete Walls. *Civil Engng, Lond.*, 1954, **49** (576), 597–599; (577), 729–731; (578), 841–843
BIRTWISTLE, S. Experiments at the Fire Research Station. A Small-Scale Test for Measuring the Spread of Flame over the Surfaces of Wall and Ceiling Linings. *Timber Tech.*, 1953, **61** (2172), 481–482; (2173), 542–543
BOWES, P. C. Spontaneous Heating and Ignition in Iron Pyrites. *Industr. Chem. Mfr*, 1954, **30** (348), 12–14
BOWES, P. C. Factors Limiting General Application of the Mackey Test for Spontaneous Heating and Ignition. *J. appl. Chem.*, 1954, **4** (3), 140–144
BURGOYNE, J. H. and WEINBERG, F. J. Determination of the Distribution of Some Parameters across the Combustion Zone of a Flat Flame. *Proc. roy. Soc. A.*, 1954, **224**, 286–308
CLARKE, S. H. Research into Fire Protection. *Financial Times*, 1954 (20260), IV
COLEMAN, E. H. and TONKIN, P. S. The Fire Hazard of Mixtures of Acetone and Methylene Chloride. *Fire Prot. Assoc. J.*, 1954 (25), 226–229
COLEMAN, E. H. and THOMAS, C. H. The Products of Combustion of Chlorinated Plastics. *J. appl. Chem.*, 1954, **4** (7), 379–383
FRENCH, R. J. and HINKLEY, P. L. The Resistance of Fire-Fighting Foams to Destruction by Petrol. *J. appl. Chem.*, 1954, **4** (9), 513–516
FRY, J. F. The Hazard of the Domestic Fire. *J. R. Inst. Brit. Archit.*, 1953, **61** (1), 18–20
FRY, J. F., THOMAS, P. H. and SMART, P. M. T. The Production of Fire-Fighting Sprays by Impinging Jets. *Quart. Instn Fire Engrs, Edinb.*, 1954, **14** (14), 112–128
LAWSON, D. I. and HIRD, D. A Photometric Method of Determining Configuration Factors. *Brit. J. appl. Phys.*, 1954, **5** (2), 72–74
LAWSON, D. I. and MCGUIRE, J. H. The Solution of Transient Heat-Flow Problems by Analogous Electrical Networks. *Proc. Instn. mech. Engrs, Lond.* (A), 1953, **167** (3), 275–290
MCGUIRE, J. H. and FISCHL, C. F. Nomograms for Solving One-Dimensional Steady-State Conduction Problems Involving Cooling to the Atmosphere. *J. Instn Heat. Vent. Engrs*, 1953, **21** (219), 303–308

NASH, P. and GREGSTEN, M. J. The Radial Temperature Gardient across the Walls of Cylindrical Pipes Containing Heated Fluids. *J. Instn Heat. Vent. Engrs*, 1954, **21** (223), 475–483; **22** (228), 183–185

RASBASH, D. J. The Problem of Smoke in Fire-Fighting. *Fire Prot. Assoc. J.*, 1954 (24), 163–169

RASBASH, D. J. and ROGOWSKI, Z. W. The Extinction of Liquid Fires with Water Sprays. *Chem. and Ind. (Rev.)*, 1954 (24), 693–695

OTHER PUBLICATIONS

KINGMAN, F. E. T. Spontaneous Heating and Smouldering Conference Proceedings of the Thirtieth Annual General Meeting held in the Winter Gardens, Llandudno, N. Wales. Institution of Fire Engineers, 1953, 90–99

FOOD INVESTIGATION

PUBLISHED BY H.M. STATIONERY OFFICE

Annual Report of the Food Investigation Board and the Director of Food Investigation—
Food Investigation, 1953 — 3*s.* 6*d.* (3*s.* 8*d.*)
Food Science Abstracts. Published Bi-monthly — 14*s.* 0*d.* (14*s.* 4*d.*)
Annual subscription rate (including Index number) (Including postage) — £4 10*s.*
Vol. 25, No. 6, Nov. 1953
Vol. 26, Nos. 1–5, Jan.–Sept. 1954
Leaflets
No. 3. The Care of the Trawler's Fish (Revised) — 9*d.* (10½*d.*)
Miscellaneous
Research on Food Preservation in the United Kingdom — 2*s.* 0*d.* (2*s.* 1½*d.*)

PUBLISHED IN JOURNALS

ANSBACHER, F. and JASON, A. C. Effect of Water Vapour on the Electrical Properties of Anodized Aluminium. *Nature, Lond.*, 1953, **171**, 177

BANKS, A. The Drying of Fish in Cold Store. *Proc. Inst. Refrig.*, 1951–52, p. 109 (1953)

BANKS, A., EDDIE, G. C. and LONG, R. A. F. The Design of the New Cold Stores at Torry Research Station. *Mod. Refrig.*, 1954, **57**, 6

BARKER, J. and MAPSON, L. W. Studies in the Respiratory and Carbohydrate Metabolism of Plant Tissues. V. Experimental Studies of the Formation of Carbon Dioxide and of the Changes in Lactic Acid, Sucrose and in certain Fractions of Keto-acids in Potato Tubers in Air Following Anaerobic Conditions. VI. Analysis of the Inter-relationship Between the Rate of Carbon Dioxide Production and the Changes in the Contents of Lactic Acid, Sucrose and of Certain Fractions of Keto-acids in Potato Tubers in Air Following Anaerobic Conditions. *Proc. roy. Soc.* B, 1953, **141**, 321, 338

BARKER, J. and SAIFA, A. F. EL. Studies in the Respiratory and Carbohydrate Metabolism of Plant Tissues. III. Experimental Studies of the Formation of Carbon Dioxide and of the Changes in Lactic Acid and Other Products in Potato Tubers in Air Following Anaerobic Conditions. IV. The Relation Between the Rate of Carbon Dioxide Production in Potato Tubers in Air Following Anaerobic Conditions, and the Accompanying Changes in Lactic Acid Content and Sugar Concentration. *Proc. roy. Soc.*, 1953B, **140**, 508, 522

BARUAH, P. and SWAIN, T. The Effect of L-ascorbic Acid on the *In Vitro* Activity of Polyphenoloxidase from Potato. *Biochem. J.*, 1953, **55**, 392

BATE-SMITH, E. C. Astringency in Foods. *Food*, 1954, **23**, 124

BATE-SMITH, E. C. Freezing, Chilling and Cold Storage of Meat. I. Theoretical Considerations. *Proc. Inst. Refrig.*, 1952–53, 49, 103

BATE-SMITH, E. C. Subjective Assessment. *Research, Lond.*, 1953, **6**, 26

BATE-SMITH, E. C. and SWAIN, T. Identification of Leuco-anthocyanins as "Tannins" in Foods. *Chem. and Ind. (Rev.)*, 1953, p. 377

BATE-SMITH, E. C. and SWAIN, T. The Isolation of 2^1: 4: 4^1–Trihydroxychalkone from Yellow Varieties of *Dahlia Variabilis*. *J. chem. Soc.*, 1953, (450), p. 2185

BATE-SMITH, E. C. and SWAIN, T. and POPE, G. S. The Isolation of 7-hydroxy-4^1-methyoxyisoflavone (formononctin) from Red Clover *Trifolium pratense*, (L) and a Note of the Identity of Pratol. *Chem. and Ind. (Rev.)*, 1953, p. 1127

BENDALL, J. R. The Effect of Pyrophosphate on the Shortening of Muscle-Fibre Models in the Presence of Adenosine Triphosphate. *Nature, Lond.*, 1953, **172**, 586

BENDALL, J. R. Further Observations on a Factor (the "Marsh factor") Affecting Relaxation of ATP-shortened Muscle-fibre Models, and the Effect of Ca and Mg ions upon it. *J. Physiol.*, 1953, **121**, 232

BENDALL, J. R. Myokinase as a Relaxing Factor in Muscle. *Nature, Lond.*, 1954, **173**, 548

BENDALL, J. R. The Relaxing Effect of Myokinase on Muscle-Fibres; its Identity with the "Marsh factor". *Proc. roy. Soc.* B., 1954, **142**, 409

BENDALL, J. R. and MARSH, B. B. The Biochemistry of Muscular Tissue in Relation to Loss of Drip During Freezing. *Proc. 8th Int. Congr. Refrig., London*, 1951, p. 351, 1953.

BOARDMAN, N. K. and PARTRIDGE, S. M. Separation of Neutral Proteins on Ion-exchange Resins. *Nature, Lond.*, 1953, **171**, 208

BOARDMAN, N. K. and PARTRIDGE, S. M. Separation of Neutral Proteins on Ion-exchange Resins. *J. Polym. Sci.*, 1954, **12**, 281

BROOKS, J. Humidity Control in Egg Storage. *Proc. Inst. Refrig.*, 1951–52, 1953, p. 94.

BROOKS, J. The Preservation of Eggs. *Chem. and Ind. (Rev.)*, 1953, p. 636

BROOKS, J. and HOLMES, N. E. The Oiling and Cold Storage of English Eggs. *Proc. 8th Int. Congr. Refrig., Lond.*, 1951, 1953, p. 538

BRYAN, J. M. Plating Tin on Aluminium by Chemical Displacement. *Metal Ind.*, 1953, **83**, 461, 502

BURTON, W. G. and MANN, G. The Late Storage of Potatoes in England and Wales. *Agric., Lond.*, 1954, **60**, 466

CHEN, Y. T., ISHERWOOD, F. A. and MAPSON, L. W. Quantitive Estimation of L-ascorbic Acid and Related Substances in Biological Extracts by Separation on a Paper Chromatogram. *Biochem. J.*, 1953, **55**, 821

CONNELL, J. J. Studies on the Proteins of Fish Skeletal Muscle. 1. Electrophoretic Analysis of Codling Extracts of Low Tonic Strength. *Biochem. J.*, 1953, **54**, 119

CONNELL, J. J. Studies on the Proteins of Fish Skeletal Muscle. 2. Electrophoretic Analysis of Low Tonic Strength Extracts of Several Species of Fish. *Biochem. J.*, 1953, **55**, 378

CUTTING, C. L. Changes in the pH and Suffering Capacity of Fish During Spoilage. *J. Sci. Fd Agric.*, 1953, **4**, 597

CUTTING, C. L. Fish Preservation down the Ages. *Fish Ind.*, 1953, **2** (7), 36, (8), 38, (9), 19.

CUTTING, C. L. The Humber Laboratory—a new D.S.I.R. Laboratory for Fish Research. *Nature, Lond.*, 1953, **171**, 159

CUTTING, C. L. The Quality of Fish—can it be Improved? *Fishing News*, 1954, (2144) 9, (2145), 9, (2146), 9, (2147), 9, (2148), 9, (2149), 9.

CUTTING, C. L. and JASON, A. C. A Simple Apparatus for the Calibration of Hygrometers. *J. sci. Instrum.*, 1953, **30**, 338.

EDDY, B. P. Bacterial Degradation of Chlorine. *Nature, Lond.*, 1953, **171**, 573.

EDDY, B. P. The Chemical Sterilization of Glass Vessels. *Lab. Practice*, 1954, **3**, 58

EDDY, B. P. and INGRAM, M. Interaction between Ascorbic Acid and Bacteria. *Bact. Rev.*, 1953, **17**, 93

EDE, A. J. Heat Transfer by Natural Convection in Refrigerated Liquids. *Proc. 8th Int. Congr. Refrig., Lond.*, 1951, p. 260, 1953

EHRENBERG, A. S. C. Notes on Plank's Rational Method of Grading Food Quality. *Food Tech.*, 1953, **7**, 188

EHRENBERG, A. S. C. and SHEWAN, J. M. The Objective Approach to Sensory Tests of Food. *J. Sci. Fd Agric.*, 1953, **4**, 482

FARMILOE, F. J., CORNFORD, S. J., COPPOCK, J. M. B. and INGRAM, M. The Survival of Bacillus Spores in Baking Bread. *J. Sci. Fd Agric.*, 1954, **5**, 292

FIDLER, J. C. The Concentration of Volatile Organic Compounds in Gas-stores Containing Apples and Pears, and Methods for Removing them. *Proc. 8th Int. Congr. Refrig., Lond.*, 1951, p. 429, 1953

FIDLER, J. C. How the Biologist can Assist in Design of Refrigerating Plant. *Mod. Refrig.*, 1953, **56**, 461

FIDLER, J. C. Trends and Practices in the Refrigerated Storage of Foodstuffs in the Commonwealth. *Mod. Refrig.*, 1953, 66, 373, and *Annexe* 1953–54 in *Bull. Inst. Int. Froid. Commissions* 3 *and* 5, *Mons, Belgium*, 14–16 April, 1953, p. 29.

GANE, R. Pilot Plant Experiments on the Refrigerated Gas-storage of Gros Michel Bananas. *Trop. Agric., Trin.*, 1953, **29**, 150

GANE, R. The Work of the Food Investigation Organization. *Proc. 8th Int. Congr. Refrig., Lond.*, 1951, p. 766, 1953

HANNAN, R. S. The Effect of the Ionizing Radiations on Foodstuffs. *Chem. and Ind. (Rev.)*, 1954, p. 393

HANNAN, R. S. Electronic Sterilization. *Proc. Soc. appl. Bact.*, 1953, **16**, 88

HANNAN, R. S. Electronic Sterilization of Foods. *Research, Lond.*, 1953, **6**, 376

HANNAN, R. S. The Preservation of Food with Ionizing Radiation. *Food Sci. Abstr.*, 1954, **26**, 121

HANNAN, R. S. The Preservation of Foods with Ionizing Radiations. *Nature, Lond.*, 1954, **173**, 752

HANNAN, R. S., DAVIES, M. I. and INGRAM, M. The Effects of Ionizing Radiations on Micro-organisms. *Chem. and Ind. (Rev.)*, 1954, p. 392

HANNAN, R. S. and SHEPHERD, H. J. Some After-effects in Fats Irradiated with High Energy Electrons and X-rays. *Trans. Faraday Soc.*, 1953, **49**, 326

HANNAN, R. S. and SHEPHERD, H. J. Some After-effects in Fats Irradiated with High Energy Electrons and X-rays. *Brit. J. Radiol.*, 1954, **27**, 36

HULME, A. C. The Isolation of L-citramalic Acid from the Peel of the Apple Fruit. *Biochem. Biophys. Acta*, 1954, **14**, 36

HULME, A. C. An Action of Strongly Basic Anion-exchange Resins and Solutions Containing Sugars. *Nature, Lond.*, 1953, **171**, 610

HULME, A. C. A new Hydroxy-acid in the Peel of Apple Fruits. *Nature, Lond.*, 1953, **172**, 346.

HULME, A. C. The Oxidation of Citramalic Acid and β-hydroxy Glutaric Acid to Acetacetic Acid and the Possible Significance of Citramalic in Plant Metabolism. *Biochem. Biophys. Acta*, 1954, **14**, 44

HULME, A. C. The Relation Between the Rate of Respiration of an Apple Fruit and its Content of Protein. II. The Value of the Relation Immediately After Picking and at the Respiration Climacteric for Several Varieties of Apples. *J. hort. Sci.*, 1954, **29**, 98

HULME, A. C. Studies on the Maturity of Apples. I. Respiration Progress-curves for Cox's Orange Pippin Apples for a Number of Consecutive Seasons. *J. hort. Sci.*, 1954, **29**, 142

HULME, A. C. Studies in the Nitrogen Metabolism of Apple Fruits. The Climacteric Rise in Respiration in Relation to Changes in Equilibrium Protein Synthesis and Breakdown. *J. exp. Bot.*, 1954, **5**, 159

HULME, A. C. and ARTHINGTON, W. The Oxidation of Quinic Acid. *J. exp. Bot.*, 1953, **4**, 129

HULME, A. C. and RICHARDSON, A. The Non-volatile Organic Acids of Grass. *J. Sci. Fd Agric.*, 1954, **5**, 221

INGRAM, M. Sterilization by Radiation. *Chem. and Ind. (Rev.)*, 1953, p. 348

INGRAM, M. and PAGE, L. J. A Simple Electrical Recorder of the Bacterial Colonies Enumerated in Viable Counts. *Lab. Practice*, 1954, **3**, 385.

INGRAM, M. and PAGE, L. J. The Survival of Microbes in High-frequency Voltage Fields. *Proc. Soc. appl. Bact.*, 1953, **16**, 69

ISHERWOOD, F. A. Synthesis of L-ascorbic Acid in Plants and Animals. *Proc. nutrit. Soc.*, 1953, **12**, 335

ISHERWOOD, F. A. and CRUICKSHANK, D. H. Chromatographic Separation and Analysis of Mixtures of Pyruvic, Oxalacetic and L-ketoglutaric Acids. *Nature, Lond.*, 1954, **173**, 121

ISHERWOOD, F. A. and CRUICKSHANK, D. H. A New Method for the Colorimetric Estimation of Amino Acids on Paper Chromatograms. *Nature, Lond.*, 1954, **174**, 123

ISHERWOOD, F. A. and HANES, C. S. Separation and Estimation of Organic acids on Paper Chromatograms. *Biochem. J.*, 1953, **55**, 824

ISHERWOOD, F. A., CHEN, Y. T. and MAPSON, L. W. Isolation of D-glyceric Acid from Cress Seedlings and its Relationship to the Synthesis of L-ascorbic Acid. *Biochem. J.*, 1954, **56**, 15

ISHERWOOD, F. A., CHEN, Y. T. and MAPSON, L. W. Synthesis of L-ascorbic Acid in Plants and Animals. *Nature, Lond.*, 1953, **171**, 348

ISHERWOOD, F. A., CHEN, Y. T. and MAPSON, L. W. Synthesis of L-ascorbic Acid in Plants and Animals. *Biochem. J.*, 1954, **56**, 1

JASON, A. C. Fish Preservation and Physics. *Research, Lond.*, 1954. **7**, 10

JASON, A. C. The use of High Speed Electromagnetic Relays in the Measurement of Capacitance and Frequency. *Lab. Practice*, 1954, **3**, 25

JONES, N. R. Enzymic cleavage of Anserine in Skeletal Muscle of Codling (*Gadus callarias*). *Biochem. J.*, 1954, **57**, xxiv

JONES, N. R. Taurine in Fresh and Iced Skeletal Muscle of Codling (*Gadus callarias*). *Biochem. J.*, 1954, **56**, xxii

KIDD, F. The Work of the Food Investigation Organization, D.S.I.R. *Chem. and Ind. (Rev.)*, 1953, p. 672

LAWRIE, R. A. The Activity of the Cytochrome System in Muscle and its Relation to Myoglobin. *Biochem. J.*, 1953, **55**, 298.

LAWRIE, R. A. The Onset of Rigor Mortis in Various Muscles of the Draught Horse. *J. Physiol.*, 1953, **121**, 275

LAWRIE, R. A. The Relation of Energy-rich Phosphate in Muscle to Myoglobin and to Cytochrome-oxidase Activity. *Biochem. J.*, 1953, **55**, 305.

LEA, C. H. Oxidation Defects of Milk and Dairy Products. *Proc. 8th Int. Dairy Congr., The Hague*, 1953, p. 1037

LEA, C. H. Problems Arising from the use of Chemicals in Food—Antioxidants. *Chem. and Ind. (Rev.)*, 1952, p. 178

LEA, C. H. Recent Developments in the Study of Oxidative Deterioration of Lipids. *Chem. and Ind. (Rev.)*, 1953, p. 1303

LEA, C. H. and RHODES, D. N. Determination of the Iodine Value of Phospholipids. *Analyst*, 1954, **79**, 304

LEA, C. H. and RHODES, D. N. Phospholipins. 1. Partition Chromatography of Egg Yolk Phospholipins on Cellulose. *Biochem. J.*, 1953, **54**, 467

LEA, C. H. and RHODES, D. N. Phospholipids. 2. Estimation of Amino Nitrogen in Intact Phospholipids. *Biochem. J.*, 1954, **56**, 613

LEA, C. H. and RHODES, D. N. Quantitive Separation of the Phospholipids of Egg Yolk on Silicic Acid. *Proc. biochem. Soc.*, 1954, **57**, 23

LOCKER, R. H. C-terminal Groups in Myosin, Tropomyosin and Actin. *Biochem. Biophys. Acta*, 1954, **14**, 533

LONG, R. A. K. An Automatic Micromanometer for the Measurement of Low Air Speeds. *J. sci. Instrum.*, 1953, **30**, 481

LONG, R. A. K. The Effect of Humidity Variation on the Operation of an Electronic Proximity Switch. *J. sci. Instrum.*, 1953, **30**, 422

LOVE, R. M. Deoxypentose Nucleic Acid in the Expressible Fluid of Cod Fillets. *Nature, Lond.*, 1954, **173**, 544

LOVE, R. M. A Qualitative Test for Monosaccharides. *Analyst*, 1953, **78**, 732

LOVE, R. M. Spectroscopic Studies of Carbohydrates. 1. The Action of Sulphuric Acid on Sugars. *Biochem. J.*, 1953, **55**, 126

LOVERN, J. A. Der Uhrsprung der Eigenart der Fette bei Fischen. *Fette und Seifen*, 1953, **55**, 425

LOVERN, J. A. and OLLEY, J. The Lipids of Fish. 2. The Acetone-soluble Lipids of the Flesh of the Haddock. *Biochem. J.*, 1953, **54**, 128

LOVERN, J. A. and OLLEY, J. The Lipids of Fish. 4. The Lipids Extracted by an Ethanol/ether Mixture from Haddock Flesh Previously Extracted with Acetone. *Biochem. J.*, 1953, **55**, 686

MANN, G. The Control of Relative Humidity in Cold Stores. The Loss of Water from Perishable Produce During Storage. *Proc. Inst. Refrig.*, 1953–54

MANSFIELD, G. H., SWAIN, T. and NORDSTRÖM, C. G. The Identification of Flavones by the Ultra-violet Absorption Spectra of Their Ions. *Nature, Lond.*, 1953, **172**, 23

MAPSON, L. W. The Enzymic Conversion of L-galactone-y-lactone to L-ascorbic Acid by Plant Mitochondria. *Proc. nutrit. Soc.*, 1953, **12**, 339

MAPSON, L. W. The Estimation of Oxidised Glutathione. *Biochem. J.*, 1953, **55**, 714

MAPSON, L. J. Function of Ascorbic Acid in Plants. *Vitamins and Hormones*, 1953, **11**, 1

MAPSON, L. W., SHERWOOD, F. A. and CHEN, Y. T. Biological Synthesis of L-ascorbic Acid: the Conversion of L-galactone-y-lactone to L-ascorbic Acid by Plant Mitochondria. *Biochem. J.*, 1954, **56**, 21

MUTCH, R. L. and EDDIE, G. C. An Air Blast Freezer for Research. *Mod. Refrig.*, 1953, **56**, 234

NORDSTRÖM, C. G. and SWAIN, T. The Flavonoid Glycosides of *Dahlia variabilis*. Parts I and II. *J. Chem. Soc.*, 1953 (555), p. 2764

NORDSTRÖM, C. G. and SWAIN, T. Isolation of a Benzylidenecoumaranone (aurone) from a Yellow Dahlia. *Chem. and Ind. (Rev.)*, 1953, p. 823

NORDSTRÖM, C. G., SWAIN, T. and HAMBLIN, A. J. The Flavone Glycosides of Parsley. Parts I and II. *Chem. and Ind. (Rev.)*, 1953, p. 85

OLLEY, J. Effect of Solute Concentration on Countercurrent Distribution of Phospholipins. *Biochem. Biophys. Acta*, 1953, **10**, 493

OLLEY, J. Instability of Phosphatidic Acids. *Chem. and Ind. (Rev.)*, 1954, p. 1069

OLLEY, J. and LOVERN, J. A. The Lipids of Fish. 3. The Acetone-insoluble Fraction of an Acetone Extract of the Flesh of the Haddock. *Biochem. J.*, 1953, **54**, 559

OLLEY, J. and LOVERN, J. A. The Lipids of Fish. 5. The Lipids Remaining in the Flesh of the Haddock After Extraction by Acetone and Ethanol-ether. *Biochem. J.*, 1954, **57**, 610

REAY, G. A. The Ocean as a Potential Source of World Food Supply. *Food Tech.*, 1954, **8**, 65

REAY, G. A. The Preservation of White Fish at Sea. *Proc. 8th Int. Congr. Refrig., Lond.*, 1951, p. 374, 1952

SHEWAN, J. M. The Bacteriology of Dehydrated Fish. II. The Effect of Storage Conditions on the Bacterial Flora. *J. Hyg., Camb.*, 1953, **51**, 347

SHEWAN, J. M. The Bacteriology of Dehydrated Fish. III. Observations and Experiments Made During Small Scale Commercial Production. *J. Hyg., Camb.*, 1954, **52**, 247

SHEWAN, J. M. The Nitrogenous Extractives from Fresh Fish Muscle. II. Comparison of Several Gadoid and Elasmobranch Species. *J. Sci. Fd Agric.*, 1953, **4**, 565

SHEWAN, J. M., HODGKISS, W. and LISTON, J. A Method for the Rapid Differentiation of Certain Non-pathogenic, Asporogenous Bacilli. *Nature, Lond.*, 1954, **173**, 208

SIMPSON, T. H. and WHALLEY, W. B. 2'-hydroxy- and 2'-methoxyflavones. *Chem. and Ind., (Rev.)*, 1954, p. 1111

SMITH, W. H. Can we Reduce Spoilage in Strawberry Marketing. *Fruit Tr. J.*, 1954, **105** (22), 22

SMITH, W. H. Non-freezing Injury to Plant Tissues Caused by Exposure to Low Temperature. *Proc. 8th Int. Congr. Refrig., Lond.*, 1951, p. 338, 1953

SWAIN, T. The Identification of Coumarins and Related Compounds by Filter Paper Chromatography. *Biochem. J.*, 1953, 200

SWAIN, T. Leucocyanidin. *Chem. and Ind. (Rev.)*, 1954, p. 1144

TOMKINS, R. G. Progress in the Storage of Fresh Fruit and Vegetables. *Grower*, Annual Fruit Review, Autumn 1954

TOMKINS, R. G. Unsolved Problems in the Preservation of Food. The Influence of Cultural Conditions on the Quality and Preservation of Fruits and Vegetables. *J. Sci. Fd Agric.*, 1954, **5**, 161

WAGER, H. G. The Effect of Artificial Wilting on the Sugar Content and Respiration Rate of Maturing Green Peas. *New Phytol.*, 1954, **53**, 354

WAGER, H. F. An Improved Copper Reduction Method for the Micro-determination of Reducing Sugars. *Analyst*, 1954, **79**, 34

WEBSTER, H. L. Direct Deamination of Adenosine Diphosphate by Washed Myofibrils. *Nature, Lond.*, 1953, **172**, 453

WEST, C. The History of Refrigerated Gas Storage for Horticultural Produce. *Proc. 8th Int. Congr. Refrig., Lond.*, 1951, p. 406, 1953

WEURMAN, C. and SWAIN, T. Chlorogenic Acid and the Enzymic Browning of Apples and Pears. *Nature, Lond.*, 1953, **172**, 678

YULE, P. A. A. and EDDIE, G. C. A Vertical Plate Freezer for Whole Fish. *Mod. Refrig.*, 1953, **56**, 441

ISSUED GRATIS

Food Advisory Note No. 3. The Care of the Trawler's Catch (Third Edition)
Food Advisory Note No. 10. Notes on the Preparation of Smoked Salmon

FOREST PRODUCTS RESEARCH

PUBLISHED BY H.M. STATIONERY OFFICE

Annual Report of the Forest Products Research Board and the Director of Forest Products Research—
Forest Products Research, 1953 3*s.* 0*d.* (3*s.* 2*d.*)

Bulletins

No. 26. An Atlas of End-grain Photomicrographs for the Indentification of Hardwoods 12*s.* 6*d.* (12*s.* 10*d.*)
No. 28. The Strength Properties of Timber, by F. H. Armstrong 2*s.* 0*d.* (2*s.* 1½*d.*)
No. 29. The Strength Properties of Plywood—
Part I. Comparison of 3-Ply Woods of a Standard Thickness, by W. T. Curry 1*s.* 3*d.* (1*s.* 4½*d.*)
No. 30. Mechanics of Sawing: Band and Circular Saws, by P. Harris 1*s.* 6*d.* (1*s.* 7½*d.*)
No. 31. Prevention of Decay of Wood in Boats, by J. G. Savory, with a contribution on Electrochemical Attack by D. F. Packman 2*s.* 0*d.* (2*s.* 1½*d.*)

PUBLISHED IN JOURNALS

BLETCHLY, J. D. The Effect of Hydrogen Cyanide on the Eggs of the Common Furniture Beetle. *Anobium punctatum* De G. *Bull. ent. Res.*, 1953, **44** (3), 415–418

BROCK, G. R. The Strength of Nailed Timber Joints. *Timb. Tech.*, 1954, **62**, 283–286 333–335

DOMAN, L. S. Wood and Glue. The Work of the Composite Wood Section of the Forest Products Research Laboratory. *Adhesives and Resins*, 1954

ENDERSBY, H. J. Improved Output from an Inserted Tooth Saw. *Wood*, 1954, **19** (1), 11–14

FINDLAY, W. P. K. and BADCOCK, E. C. Survival of Dry Rot Fungi in Air-dry Wood. *Timb. Tech.*, 1954, **62**, 137–138

FISHER, R. C. A Longhorn Beetle New to Britain. *Timb. Tech.*, 1954, **62**, 75

FISHER, R. C., THOMPSON, G. H. and WEBB, W. E. Ambrosia Beetles in Forest and Sawmill. Part I. Biology and Economic Importance. *For. Abs.*, 1953, **14** (4), 381–389. Part II. Prevention and Control. *For. Abs.*, 1954, **15** (1), 3–15

HENDERSON, F. Y. The Forest Products Research Laboratory of Great Britain. *J. For. Prod. Res. Soc.* (U.S.A.), 1954, **4** (2), 35A–37A

KNIGHT, R. A. G. Trials of Timbers for Plywood Manufacture. *Wood*, 1954, **19** (2), 76–80

KNIGHT, R. A. G. The Durability of Adhesives for Wood. *Timb. Tech.*, 1954, **62**, 124–126

KNIGHT, R. A. G. and NEWALL, R. J. Seven and a Half Years of Durability Tests on Adhesives in Plywood. *Wood*, 1954, **19** (7), 287–290

LAIDLAW, R. A. Wood Saponins. Part I. A Preliminary Investigation of the Saponins from Morabukea (*Mora gonggrijpii* (Kleinh.)) Sandwith. *J. Chem. Soc.*, 1954, 752–757

NEWALL, R. J. Surface Defects in Veneering. *Wood*, 1953, **18** (12), 462–465

PHILLIPS, E. W. J. Structure of Wood. *Research, Lond.*, 1953, **6** (10), 401–408

PHILLIPS, E. W. J. Influence of Leaf Activity on the Composition of the Wood Cell Wall. *Nature, Lond.*, 1954, **174**, (4419), 85–86

RICHARDSON, N. A. Wood Preservation. *Proc. Instn. Civ. Engrs.* (Pt. I), 1953, **2** (6), 649–663

SAVORY, J. G. Breakdown of Timber by Ascomycetes and Fungi Imperfecti. *Ann. appl. Biol.*, 1954, **41** (2), 336–347

SAVORY, J. G. Damage to Wood Caused by Micro-organisms. *Proc. Soc. appl. Bact.*, 1954, **41** (2), 336–347
SMITH, D. N. Examination of a Defective Creosoted Pole after Treatment by the Cobra Process. *Timb. Tech.*, 1953, **61**, 593–596
STEVENS, W. C. Softwood Floors in New Buildings. *Wood*, 1954, **19** (5), 194
WHITE, M. G. The House Longhorn Beetle (*Hylotrupes bajulus*) in Great Britain. *Forestry*, 1954, **27** (1), 31–40

ISSUED GRATIS

Forest Products Research Leaflets
No. 6. Dry Rot in Buildings—Recognition, Prevention and Cure. (Revised Edition)
No. 45. The Steam-bending Properties of Various Timbers. (Revised Edition)

FUEL RESEARCH

PUBLISHED BY H.M. STATIONERY OFFICE

Annual Report of the Fuel Research Board, and the Director of Fuel Research
Fuel Research, 1953 2*s.* 6*d.* (2*s.* 8*d.*)
Fuel Abstracts. Published monthly 8*s.* 6*d.* (8*s.* 9*d.*)
Annual subscription rate (including half-yearly Indexes (Including postage)) £5 5*s.* 0*d.*
Vol. XIII. Index, Jan.–June, 1953
Vol. XIV. Nos. 4–6, Oct.–Dec., 1953
Vol. XIV. Index, July–Dec., 1953
Vol. XV. Nos. 1–6, Jan.–June, 1954
Vol. XV. Index, Jan.–June, 1954
Vol. XVI. Nos. 1–3, July–Sept., 1954

PUBLISHED IN JOURNALS

ACKROYD, G. C. and CAWLEY, C. M. Preliminary Study of the Rheological Properties of Residual Fuel Oils in Relation to their Composition. *J. Inst. Petrol.*, 1953, **39**, 82–104
ACKROYD, G. C. and AUBREY, K. V. Some Observations on the Flow Properties of Residual Fuel Oils from Petroleum. *Proc. 2nd Internat. Congr. on Rheology*, 1953, 397–407.
AUBREY, K. V. Frequency Distribution of the Concentrations of Elements in Rocks. *Nature, Lond.*, 1954, **174**, 141–142
AUBREY, K. V. Occurrence of μ—Ca CO_3 in Boiler Scale. *Nature, Lond.*, 1954, **174**, 81
AUBREY, K. V. and PAYNE, K. W. Volatilization of Germanium during the Ashing of Coal. *J. Inst. Fuel*, 1954, **23** (20–21), 110
BAKER, C. Burning Baled Straw to Prevent Orchard Frost Damage. *Commercial Grower*, June, 1953, 1298–1299
BARDGETT, H. Carbonization of Blends of Coal to Produce Metallurgical Coke. *J. Inst. Fuel*, 1954, **27**, 274–298
BAILEY, A. E., KIMBERLEY, I. E. and WARD, S. G. Chemical Constitution of Coal I—Preparation and Properties of Humic Acids from Coal. *J. Inst. Fuel*, 1954, **33**, 209–221
CRAXFORD, S. R., POLL, A. and WALKER, W. J. S. Recovery of Sulphur from Flue Gas by the Use of Ammonia: A Summary of the Probable Costs of the Process. *J. Inst. Fuel*, 1953, **25**, 57–58
DANBY, C. J., SPALL, B. C., STUBBS, F. J. and HINSHELWOOD, SIR CYRIL. Modes of Decomposition of *n*-pentane. I. Pressure Changes and Mass Spectrometric Analysis. *Proc. roy. Soc. A.*, 1954, **223**, 421–429
ELDER, J. L., FIES, M. H., GRAHAM, H. G., MONTGOMERY, R. C., SCHMIDT, L. D. and WILKINS, E. T. The Second Underground Gasification Experiment at Gorgas, Alabama. *U.S. Bur. Mines Rep. Invest.*, 4808, October, 1951
FLETCHER, A. W. The Determination of Sulphur Trioxide in Gases. *Chem. and Ind. (Rev.)*, 1954 (27), 777–778
FOX, L. L. Some Measurements on the Smoke from Open Fires. *J. Inst. Fuel*, 1954, **27**, 385–389
FOX, L. L. and PALMER, P. L. The Use of Differential Thermocouples in the Measurement of the Heat Output of a Domestic Water Heater. *J. Instn Heat. Vent. Engrs*, 1954, **22**, 114–119
FOX, L. L., PACKHAM, C. G., PALMER, P. L. and WHITTAKER, D. Sampling Errors in Radiation Measurement Using the Moll Thermopile Method. *Brit. J. appl. Phys.*, 1953, **4**, 273–278

FOX, L. L., PARKER, J. and WHITTAKER, D. Water-heating Efficiency of Small Independent Boilers. *J. Inst. Fuel*, 1954, **27**, 193–195

FOX, L. L. and WHITTAKER, D. Relation Between Radiant Efficiency and Output of an Open Fire. *J. Instn Heat. Vent. Engrs*, 1953, **21**, 190–192: Discussion, 347–348

Fuel and Productivity. Presidential Address of the Director of Fuel Research to the Fuel Luncheon Club on 20th October, 1953, *Engineering*, 1953, **176**, 619

GIBSON, E. J. The Role of Alcohols in the Mechanism of the Fischer-Tropsch Synthesis: The Decomposition of Alcohols in the Presence of Cobalt Catalysts. *J. appl. Chem.*, 1953, **3**, 375–384

GIBSON, E. J. and HALL, C. C. The Fischer-Tropsch Synthesis with Cobalt Catalysts: The Effect of Process Conditions on the Composition of the Reaction Products. *J. appl. Chem.*, 1954, **4**, 49–61

HALL, C. C. Recent Developments in the Fischer-Tropsch Process. *The Gas World*, 1954, **89**, 49–54

HALL, C. C. The Fischer-Tropsch Process and its Potential Applications. *Industr. Chem.*, 1953, **29**, 400–404, 417

HURLEY, T. F. International Peat Symposium, 1954. *Nature, Lond.*, 1954, **174**, 483–485

JOLLEY, L. J. and POLL, A. Effects of Reactivity and Some Other Variables on Gasification of Coke with Steam. *J. Inst. Fuel*, 1953, **26**, 375–384

JOLLEY, L. J., POLL, A. and STANTAN, J. E. Fluidized Gasification Non-caking Coals with Steam in a Small Pilot Plant. Symposium on Gasification and Liquefication of Coal. Papers given at *Amer. Inst. Min. Met. Engrs*, 1952, 1953, 60–72

LAMBIE, R. Estimation of the Combustibility of Coal and Peat by the Godbert Inflammability Apparatus. *J. Inst. Fuel*, 1953, **26**, 251–254

MANNING, A. B. Size Analysis of Coke. *Coke and Gas*, 1954, **16**, 104–106

MANNING, A. B. The Use of "Random Numbers" in the Theory of Coal Sampling. *J. Inst. Fuel*, 1953, **26**, 107–108

MACDOUGALL, D. and BARDGETT, H. Low Temperature Carbonization of Coal. *Proc. XIth Internat. Congr. Pure and Appl. Chem.*, 1947, **4**, 451–460

NEWALL, H. E. Oils from Coal, Shale, and Other Materials. Part II. Distillation and Other Processes. *Ann. Petrol. Tech. Inst. Petrol*, 1951, **13**, 288–296

PARKER, A. Fuel and Productivity. Presidential Address of Director of Fuel Research to the Fuel Luncheon Club on 20th October, 1953. *Engineering*, 1953, **176**, 618

PARKER, A. The London Fog Disaster. *Proc. Ann. Conf. Nat. Smoke Abatement Soc., Glasgow*, 1953, 31–33

PARKER, A. Atmospheric Pollution Causes, Effects, and Prevention. *Proc. Instn Civ. Engng*, April 1954, Pt III, 99–124

PARKER, A. Fuel Research in Great Britain. IVA (Stockholm), 1951, **3**, 92–103

PARKER, A. and RICHARDS, S. H. Instruments used for the Measurement of Atmospheric Pollution in Great Britain. *Proc. U.S. Tech. Conf. Air Pollution*, 1950, 531–546

PALMER, P. L. A Device for Extending the Range of a Recording Potentiameter. *J. sci. Instrum.*, 1954, **31**, 197–199

PEARCE, C. A. R. An Electromagnetic Torquemeter for Use in Viscometry. *J. sci. Instrum.*, 1953, **30**, 232–236

PEARCE, C. A. R. A Simple Process Controller Using Uni-Selectors. *Instrum. Pract.*, 1953, **7**, 897–900

PEARCE, C. A. R. The Mechanism of the Resolution of Water-in-Oil Emulsions by Electrical Treatment. *Brit. J. appl. Phys.*, 1954, **5**, 136–143

PETTITT, N. E. Display Rack for Periodicals. *Libr. Assn Record*, 1953, **55** (12), 397

SHAW, W. F. B. The Testing of Domestic Solid Fuel Appliances. *Coal Mech. Shipp.*, **108** (2771), 11–17, **108** (2780), 203–210 and **108** (2784), 291–297

SPALL, B. C., STUBBS, F. J. and HINSHELWOOD, SIR CYRIL. Modes of Decomposition of *n*-pentane. II. Kinetic Considerations. *Proc. roy. Soc. A*, 1954, **223**, 429–437

SPALL, B. C., STUBBS, F. J., DANBY, C. J. and HINSHELWOOD, SIR CYRIL. The Modes of Decomposition of *n*-pentane. III. Fate of Ethane at Low Pressures. *Proc. roy. Soc. A*, 1954, **225**, 64–70

SPALL, B. C., STUBBS, F. J., HINSHELWOOD, SIR CYRIL. The Irreversible Formation of Methane in the System Ethane-Ethylene-Hydrogen. *Proc. roy. Soc. A*, 1953, **218**, 450–464

SPALL, B. C., STUBBS, F. J., and HINSHELWOOD, SIR CYRIL. The Influence of Nitric Oxide on the Two Opposing Reactions of the Equilibrium $C_2H_6 = C_2H_4 + H_2$. *Proc. roy. Soc. A*, 1953, **218**, 439–449

WILKINS, E. T. Air Pollution Aspects of the London Fog of December, 1952. *Quart. J. Roy. Meteor. Soc.*, 1954, **80**, 267–270

WILKINS, E. T. Air Pollution and the London Fog of December 1952. *J. Roy. Sanit. Inst.*, 1954, **74**, 1–15

WILKINS, E. T. and JOLLEY, L. J. The Catalytic Producion of Methane. *Proc. XIth Internat. Congr. Appl. Chem.*, 1947, **4**, 481–489

GEOLOGICAL SURVEY AND MUSEUM

PUBLISHED BY H.M. STATIONERY OFFICE

Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for the year 1952. 1953. 2*s.* 6*d.* (2*s.* 8*d.*)

Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for the year 1953. 1954. 3*s.* 0*d.* (3*s.* 2*d.*)

Bulletin of the Geological Survey of Great Britain, No. 5. 1954. 10*s.* (10*s.* 3*d.*)

I.—The Whittington Heath Borehole.
II.—Reddened Beds in the Coal Measures of South Lancashire.
III.—The Coal Measures of the *Anthraconaia lenisulcata* Zone in the East Midlands Coalfield.

Bulletin of the Geological Survey of Great Britain, No. 6. 1954 5*s.* 6*d.* (5*s.* 8*d.*)

I.—A Gravitational Survey of a Concealed Portion of the Warburton Fault near Lymm, Cheshire.
II.—A Gravimeter Survey over the Tilmanstone Fault, Kent Coalfield.
III.—A Vertical Force Magnetic Survey of the Coalisland District, Co. Tyrone, Northern Ireland.
IV.—The Least-Squares Method of Determining Regional Contours.
V.—A Gravimeter Survey of the Ston Easton–Harptree District, East Somerset.

Special Report on the Mineral Resources of Great Britain: vol. xxxvi. The Cambro-Ordovician Limestones and Dolomites of the Ord and Torran Areas, Skye, and the Kishorn Area, Ross-shire. 1954. 2*s.* 6*d.* (2*s.* 7½*d.*)

British Regional Handbooks:

East Anglia and Adjacent Areas (Third Edition). 1954. 5*s.* 0*d.* (5*s.* 3*d.*)
Wealden District (Third Edition). 1954. 5*s.* 0*d.* (5*s.* 3*d.*)

Geological Survey of Great Britain

ENGLAND AND WALES

Geology of the Country between Bradford and Skipton (Explanation of one-inch Sheet 69). 1953. 25*s.* 0*d.* (25*s.* 5*d.*)

Geology of the Country around Weymouth, Swanage, Corfe and Lulworth: Addenda and Corrigenda, 1952. 1954. 3*d.* (4½*d.*)

GEOLOGICAL SURVEY MAPS

Printed and obtainable through Ordnance Survey

ENGLAND AND WALES

Scale: Quarter-inch to One Mile

Sheet 12 Louth, Boston, Wisbech, Norwich. Reprint
„ 22 Plymouth, Exeter, Lyme Regis, etc. Revised Edition
} 7*s.* 6*d.* each

Scale: One Inch to one Mile

„ 4 Holy Island (Solid)
„ 28 Whitehaven (Solid)
„ 155 Atherstone (Drift)
„ 217 Moreton in Marsh (Drift)
„ 226/227 Milford (Drift)
„ 244 Linney Head (Drift)
„ 335 Trevose Head (Solid and Drift)
„ 336 Camelford (Solid with Drift)
„ 350 Torquay (Drift)
} Reprints Price 5s. 0d. each

„ 15 Tynemouth (Solid)
„ 15 Tynemouth (Drift)
„ 140 Burton upon Trent (Solid and Drift)
„ 273 Faversham (Solid and Drift)
} First Editions Price 5s. 0d. each

Scale: Six Inches to One Mile

Lancashire, 107 S.E.: 108 N.E., S.W.
Northumberland, n 85 S.W., S.E.
Staffordshire, 17 S.W.: 18 S.W., S.E.
} Price: Uncoloured 6*s.* 0*d.* each
Coloured [on application]

SCOTLAND

Scale: One Inch to One Mile

Sheet 36 Kilmartin (Drift)
„ 44 Mull (Drift)
} First Editions. Price 7*s.* 0*d.* each

Scale: Six Inches to One Mile

Dumbartonshire, n 23 N.E., S.E.
Stirlingshire and Dumbartonshire (det.) n 30 S.W.
} Price: Uncoloured 6*s.* 0*d.* each
Coloured [on application]

PUBLISHED IN JOURNALS

ANDERSON, W. and DUNHAM, K. C. Reddened beds in the Coal Measures Beneath the Permian of Durham and South Northumberland. *Proc. Yorks. geol. Soc.*, 1953, **29**, 21–52

BOWIE, S. H. U. and HORNE, J. E. T. Cheralite, a New Mineral of the Monazite Group. *Miner. Mag.*, 1953, **30**, 93–9

BUCHAN, S. Ground-water Supplies in the Lea Valley. *Lea Valley Growers' Association News-letter* No. 80, 1953, 34–41

BUTLER, A. J. The Display of Geological Material. *Mus. J.*, 1954, **53** (11), 271–278

CASEY, R. Proposed use of the Plenary Powers to Designate (i) a Neotype for the Nominal Species "*Ammonites mammillatus*", Schlotheim, 1813, and (ii) a Type-species for the Genus "*Douvilleiceras*", de Grassouvre, 1893 (class Cephalopoda, Order Ammonoidea). *Bull Zool. Nom.*, 1954, **9** (8), 250–254

CASEY, R. New Genera and Sub-genera of Lower Cretaceous Ammonites. *J. Wash. Acad. Sci.*, 1954, **44** (4), 106–115

DAVIDSON, C. F. The Gold-uranium Ores of the Witwatersrand. *Min. indust: Mag. S. Afr.*, 1953, 373–381, 445–447

DAVIDSON, C. F. Ore Genesis of Northern Rhodesian Copper Deposits. *Bull. Inst. Min. Metall.*, 1954, No. 567, 244–50

DAVIDSON, C. F. and ATKIN, D. On the Occurrence of Uranium in Phosphate Rock. *C.R. 19th Intern. Geol. Cong.*, 1953, fasc. XI, 15–31

KELLAWAY, G. A. and TAYLOR, J. H. Early Stages in the Physiographical Evolution of a Portion of the East Midlands. *Quart. J. geol. Soc.*, 1953, **108** for 1952, 343–75

MOREY, JUNE E. and DUNHAM, K. C. A Petrographical Study of Mediaeval Hones from Yorkshire. *Proc. Yorks. geol. Soc.*, 1953, **29**, 141–148

MOREY, JUNE E. and SABINE, P. A. Porcellanite Axes from Factories in North-east Ireland: Tievebulliagh and Rathlin. Pt. II. A Petrographical Review of the Porcellanite Axes of North-east Ireland. *Ulster J. Archaeol.*, 1952 (1953), **15**, 56–60

SABINE, P. A. The Petrography and Geological Significance of the post-Cambrian Minor Intrusions of Assynt and the Adjoining Districts of North-west Scotland. *Quart. J. geol. Soc.*, 1953, **109**, 137–71

SABINE, P. A., MOREY, JUNE E. and SHERGOLD, F. A. The Correlation of the Mechanical Properties and Petrography of a Series of Quartz-dolerite Roadstones. *J. Appl. Chem.*, 1954, **4**, 131–7

TROTTER, F. M. Exploratory Borings in South-west Lancashire. *Trans. Inst. Min. Engrs, Lond.*, 1953, **112**, 261–83

TROTTER, F. M. Reddened beds of Carboniferous age in North-west England and their origin. *Proc. Yorks. geol. Soc.*, 1953, **29**, 1–20

OTHER PUBLICATIONS

EDWARDS, W. Chapter IX, The Yorkshire–Nottinghamshire Coalfield, pp. 167–198 of "The Coalfields of Great Britain" edited by Sir Arthur Trueman, London, 1954

MITCHELL, G. H. Chapter XIII, The Coalfields of the South Midlands (Leicestershire; South Derbyshire; Warwickshire; South Staffordshire; Forest of Wyre, Coalbrookdale and Shrewsbury), pp. 255–288 of "The Coalfields of Great Britain" edited by Sir Arthur Trueman, London, 1954

SABINE, P. A. and YOUNG, B. R. Cell-size and Composition of the Baryte-celestine Isomorphous Series. Union Internationale de Cristallographie. Troisième Congrès Internationale. Resumés des Communications. Paris, 1954, 17

STUBBLEFIELD, C. J. Chapter VIII. The Kent Coalfield and Other Possible Concealed Coalfields South of the English Midlands, pp. 154–166 of "The Coalfields of Great Britain" edited by Sir Arthur Trueman, London, 1954

TROTTER, F. M. Chapter X, The Lancashire Coalfield, pp. 199–218 and Chapter XV, The Cumberland Coalfield, pp. 314–324 of "The Coalfields of Great Britain" edited by Sir Arthur Trueman, London, 1954

HYDRAULICS RESEARCH ORGANIZATION

PUBLISHED BY H.M. STATIONERY OFFICE

Annual Report of the Hydraulics Research Board, and the Director of Hydraulics Research Hydraulics Research, 1953 7*s.* 6*d.* (7*s.* 8*d.*)

PUBLISHED IN JOURNALS

ALLEN, F. H. The Thames Model Investigation: A Study of Siltation Problems. *J. Instn Wat. Engrs*, 1945, **8** (3), 232–242

BAGNOLD, R. A. Experiments on a Gravity-free Dispersion of Large Solid Spheres in a Newtonian Fluid under Shear. *Proc. roy. Soc. A*, 1954, **225** (1160), 49–63

DEDOW, H. R. and KING, R. F. J. Miniature Liquid-flow meter. Remote Detection of Speed of Rotation. *Engineering, Lond.*, **178**, 4626, 396–398

HUNT, J. N. The Turbulent Transport of Suspended Sediment in Open Channels. *Proc. roy. Soc. A*, 1954, **224**, 322–335

WILKIE, M. J. and KING, R. F. J. The Bed Level Indicator. A Device for Detecting the Boundary of a Body of Water. *J. sci. Instrum.*, 1954, **31**, 8–9

MECHANICAL ENGINEERING RESEARCH

PUBLISHED BY H.M. STATIONERY OFFICE

Annual Report of the Mechanical Engineering Research Board with the Report of the Director of Mechanical Engineering Research for the Year 1953
Mechanical Engineering Research, 1953 2*s.* 6*d.* (2*s.* 8*d.*)

PUBLISHED IN JOURNALS

BERRY, W. R. An Investigation of Small Helical Torsion Springs. *Proc. Instn mech. Engrs*, 1953, **167**, 375–393

BISHOP, J. F. W. Calculations on Sheet-drawing under Back Tension Through a Rough Wedge-shaped Die. *J. Mech. Phys. Solids*, 1953, **2**, 39–42

BISHOP, J. F. W. On the Complete Solution to Problems of Deformation of a Plastic-rigid Material. *J. Mech. Phys. Solids*, 1953, **2**, 43–53

BOTHA, J. P. and SPALDING, D. B. The Laminar Flame Speed of Propane/Air Mixtures with Heat Extraction from the Flame. *Proc. roy. Soc. A*, 1954, **225**, 71–96

BROWN, A. F. C. and HICKSON, V. M. A Photo-elastic Study of Stresses in Screw Threads. *Proc. Instn mech. Engrs*, 1952–53, 1B, 605–612

COOK, D. The Carbon Dioxide—Nitrous Oxide System in the Critical Region. *Proc. roy. Soc. A*, 1953, **219**, 245–256

COOK, D. and ROWLINSON, J. S. Deviations from the Principle of Corresponding States. *Proc. roy. Soc. A*, 1953, **219**, 405–418

COX, H. L. and FIELD, J. E. The Initiation and Propagation of Fatigue Cracks in Mild Steel Pieces of Square Section. *Aeronaut. Quart.*, 1952, **4**, 1–18

FIELD, J. E. Fatigue Strength of Screw Threads: Effect of Specimen Size and Hardness of Nut Material. *Engineer, Lond.*, 1954, **198**, 123–124

FIRTH, D. A Multiway Valve for Pressure Connexions. *J. sci. Instrum*, 1954, **31**, 346

FIRTH, D. and YOUNG, L. Some Model Experiments on Special Control Valves (abridged). *Engineer, Lond.*, 1954, **197**, 207–209 and 257–259; *Mach. Mkt*, 1954, 315–317 and 340–342

FOGG, A. and WEBBER, J. S. The Lubrication of Ball and Roller Bearings at High Speed. *J. Inst. Petrol.*, 1953, **39**, 743–764

GRUNBERG, L. Viscosity and Density of Lubricating Oils at High Pressures. *Proc. 2nd int. Congr. Rheol.*, 1953, 437–444

HUTTON, S. P. The Prediction of Venturi-meter Coefficients and their Variation with Roughness and Age. *Proc. Instn civ. Engrs*, Part 3, 1954, **3**, 216–241

MILNE, A. A. A Theory of Grease Lubrication of a Slider Bearing. *Proc. 2nd int. Congr. Rheol.*, 1953, 427–436

MILNE, A. A. and COLE, J. A. Hydrodynamic Lubrication of Roller Bearings. *Engineer, Lond.*, 1954, **198**, 330

MITCHELL, S. E. Safety Factor in the Design of Seamless Steel Gas Cylinders. *Engineer, Lond.*, 1954, **198**, 99–100; *Engineering, Lond.*, 1954, **178**, 75–76; *Metallurgia, Manchr*, 1954, **50**, 87–89

ROWLINSON, J. S., SUMNER, F. H. and SUTTON, J. R. The Virial Coefficients of a Gas Mixture. *Trans. Faraday Soc.*, 1954, **50**, 1–8

ROWLINSON, J. S. and TOWNLEY, J. R. The Application of the Principle of Corresponding States to the Transport Properties of Gases. *Trans. Faraday Soc.*, 1953, **49**, 20–27

SPALDING, D. E. A Method for Measuring Flame Speed. *Research, Lond.*, 1953, **6**, 525

SPALDING, D. B. Conditions for the Stable Burning of Carbon in an Air Stream. *J. Inst. Fuel*, 1953, **26**, 289–294

SPALDING, D. B. Mass Transfer in Laminar Flow. *Proc. roy. Soc. A*, **221**, 78–99

SPALDING, D. B. Mass Transfer from a Laminar Stream to a Flat Plate. *Proc. roy. Soc. A*, 1954, **221**, 100–104

SPALDING, D. B. A Theory of the Extinction of Diffusion Flames. *Fuel, Lond.*, 1954, **33**, 255–273

SPENCER, E. A. and KNOWLES, G. Clear Water for Hydraulics Research. *Wat. and Wat. Engng*, 1954, **58**, 350–354

STAFF OF THE HEAT DIVISION, M.E.R.L. Progress Review No. 26: Heat Transfer. *J. Inst. Fuel*, 1953, **26**, 178–189

WILLIAMS, E. E. The Determination of Dissolved Air in Water. *Lab. Pract.*, 1954, **3**, 275–278

WRIGHT, K. H. R. An Investigation of Fretting Corrosion. *Proc. Instn. mech. Engrs*, 1952–1953, **1B**, 556–574

OTHER PUBLICATIONS

LE FEVRE, E. J. A Preliminary Note on the Correlation of the Viscosities of Gases and Other Fluids, A.S.M.E. Paper No. 53A, 192

SPALDING, D. B. Combustion of a Single Droplet and of a Fuel Spray. Selected Combustion Problems: Fundamental and Aeronautical Applications. *Combustion Collouqium, Cambridge, Mass.*, 1953, 340–351 (Butterworths Scientific Publications, 1954)

NATIONAL PHYSICAL LABORATORY

PUBLISHED BY H.M. STATIONERY OFFICE

Annual Report of the National Physical Laboratory—
Report for 1953 3*s.* 0*d.* (3*s.* 2*d.*)

Notes on Applied Science
No. 5 Gauge Making and Measuring 1954 3*s.* 0*d.* (3*s.* 3*d.*)
No. 6 Volumetric Glassware: Scientific Aspects of Design and Accuracy 1954 1*s.* 6*d.* (1*s.* 7½*d.*)
No. 7 Balances, Weights and Precise Laboratory Weighing 2*s.* 0*d.* (2*s.* 1½*d.*)

Miscellaneous
Automatic Digital Computation. Proceedings of a Symposium held at the National Physical Laboratory, March 25th to 28th, 1953, 21*s.* 0*d.* (21*s.* 7*d.*)

PUBLISHED IN JOURNALS

ALLAN, J. F. Contribution to Discussion on "Corrugation of Bottom Shell Plating". *Trans. Instn. nav. Archit., Lond.*, 1954, **96** (3), 263

ALLEN, N. P. Fifty Years' Progress in the Understanding of Metals. *J. Birmingham Metal Soc.*, Golden Jubilee Issue, 1953, 89

ALLEN, N. P. The Mechanical Properties of Ferritic Steels at Low Temperatures. *Bull. Inst. int. Froid*, 1954, Suppl. 2, 93

ALLEN, N. P. and CARRINGTON, W. E. Exploratory Creep Tests on Metals of High Melting Point. *J. Inst. Met.* 1954, **82**, 525

ALLEN, N. P. and MCLENNAN, J. E. Contribution to Discussion on "Flow and Fracture in Single Crystals of High Purity Ferrites" by R. P. Steijn and R. M. Brick. *Trans. Amer. Soc. Metals*, 1954, **46**, 1444

ALLEN, N. P., SCHOFIELD, T. H. and MELLISH, B. The Constitution of the Titanium-rich Alloys of Titanium Iron and Oxygen. *J. Inst. Met.*, 1954, **82**, 534

ALWAY, G. G. Automatic Computing in Aircraft Engineering. *Engineering*, 1953, **176**, 351

ARNOLD, A. H. M. Alternating Current Instrument Testing Equipment. *Proc. Instn. elect. Engrs.*, 1954, **101**, Pt. 2, 121

ARNOLD, A. H. M. Opener's Discussion on High Sensitivity Wattmeters at the Institution of Electrical Engineers. *Proc. Instn. elect. Engrs.*, 1954, **101**, Pt. 2, 196

ATKINS, W. F. Contribution to Discussion on "Kinematics as Applied to Instrument Design". *Trans. Soc. Instrum. Technol.*, 1954, **6**, 66

BANE, W. T. Design Charts for an on/off Control System. *Trans. Soc. Instrum. Tech.*, 1953, **5**, (2), 52

BARNES, D. C. and BARNETT, C. A Dial Gauge Testing Machine. *Mach. Shop Mag.* 1954, **15**, 566; *Engineer*, 1954, **198**, 496; *Machinist*, 1954, **98**, 1852

BARNES, D. C. and PUTTOCK, M. J. A New Model of the NPL Interferometer for Measuring Slip Gauges. *Engineering*, 1953, **176**, 757; *Machinist*, 1953, **97**, 2059; *Engineer*, 1953, **196**, 763; *Machinery, Lond.*, 1953, **83**, 1170; *Mach. Shop Mag.*, 1953, **14**, 540.

BARNES, D. C. and WAINWRIGHT, C. A Precision X-ray Diffraction Spectrometer Ring. *Engineer*, 1954, **197**, 97; *Machinery, Lond.*, 1954, **84**, 189; *Mach. Shop Mag.*, 1954, **15**, 51

BERRY, L. W. Contribution to Discussion on "Propeller Cavitation; Some Observations from 16 in. Propeller Tests in the New King's College Cavitation Tunnel". *Trans. N.-E. Cst. Instn. Engrs. Shipb.*, 1954, **70** (4), D.57

BLAKE, D. V. Contribution to Discussion on "Sectional Paper Machine Drives with Electronic Control" by T. E. Barany. *Trans. Soc. Instrum. Tech.*, 1954, **6**, 13

BRADFIELD, G. Improvements in Ultrasonic Flaw Detection. *J. Brit. Inst. Radio Engrs.*, 1954, **14**, 304

BROWN, A. F. C. Triaxial Stresses caused by Notches. *Brit. J. appl. Phys.*, 1954, **5**, 280

CARRINGTON, W. E. Lamellae in Chromium. *J. Inst. Met.*, 1953, **82**, 170

CLARK, J. S. Remeasurement of the Old 10 ft. Length Standards O_1 and OI_1 of the Ordnance Survey, and Some Notes on the Relative Stability of Certain Standards of Length. *Emp. Surv. Rev.*, 1953, **12**, 166

CLENSHAW, C. W. Polynomial Approximations to Elementary Functions. *Math. Tab. Wash.*, 1954, **8**, 143

COOK, A. H. Adjustment of the Principal Gravity Observations in Great Britain. *Mon. Not. R. astr. Soc. Geophys. Suppl.* 1953, **6** (8), 494

COOK, A. H. The Calibration of Circular Scales and Precision Polygons. *Brit. J. appl. Phys.*, 1954, **5**, 367

COOK, A. H. The Possibility of Comparing Line Standards of Length Photographically. *Proc. roy. Soc.*, A, 1953, **219**, 500

COOK, A. H. and STONE, N. W. B. The Angle of Contact of Mercury Against a Moving Tungsten Wire. *Nature, Lond.*, 1954, **174**, 366

COPE, W. F. Contributions to Discussion on " H.M. Yacht Britannia ". *Trans. Instn. nav. Archit., Lond.*, 1954, **96** (3), 209

CRAWFORD, B. H. The Preparation of Ultra-fine Grain Photographic Emulsions. *J. sci. Instrum.*, 1954, **31**, 333

CROFT, A. J., OLSEN-BAER, J. L. and POWELL, R. W. An Attempt to Find Anisotropy in the Superconductive Properties of Gallium. *Phil. Mag.*, 1954, **45**, 123

CURTIS, A. R. Some Elliptic Integrals. *Math. Gaz.*, 1954, **38**, 199

DADSON, R. S. Contribution to Discussion on " Hearing Tests and Their Shortcomings ". *Proc. R. Soc. Med.*, 1953, **46**, 995

DAWSON, J. Contribution to Discussion on " A Century of Coaster Design and Operation ". *Trans. Instn. Engrs. Shipb. Scot.*, 1953/4, **97** (4), 245

DAWSON, J. Contribution to Discussion on " The Position of Longitudinal Centre of Buoyancy for Minimum Resistance ". *Trans. Instn. Engrs. Shipb. Scot.*, 1953/4, **97**, 55

DAWSON, J. Some Further Experiments on Single-screw Merchant Ship Forms. *Trans. Soc. nav. Archit. N.Y.*, 1953, **61**, 583

DONALDSON, R. Spectrophotometry of Fluorescent Pigments. *Brit. J. appl. Phys.*, 1954, **5**, 210

ESSEN, L. Proposal for a New Aether-draft Experiment. *Nature*, 1954, **173**, 734

ESSEN, L. Standard Frequency Transmissions. *Proc. Instn. elect. Engrs*, 1954, **101** (3), 249

FLEMING, N. Measurements of Noise on the Ground from Aircraft in Flight. *J. R. aero. Soc.*, 1954, **58**, 255

FOX, L. A Note on the Numerical Integration of First Order Differential Equations. *Quart. J. Mech.*, 1954, **7**, 367

FROOME, K. D. The Current Density at the Cathode of the Mercury Arc. *J. appl. Phys.*, 1953, **4** (3), 91

FROOME, K. D. Investigation of a New Form of Microwave Interferometer for Determining the Velocity of Electromagnetic Waves. *Proc. roy. Soc. A.*, 1954, **223**, 195

GADD, G. E. Interactions Between Wholly Laminar or Wholly Turbulent Boundary Layers and Shock Waves Strong Enough to Cause Separation. *J. aero. Sci.*, 1953, **20**, 729

GADD, G. E. and HOLDER, D. W. Contribution to Discussion on " Interactions Between Wholly Laminar or Wholly Turbulent Boundary Layers and Shock Waves Strong Enough to Cause Separation ". *J. aero. Sci.*, 1954, **21**, 571

GATES, J. W. The Evaluation of Interferograms by Displacement and Stereoscopic Methods. *Brit. J. appl. Phys.*, 1954, **5**, 133

GATES, J. W. A Slow Motion Adjustment for Horizontal Interferometer Mirrors. *J. sci. Instrum.*, 1953, **30**, 484

GATES, J. W., HABELL, K. J. and MIDDLETON, S. P. A Precision Spherometer. *J. sci. Instrum.*, 1954, **31**, 60

GRIFFITHS, E. Survey of Field of Work of Commission II, Zurich Conference, September, 1953. *Bull. Inst. int. Froid*, Annexe 1954–2, 85

GROGAN, J. D. and PLEASANCE, R. J. A Survey of the Uranium-nickel System, with an Appendix on an X-ray Examination of the Uranium-nickel Alloys by Betty E. Williams. *J. Inst. Met.*, 1953, **82**, 141

HALL, B. J. Contribution to Discussion on " The Application of Wave Resistance Calculation to Ship Hull Design ". *Trans. Instn nav. Archit.*, 1954, **96** (3), 277

HALL, B. J. Contribution to Discussion on " B.S.R.A. Resistance Experiments on the Lucy Ashton. Part II. The Ship-model Correlation for the Naked Hull Condition ". *Quart. Trans. Instn nav. Archit.*, 1953, **95** (4), 421

HALL, B. J. Contribution to Discussion on " The Forces on a Submerged Body Moving Under Waves " by T. H. Havelock. *Trans. Instn nav. Archit., Lond.*, 1954, **96** (2), 86

HALL, B. J. Contribution to Discussion on " A New Integrator for Use in Wave Resistance Calculations ". *Trans. Instn nav. Archit.*, 1954, **96** (3), 177

HALL, B. J. Contribution to Discussion on " Ship Model Correlation and Tank Wall Effect ". *Trans. N.-E. Cst Instn Engrs Shipb.*, 1954, **70** (3), D.7

HARRISON, P. W. An Interferometric Alignment Set. *Engineer*, 1954, **197**, 670

HARRISON, P. W. Marine Shafting Alignment. *Trans. N.-E. Cst Instn Engrs Shipb.*, 1954, **70**, D.148

HARTSHORN, L. The Dielectric Losses in Some Representative Insulating Materials. *Proc. Instn elect. Engrs*, 1954, **100**, Pt. 2A, 23

HARTSHORN, L. and MANNING, FREDA. The Behaviour of Standard Cells in Conditions which Include the Generation of Appreciable Current. *J. sci. Instrum.*, 1954, **31**, 115

HOLDER, D. W. Flow Past Elliptic-nosed Cylinders and Bodies of Revolution in Supersonic Airstreams. *Aeronaut. Quart.*, 1954, **4**, 317

HOLDER, D. W., CHINNECK, A. and GADD, G. E. An Experimental Investigation of the Interaction of a Shock Wave with a Subsonic Stream Bounded by a Wall. *Phil. Mag.*, 1954, **45**, 997

HOPKINS, B. E. and TIPLER, H. R. Factors Affecting the Severity of Intergranular Brittleness in High-purity Iron-nitrogen Alloys. *J. Iron St. Inst.*, 1954, **177**, 110

HOWARD, P. B. Contribution to Discussion on "Some Experiments on Positive Point-to-plane Corona and Spark Breakdown of Compressed Gases" by T. R. Foord. *Proc. Instn elect. Engrs*, 1954, **101** (2), 102

HUGHES, G. Contribution to Discussion on "B.S.R.A. Resistance Experiments on the Lucy Ashton. Pt. II. The Ship-model Correlation for the Naked Hull Condition". *Quart. Trans. Instn nav. Archit.*, 1953, **95** (4), 410

HUGHES, G. Contribution to Discussion on "Correlation of Model and Ship Trials of a Shallow Draught Rhine Vessel" by Prof. van Lammeren and Dr. van Manen. *Trans. N.-E. Cst Instn Engrs Shipb.*, 1954, **70** (7), D.123

HUGHES, G. Contribution to Discussion on "Ship Model Correlation and Tank Wall Effect". *Trans. N.-E. Cst Instn Engrs Shipb.*, 1954, **70** (3), D.9

HUGHES, G. Contribution to Discussion on "A Skin Friction Determination Using Wall-sided Models of Great Draughts". *Quart. Trans. Instn nav. Archit.*, 1953, **95** (3), 293

JENKINS, C. H. M. Contribution to Written Discussion on "Caustic Cracking in Steam Boilers", Symposium of the Society of Chemical Industry, 1952, *Chem. and Ind.*, 1953, 10th October, 1084

JONES, T. I. Contribution to Discussion on "The Dielectric Losses in Some Representative Insulating Materials". *Proc. Instn elect. Engrs*, 1953, **100**, Part 2A, 59

KUBASCHEWSKI, F. P. O. and DENCH, W. A. The Free Energy Diagram of the System Titanium-oxygen. *J. Inst. Met.*, 1953, **82**, 87

LOVELL, HOPE. The National Physical Laboratory. *The Trident*, 1954, **16**, 65

MARWOOD, W. J. and JOHNSON, A. J. Vibration Tests on an Up-river Collier with Special Reference to the Influence of Depth of Water. *Trans. N.-E. Cst Instn Engrs Shipb.*, 1954, **70** (3), 193

MCLEAN, D. and FARMER, M. H. Grain Boundary Movements, Slip Fragmentation During Creep of Aluminium-copper, Aluminium-magnesium and Aluminium-zinc Alloys. *J. Inst. Met.*, 1954, **83**, 1

MEETHAM, A. R. Natural Removal of Atmospheric Pollution During Fog. *Quart. J. roy. Met. Soc.*, 1954, **80**, 96

MEETHAM, A. R., CHALLONER, A. R. and COX, J. D. The Heats of Combustion of Pyridine and Certain of its Derivatives. *J. Chem. Soc.*, 1954, 265

MURPHY, HEATHER M. and CALNAN, E. A. Contribution to Discussion on "Plastic Deformation of Single Crystals of Copper" by J. J. Becker and J. N. Hobstetter. *J. Metals*, 1954, **6**, 665

NEAL, W. T. L. The Determination of Titanium by Precision Absorptiometry. *Analyst*, 1954, **79**, 403

NEWMAN, E. A., CLAYDEN, D. O. and WRIGHT, M. A. Reply to Discussion on "The Mercury Delay Line Storage System of the ACE pilot Model Electronic Computer". *Proc. Instn elect. Engrs*, 1954, **101**, Pt. 2, 65

OAKLEY, T. R. J. Symposium on Engineering Dimensional Metrology, 21st to 23rd October, 1953. *Nature, Lond.* 1954, **173**, 293

OLVER, F. W. J. The Asymptotic Expansion of Legendre Functions of Large Order. *Proc. int. Math. Congr.*, 1954, **2**, 152

OLVER, F. W. J. Notes on the Asymptotic Expansion of Generalized Hypergeometric Functions. *J. Lond. Math. Soc.*, 1953, **28**, 462

PERRY, W. E. T. National Physical Laboratory Standards of Radioactive Isotopes. *Brit. J. Radiol.*, 1954, **27**, 116

PERRY, W. E. T. The Standardisation of Radioactive Isotopes in Great Britain. *Nature, Lond.*, 1953, **172**, 1026

POWELL, R. W. The Thermal Conductivity of Beryllia. *Trans. Brit. ceram. Soc.*, 1954, **53**, 389

POWELL, R. W. The Thermal Conductivities of Metals Below Room Temperature. *Bull. Inst. int. Froid*, Annexe 1954–2, 111

POWELL, R. W. and HICKMAN, M. J. Methods for Studying the Thermal Resistance of Sprayed and Electro-deposited Metal Coatings. *Brit. J. appl. Phys.*, 1954, **5**, 312

PURSEY, H. A Set of 0·4 Octave Bandpass Filters for Frequencies Between 10 and 200 Kc/s. *Electron. Engng*, 1954, **26**, 31

PURSEY, H. Thermal Anomaly in the Elastic Constants of Chromium. *Nature, Lond.*, 1953, **172**, 864

PURSEY, H. and COX, H. L. The Correction of Elasticity Measurements on Slightly Anisotropic Materials. *Phil. Mag.*, 1954, **45**, 295

PURSEY, H. and MILLER, G. F. The Field and Radiation Impedence of Mechanical Radiators on the Free Surface of a Semi-infinite Isotropic Solid. *Proc. roy. Soc. A.*, 1954, **223**, 521

PURSEY, H. and PYATT, E. C. An Improved Method of Measuring Dynamic Elastic Constants Using Electrostatic Drive and Frequency Modulation Detection. *J. sci. Instrum.*, 1954, **31**, 248

PYATT, E. C. Some Consideration of the Errors of Brightness and Two-Colour Types of Spectral Radiation Pyrometer. *Brit. J. appl. Phys.*, 1954, **5**, 264

RAYNER, G. H. and FORD, L. H. The Performance of Dried and Sealed Mica Capacitors. *J. sci. Instrum.*, 1954, **31**, 3

REES, W. P., HOPKINS, B. E. and TIPLER, H. R. Tensile and Impact Properties of Iron-silicon, Iron-nickel, Iron-chromium and Iron-molybdenum Alloys of High Purity. *J. Iron St. Inst.*, 1954, **177**, 93

RENDALL, J. H., JOHNSTONE, S. T. M. and CARRINGTON, W. E. Molybdenum-base Alloys. *J. Inst. Met.*, 1954, **82**, 345

ROBINSON, D. W. The Relation Between the Sone and Phon Scales of Loudness. *Acustica*, 1953, **3** (5), 344

SAYCE, L. A. Alginate Polishing Laps. *J. sci. Instrum.*, 1954, **31**, 193

SCHOFIELD, T. H. and BACON, A. E. The Melting Point of Titanium. *J. Inst. Met.*, 1953, **82**, 167

SHEARER, J. R. Contribution to Discussion on "The Application of Wave Resistance Calculations to Ship Hull Design". *Trans. Instn nav. Archit.*, 1954, **96** (3), 278

SHEARER, J. R. Contribution to Discussion on "A New Integrator For Use in Wave Resistance Calculations". *Trans. Instn nav. Archit.*, 1954, **96** (3), 178

SHEARER, J. R. Contribution to Discussion on "Ship Model Correlation and Tank Wall Effect". *Trans. N.-E. Cst Instn Engrs. Shipb.*, 1954, **70**, Pt. 3, D. 14

SILVERLEAF, A. Contribution to Discussion on "B.S.R.A. Resistance Experiments on the Lucy Ashton. Pt. II. The Ship-model Correlation for the Naked Hull Condition". *Quart. Trans. Instn nav. Archit.*, 1953, **95**, Pt. 4, 412

SILVERLEAF, A. Contribution to Discussion on "On Propeller Manufacture" by L. C. Burrill. *Trans. Instn nav. Archit.*, 1954, **96** (2), 154

SILVERLEAF, A. Contribution to Discussion on "Propeller Cavitation; Some Observations from 16 in. Propeller Tests in the New King's College Cavitation Tunnel". *Trans. N.-E. Cst Instn, Engrs, Shipb.*, 1954, **70**, Pt. 4, D. 60

SLOMAN, H. A. Extension to the Metallurgy Division of the National Physical Laboratory. *Nature, Lond.* 1954, **173**, 808

STONE, N. W. B., ELLIOTT, K. W. T., and BIGG, P. H. The Influence of Barometric Pressure on Watch and Chronometer Rates. *Brit. J. appl. Phys.*, 1953, **4**, 379

STOTT, V. H. Some Aspects of Research Involving High Temperatures. *Research*, 1953, **6**, 454

STOTT, V. H. and RENDALL, J. H. The Density of Molten Iron. *J. Iron St. Inst.*, 1953, **175**, 374

STUART, J. T. On the Stability of Viscous Flow Between Parallel Planes in the Presence of a Coplanar Magnetic Field. *Proc. roy. Soc. A.*, 1954, **221**, 189

TIZARD, R. H. Contribution to Discussion on "Sectional Paper Machine Drives with Electronic Control" by T. E. Barany. *Trans. Soc. Instrum. Tech.*, 1954, **6**, 14

TIZARD, R. H. Contribution to Discussion on "The Determination of Optimum Process-controller Settings and Their Confirmation by Means of an Electronic Simulator" by R. L. Ford. *Proc. Instn elect. Engrs.*, 1954, **101**, Pt. 2, 174

WILLIAMS, BETTY E. Diffraction Grating Copies for Electron Microscope Calibration. *J. sci. Instrum.*, 1954, **31**, 190

WYCKOFF, H. O., ASTON, G. H. and SMITH, E. E. A Comparison of X-ray Standards. *Brit. J. Radiol.*, 1954, **27**, 325

ISSUED GRATIS

HARDING, H. G. W. and VICKERS, R. T. The Spectral Distribution of Photopic and Scotopic Luminance of a Planckian Radiator. Available on application to the Director

HARDING, H. G. W. and VICKERS, R. T. The Spectral Distribution of Power from a Planckian Radiator. Available on application to the Director

OTHER PUBLICATIONS

ALLAN, J. F. Choice of Suitable Reynolds Number for Model Propeller Experiments. Proc. Sixth Int. Conf. Ship Tank Superintendents, publ. Soc. nav. Archit., New York, 1953, 24

ALLAN, J. F. Ship Model Correlation. Proc. Symp. "Trial on Ships at Sea" publ. Brussel., Gentre Belge Recherches Navales, 1954

BRADFIELD, G. Ultrasonic Electro-acoustics. *Proc. Int. electro-acoust. Congr.* (Netherlands 1953), 1954, Section 5, 171 Delft

COLEBROOK, F. M. The Pilot Model of the National Physical Laboratory Automatic Electronic Digital Computer (ACE). Centre Nat. de la Recherche Sci., Colloque Int. 37: Les machines à calculer et la penseé humaine, 65

DADSON, R. S. The Normal Threshold of Hearing and Other Aspects of Standardisation in Audiometry. *Proc. Int. electro-acoust. Congr.* (Netherlands 1953), Section 4, 151, Delft, 1954

DADSON, R. S. and BUTCHER, E. G. Recent work at the National Physical Laboratory on the Free-field Calibration of Standard Microphones. *Proc. Int. electro-acoust. Congr.* (Netherlands 1953), Section 3, 103, Delft, 1954

FOX, L. A Short Table for Bessel Functions of Integer Orders and Large Arguments. *Shorter Math. Tab. Roy. Soc.* No. 3, 1954, Cambridge University Press, price 6*s.* 6*d.*

GRIFFITHS, E. Thermal Conductivity. *Thorpe's Dictionary of Applied Chemistry*, 4th Edition 1954, **2**, 554

HARTSHORN, L. Permittivity and Dielectric Loss. The Insulation of Electrical Equipment, ed. Willis Jackson, pub. Chapman and Hall, London, 1954, 59

HUGHES, G. A Note on Friction Resistance with Special Reference to Ship Forms. "Mémoires sur la mécaniques des fluides", Riabouchinsky Scientific Jubilee Volume (publ. Paris, Ministére de la Défense Nationale, 1954)

RAYNER, G. H. An Absolute Measurement of Resistance by Albert Campbell's Bridge Method. Monograph 95, Measurements Section, *Instn elect. Engrs*, 1954, April

PEST INFESTATION RESEARCH

PUBLISHED BY H.M. STATIONERY OFFICE

Annual Report of the Pest Infestation Research Board, and Director of Pest Infestion Research —Pest Infestation Research, 1953 2*s.* 0*d.* (2*s.* 1½*d.*)

PUBLISHED IN JOURNALS

CLEGG, K. M. and LEWIS, S. E. The Vitamin-B Content of Foodstuffs Fumigated with Methyl Bromide. *J. Sci. Fd Agric.*, 1953, **4** (11), 548–552

DISNEY, R. W. The Specific Heat of some Cereal Grains. *Cereal Chem.*, 1954, **31** (3), 229–239

GREEN, A. A. The Control of Blowflies Infesting Slaughterhouses. II. Large Scale Experiments. *Ann. appl. Biol.*, 1953, **40**, 705–716

GREEN, A. A. and KANE, J. The Control of Blowflies Infesting Slaughterhouses. III. Large Scale Experiments at a Domestic-refuse depot. *Ann. appl. Biol.*, 1954, **41** (1), 165–173

HALL, D. W. and HYDE, M. B. The Modern Method of Hermetic Storage. *Trop. Agriculture, Trin.*, 1954, **31** (Apr.), 149–160

HAMMOND, J. H. An Actograph for Small Insects. *J. sci. Instrum.*, 1954, **31** (2), 43–44

HASWELL, G. A. A Note on the Specific Heat of Rice, Oats, and their Products. *Cereal Chem.*, 1954, **31** (4), 341–342

HEWLETT, P. S. Insecticidal Synergism with Valone. *Nature, Lond.*, 1954, **173** (4394), 132

HEWLETT, P. S. A Microdrop Applicator and its Use for the Treatment of Certain Small Insects with Liquid Insecticide. *Ann. appl. Biol.*, 1954, **41** (1), 45–64

HOWE, R. W. and BURGES, H. D. Studies on Beetles of the Family Ptinidae. IX. A Laboratory Study of the Biology of *Ptinus tectus*. *Bull. ent. Res.*, 1953, **44** (3), 461–516

HOWE, R. W. and BURGES, H. D. Studies on Beetles of the Family Ptinidae. X. The Biology of *Mezium affine* Boieldieu. *Ent. mon. Mag.*, 1953, **89** (1072), 217–220

HYDE, M. B. Airtight Storage of Grain. *Field*, 1953, **202** (5266), 1050–1051

HYDE, M. B. The Occurrence and Significance of Sub-Epidermal Fungi in Cereal Grains. *Proc. 7th int. bot. Congr., Stockholm* 1950, 206–207

LEWIS, S. E. Acetyicholine in Blowflies. *Nature, Lond.*, 1953, **172** (4387), 1004–1005

LEWIS, S. E. and SLATER, E. C. Oxidative Phosphoryiation in Insect Sarcosomes. *Biochem. J.*, 1953, **55** (5), xxvii

MORE, B. P. and SOUTHGATE, B. J. Embedding Specimens in Methyl Methacrylate: a New Cold-Casting Technique. *Mus. J., Lond.*, 1953, **53** (9), 219–222

PARKIN, E. A. The Susceptibility to DDT Dust of Coleoptera Infesting Stored Products. *Bull. ent. Res.*, 1953, **44** (3), 439–444

SLATER, E. C. and LEWIS, S. E. The Effect of Dinitrophenol on Insect Sarcosomes. *Biochem. J.*, 1953, **55** (5), xxvii

SOLOMON, M. E. Insect Population Balance and Chemical Control of Pests. Pest Outbreaks induced by Spraying. *Chem. & Ind. (Rev.)*, 1953, (43), 1143–1147

WINTERINGHAM, F. P. W. Two Dimensional Paper Chromatography of Radioactive Substances. *Nature, Lond.*, 1953, **172** (4381), 727–728

WINTERINGHAM, F. P. W., LOVEDAY, P. M. and HELLYER, G. C. Phosphorus Metabolism in the Housefly, *Musca domestica*. *Biochem. J.*, 1953, **55** (5), xxxiii

WOODROFFE, G. E. An Ecological Study of the Insects and Mites in the Nests of Certain Birds in Britain. *Bull. ent. Res.*, 44 (4), 739–772
WOODROFFE, G. E. An Additional Note on the Fauna of Birds Nests in Britain. *Bull. ent. Res.*, 1954, 45 (1), 135–136
WOODROFFE, G. E. and SOUTHGATE, B. J. An Investigation of the Distribution and Field Habits of the Varied Carpet Beetle, *Anthrenus verbasci* (L.) (Col., Dermestidae) in Britain, with Comparative Notes on *A. fuscus* Ol. and *A. museorum* (L). *Bull. ent. Res.*, 1954, 45 (3), 575–583

RADIO RESEARCH

PUBLISHED BY H.M. STATIONERY OFFICE

Annual Report of the Radio Research Board, and the Director of Radio Research—
Radio Research, 1953 1*s.* 9*d.* (1*s.* 10½*d.*)

PUBLISHED IN JOURNALS

APPLETON, E. V. and PIGGOTT, W. R. Ionospheric Absorption Measurements during a Sunspot Cycle. *J. atmos. and terr. Phys.*, 1954, 5, 141
BARLOW, H. M. and KARBOWIAK, A. E. An Investigation of the Characteristics of Cylindrical Surface Waves. *Proc. Instn elect. Engrs*, Part III, 1953, 100 (68), 321
BEYNON, W. J. G. The Absorption of Radio Waves Reflected from the Ionosphere at Oblique Incidence. *Proc. Instn elect. Engrs*, Part III, 1954, 101 (69), 15
BRAMLEY, E. N. The Diffraction of Waves by an Irregular Refracting Medium. *Proc. roy. Soc. A.*, 1954, 225, 515
HOPKINS, H. G. and REYNOLDS, L. G. An Experimental Investigation of Short-distance Ionospheric Propagation at Low and Very Low Frequencies. *Proc. Instn elect. Engrs*, Part III, 1954, 101 (69), 21
HORNER, F. A New Design of Radio Direction Finder for Locating Thunder-Storms. *Met. Mag., Lond.*, 1954, 83 (983), 137
HORNER, F. The Reception of Atmospherics at High Frequencies. *J. atmos. and terr. Phys.*, 1953, 4, 129
HYDE, F. J. Measurements of Noise Spectra of a Point Contract Germanium Rectifier. *Proc. phys. Soc. B., Lond.*, 1953, 66, 1017
MILES, P. A. Ferromagnetic Resonance in Ferrites. *Nature, Lond.*, 1954, 174, 177
NAISMITH, R. A Subsidiary Layer in the E. Region of the Ionosphere. *J. atmos. and terr. Phys.*, 1954, 5, 73
OSBORNE, B. W. The Electron Content of the F2 Layer above Singapore. *J. atmos. and terr. Phys.*, 1953, 4, 83
PIGGOTT, W. R. On the Interpretation of the Apparent Ionisation Distribution in the Ionosphere. *J. atmos. and terr. Phys.*, 5, 201
SAXTON, J. A. Basic Ground-wave Propagation Characteristics in the Frequency Band 50 to 800 Mc/s. *Proc. Instn elect. Engrs*, Part III, 1954, 101 (72), 211
SAXTON, J. A. Conference on Radio-Meteorology, Austin, Texas, November, 1953. *Nature, Lond.*, 1954, 174, 761
SAXTON, J. A. and HARDEN, B. N. Ground-wave Field Strength Surveys at Frequencies of 100 and 600 Mgs. *Proc. Instn elect. Engrs*, Part III, 1954, 101 (22), 215
SMITH, S. B. and HOPKINS, H. G. High-frequency Direction Finding Comparison of C.W. and Pulsed Transmissions. *Wireless Engr*, 1954, 31, 11
SMITH-ROSE, R. L. International Scientific Radio Union Meeting in Sydney. *Proc. Instn Radio Engrs, Aust.*, 1954, 15, 7
UNWIN, R. S. Ultra-Short-Wave Field Strength in a Ground-Based Radio Duct. *Nature, Lond.*, 1953, 172, 856

ROAD RESEARCH

PUBLISHED BY H.M. STATIONERY OFFICE

Annual Report of the Road Research Board, and the Director of Road Research—
Road Research, 1953 5*s.* 0*d.* (5*s.* 3*d.*)

Road Abstracts. Published monthly 1*s.* 9*d.* (1*s.* 10½*d.*)
Annual subscription rate (including index number) (including postage) £1 2*s.* 6*d.*

Vol. XX. Nos. 11–12, Nov.–Dec., 1953
Vol. XXI. Nos. 1–9, Jan.–Sept., 1954

Technical Papers

No. 15. Soil Survey Procedure. 2nd Edition 1*s.* 9*d.* (1*s.* 10½*d.*)
No. 28. Rheology of Non-Aqueous Suspensions 2*s.* 0*d.* (2*s.* 1½*d.*)
No. 29. The Use of Stabilized Soil for Road Construction in the U.S.A., by K. E. Clare 2*s.* 6*d.* (2*s.* 7½*d.*)
No. 30. A Study of Single-Sized Gravel Aggregates for Road Making 1*s.* 0*d.* (1*s.* 1½*d.*)
No. 31. Durability of Road Tar with Special Reference to its use in Tarmacadam Wearing Surfaces, by A. R. Lee and E. J. Dickenson 2*s.* 6*d.* (2*s.* 8*d.*)
No. 32. Vehicle Headlighting: Visibility and Glare, by A. J. Harris 2*s.* 0*d.* (2*s.* 1½*d.*)

Road Notes

No. 16. Bituminous Surfacings made by the Wet-Aggregate (Hydrated Lime) process 1*s.* 0*d.* (1*s.* 1½*d.*)
No. 17. Protection of Subgrades and Granular Bases by Surface Dressing 9*d.* (10½*d.*)
No. 18. Salt treatment of Snow and Ice on Roads (Superseding Road Note No. 2) 6*d.* (7½*d.*)

Miscellaneous

Index of Publications of the Road Research Laboratory, January–June, 1953 1*s.* 9*d.* (1*s.* 10½*d.*)

PUBLISHED IN JOURNALS

CHARLESWORTH, G. Research on Town Traffic. *Publ. Wks. munic. Services Congress*, 1952. *Final Report*, London, 1953, pp. 446–63; Discussion, 463–468

CHARLESWORTH, G. Roads and Commercial Transport. *J. and Proc. Inst. Rd Transp. Engrs*, 1954, **8** (1), 39, 41–49 51–59, 61–63, 65–66; Discussion, 66–69. *Rds and Rd Constr.*, 1954, **32** (376), 118–120

CHRISTIE, A. W. The Luminous Directional Reflectance of Snow. *J. opt. Soc. Amer.*, 1953, **43** (7), 621–623

CHRISTIE, A. W. Reflection Characteristics of Pavement Surfaces. *Highway Research Board Bulletin* No. 89. Washington, D.C., 1954. (National Research Council, Division of Engineering and Industrial Research), pp. 21–35; Discussion, 35–37

CHRISTIE, A. W. The Road Surface as a Factor in Street Lighting. *Proc. Instn civ. Engrs*, 1954, Part II, 3 (3), 506–521; Discussion, 521–531

CLARE, K. E. and FOULKES, R. A. German Soil Stabilization. Extensive Development of Machinery. *Engineering, Lond.* 1954, **178** (4622), 268–273

CLARE, K. E. and POLLARD, A. E. The Effect of Curing Temperature on the Compressive Strength of Soil-cement Mixtures. *Geotechnique, Lond.*, 1953, **4** (3), 97–107

CRITCHELL, P. L. and MILLARD, R. S. The Temporary Sealing of Joints in Concrete Roads on Housing Estates. *Rds and Rd Constr.*, 1953, **31** (372), 342–344

CRONEY, D. and COLEMAN, J. D. Soil Moisture Suction Properties and Their Bearing on the Moisture Distribution in Soils. *Proc. 3rd Internat. Soil Mech. Conf.*, 1953, **1**, 13–18)

CRONEY, D. and COLEMAN, J. D. Soil Structure in Relation to Soil Suction (pF). *J. Soil Sci., Lond.*, 1954, **5** (1), 75–84

GLANVILLE, W. H. A Survey of Road Research at Home and Abroad. *J. Instn Highw. Engrs*, 1954, 3 (1), 9–40; (2), 25–41; Discussion, 41–53. Extracts from this paper have also been published in: *Contractors Rec.*, 1953, **64** (16), 17–21; (17), 25, 27, 29; (18) 11–15; *Contractors Rec.* (Overseas), 1953, **5** (3), 39, 41, 43, 45, 47, 49–55; *Highw. and Br.*, 1953, **19** (979), 1, 3; *Surveyor, Lond.*, 1953, **112** (3188), 251–253; *Munic. J.*, 1953, (3138), 727–728

GLANVILLE, W. H. Safety on the Road. *J. roy. Soc. Arts*, 1954, **102** (4926), 496–519

GLANVILLE, W. H. British Roads: Advances in the last Seventy-five Years. *Contract J.*, 1954, **153** (3910), suppl. i–ii, iv

GOUGH, C. M. Comparison of Viscosities of American Grades of Gutback Bitumens Determined by Saybolt Furol Viscometer and Standard Tar Viscometer. *J. Inst. Petrol.*, 1954, **40** (363), 122; *Quarry Mgrs J.*, 1954, **37** (12), 630–631

GRAINGER, G. D. Construction of Crushed-stone Road Bases. *Highw. and Br.*, 1954, **21** (1052), 1, 3

GRIME, G. Glare from Passing Beams of Automobile Headlights. *Highway Research Board Bulletin* No. 68. Washington, D.C., 1953 (National Research Council, Division of Engineering and Industrial Research), pp. 54–61

GRIME, G. Driving in the U.S.A. A Comparison with Conditions on British Roads. *Rds. and Rd Constr.*, 1954, **32** (368), 170–176; *Pedestrian*, 1954, (15), 27, 29

GRIME, G. Vehicle Characteristics and Road Accidents. Effect of Design and Maintenance. *Engineering, Lond.* 1954, **178** (4624), 339–344

GRIME, G. A Substitute for Road Tests of Automobile Headlights. *Highway Research Board Bulletin* No. 89. Washington, D.C., 1954 (National Research Council, Division of Engineering and Industrial Research), pp. 1–6

HARRIS, A. J. Design of the Meeting Beam of the Automobile Headlight. *Highway Research Board Bulletin* No. 68. Washington, D.C., 1953 (National Research Council, Division of Engineering and Industrial Research), pp. 40–53

HARRIS, A. J. The Meeting Beams of Headlights. Effects of Deterioration and Misaim. *Trans. illum. Engng Soc., Lond.*, 1953, **18** (8), 207–220

HAYWARD, A. T. J., and PETERS, C. H. Materials for Marking Striped Pedestrian Crossings. *Surveyor, Lond.*, 1954, **113** (3230), 89–91

HILLIER, J. A. Traffic Engineering in the U.S.A. *J. Instn Highw. Engrs*, 1954, 3 (2), 4–15; Discussion, 15—25; *Contract J.*, 1953, **151** (3876), 62

JEHU, V. J. A Survey of Vehicle Headlights. *Trans. illum. Engng Soc., Lond.*, 1953, **18** (9), 249–259

JEHU, V. J. Headlight Setting. Part I. An Investigation of Commercial Testers. Part II. An Improved Headlight Tester. *Auto. Engr.*, 1954, **44** (4), 159–164; (5), 213–215

JEHU, V. J. A Simple Glare Meter. *Electron. Engng*, 1954, **26** (318), 359–360

JEHU, V. J. A Comparison of Yellow and White Headlamp Beams. *Lt and Ltg*, 1954, **47** (10), 287–291

JONES, R. Testing of Concrete by Ultrasonic Pulse Technique. *Proc. Highw. Res. Bd. Wash.*, 1953, **32**, 258–275

JONES, R. and WRIGHT, P. J. F. Some Problems Involved in Destructive and Non-destructive Testing of Concrete. *Rds and Rd Constr.*, 1954, **32** (380), 249–251

KIRKHAM, R. H. H. Factors Affecting the Riding Quality of Machine-laid Concrete Roads. *Proc. Instn civ. Engrs., Part II*, 1953, **2** (3), 656-696; Discussion, 696–709; *Surveyor, Lond.*, 1953, **112** (3186), 220; Discussion, (3191), 307–309; *Contract J.*, 1953, **149** (3850), 140–141; *Munic. Engng sanit. Rec.*, 1953, **130** (3300), 735; *Contractors Rec.*, 1953, **64** (13), 35, 37; *Highw. and Br.*, 1953, **19** (979), 12

KIRKHAM, R. H. H. Effect of Methods of Using Small Vibrating Screeds on the Depth of Compaction of Concrete. *Surveyor, Lond.*, 1954, **113** (3257), 673–675

LEE, A. R. The Latest Developments in Asphalt Technology. *Wegen*, 1953, **27** (8), 168–181 (In Dutch)

LEE, A. R. Some Research on Bituminous Materials at the Road Research Laboratory, Great Britain. *Statens Vaginstitut Rapprt* 24. Stockholm, 1953 (Statens Vaginstitut)

LEE, A. R. Size and quality of Stone used for Surface Dressing. *Road Tar*, 1953, 7 (4), 6–9

LEE, A. R. Road Research: its Influence on Highway Construction of the Future. *Contractors' Rec.*, 1954, **65** (14), 43, 59, 61

LEE, A. R. Full-scale Road Experiments. *Road Tar*, 1954, **8** (3), 11–17

LEE, A. R. and NICHOLAS, J. H. Adhesion in the Construction and Maintenance of Roads. *Adhesion and Adhesives: Fundamentals and Practice*. London, 1954 (Society of Chemical Industry), pp. 104–115

LEWIS, W. A. Surface Dressings for Protecting Soil Formations. *Engineering, Lond.*, 1953, **176** (4586), 793–796

LEWIS, W. A. The Compaction of Soil for Earthworks and the Performance of Plant. *Proc. 3rd Internat. Soil Mech. Conf.*, 1953, 1, 258–262

LISTER, R. D. and KEMP, R. N. Some Traffic and Driving Conditions which Influence Petrol Consumption. *Bull. Mot. Ind. Res. Ass.*, 1954, (2), 19–26

LONSDALE, T. Equipment for Testing Laboratories. *Rds and Rd Constr.*, 1954, **32** (373), 19–23

MACLEAN, D. J. The Application of Soil Mechanics to Road Construction in Great Britain. *Rev. gen. Routes*, 1953, **23** (261), 33–40, 43–44 (In French)

MACLEAN, D. J. Recent Progress in Soil-cement for Road Construction. *Engineer, Lond.*, 1953, **196** (5105), 712–714; *Contractors Rec.*, 1953, **64** (47), 27–931; *Surveyor, Lond.*, 1954, **113** (3226), 7–8

MACLEAN, D. J. Foundations for Concrete Roads: their Preparation and Protection. *Mag. Conor. Res.*, 1954, **6** (16), 17–32

MACLEAN, D. J. and M. D. ARMSTRONG. The Design of Road Foundations. *Proc. 3rd Internat. Soil Mech. Conf.* 1953, **2**, 118–121

MACLEAN, D. J. and K. E. CLARE. Investigation of some Problems in Soil Stabilization. *Proc. 3rd Internat. Soil Mech. Conf.*, 1953, **1**, 263–267

MONCRIEFF, D. S. The Effect of Grading and Shape on the Bulk Density of Concrete Aggregates. *Mag. Conor. Res.*, 1953 5 (14) 67–70

NEWBY, R. F. Road Traffic in Central London. *Bull. perm. int. Ass. Rd. Congr.*, 1954, **43** (136), 1–18

NIJBOER, L. W. and R. JONES. Investigation into the Dynamic Testing of Roads. *Rds. and Rd. Constr.*, 1954, **32** (379), 202–9

PETERS, C. H. and E. FRANCIS. Concrete Markings for Pedestrian Crossings. *Surveyor, Lond.*, 1954, **113** (3227), 21–23

PRICE, W. I. J. How to use Fences to Prevent Roads Being Blocked by Snow. *Rds. and Rd. Constr.*, 1954, **32** (373), 7–10

PUGH, H. LL.D. and PRICE, W. I. J. Snow Drifting and the use of Snow Fences. *Polar Rec.*, 1954, 7 (47), 4–23

RUSSELL, W. L. and SINGLETON, H. Filler Handling in Bituminous Mixing Plants: Comparison of Vibration and Aeration as Aids to Flow From a Storage Bin. *Contract J.*, 1954, **152** (3899), 1236–1238; *Quarry Mgrs. J.*, 1954, **37** (12), 658–664

SABINE, P. A., MOREY, J. E. and SHERGOLD, F. A. The Correlation of the Mechanical Properties and Petrography of a Series of Quartz-dolerite Roadstones. *J. appl. Chem.*, 1954, **4** (3), 131–137

SHERGOLD, F. A. The Percentage Voids in Compacted Gravel as a Measure of its Angularity. *Mag. Concr. Res.*, 1953, **5** (13), 3–10

SHERGOLD, F. A. The Effect of Freezing and Thawing on the Properties of Road-making Aggregates. *Rds. and Rd. Constr.*, 1954, **32** (381), 274–276

SMEED, R. J. Some Factors Affecting Visibility from a Driver's Seat and Their Effect on Road Safety. *Brit. J. physiol. Optics*, 1953, **10** (2), 63–85

SMEED, R. J. Road User Behaviour in Relation to Road Conditions. *Internat. Rd. Saf. Traff. Rev.*, 1954, **2** (1), 22–26

SMEED, R. J. Road Design in Relation to Traffic Movement and Road Safety. *J. Instn. munic. Engrs.*, 1954, **81** (3), 129–143

STARKS, H. J. H. Toughened Glass. Investigations into Some Safety Aspects. *Auto. Engr.*, 1954, **44** (10), 433–438

TANNER, J. C. Buses Replacing Trams. Effect on Road Accidents in London. *Mod. Transp.*, 1954, **70** (1823), 5

TARRANT, A. G. The Measurement of Friction at very Low Speeds. *Engineer, Lond.*, 1954, **198** (5143), 262–263

TAYLOR, F. G. Experimental Stone-crushing Plant. *Engineering, Lond.* 1953, **176** (4570), 281–283

WARDROP, J. G. The Capacity of Roads. *Operat. Res. Quart.*, 1954, **5** (1), 14–24

WARDROP, J. G. and CHARLESWORTH, G. A Method of Estimating Speed and Flow of Traffic from a Moving Vehicle. *Proc. Instn. civ. Engrs. Part II*, 1954, **3** (1), 158–171

WATERS, D. B. American Road Construction Methods and their Possible Application in Scotland. *J. Instn. Highw. Engrs.*, 1953 **2** (11), 46–55; (12), 50–60

WEST, L. Determination of the Dry Density of Compacted Layers of Coarse Granular Materials. *Surveyor, Lond.*, 1953, **112** (3205), 531–532

WEST, L. Mix-in-place Soil Stabilization. A Comparison of Spreading Cement by Hand and by a Machine. *Contract J.*, 1954, **154** (3914), 48–49

WHIFFIN, A. C. Locating Steel Reinforcing Bars in Concrete Slabs. *Engineer, Lond.*, 1954, **197** (5134), 887–888

WHIFFIN, A. C. and PRICE, W. I. J. Road Problems Arising from Snow and Ice. *Chem. and Ind., (Rev)* 1954, (9), 230–237

WILLIAMS, F. H. P. and RUSSELL, W. L. Sampling Apparatus for Use in Testing the Efficiency of Paddle Mixers of Asphalt and Coated-macadam Plant. *Quarry Mgrs. J.*, 1954, **37** (12), 666–669

WRIGHT, P. J. F. Statistical Methods in Concrete Research. *Mag. Concr. Res.*, 1954, **5** (15), 139–149

WRIGHT, P. J. F., MASTERS, J. and TANNER, J. C. Roughening of Sett Pavings. Effect on Resistance to Skidding and on Frequency of Accidents. *Surveyor, Lond.*, 1953, **112** (3202), 483–485

WATER POLLUTION RESEARCH

ISSUED BY H.M. STATIONERY OFFICE

Annual Report of the Water Pollution Research Board, and the Director of Water Pollution Research—

Water Pollution Research, 1953		2*s.* 6*d.* (2*s.* 8*d.*)
Water Pollution Abstracts Published monthly		4*s.* 0*d.* (4*s.* 1½*d.*)
Annual Subscription rate (including index)	(including postage)	£2 10*s.* 0*d.*
Vol. 26. Nos. 8–12. Aug.–Dec., 1953		
Vol. 26. Index 1953		
Vol. 27. Nos. 1–9, Jan.–Sept., 1954		

PUBLISHED IN JOURNALS

ALABASTER, J. S., and HERBERT, D. W. M. Influence of Carbon Dioxide on the Toxicity of Ammonia. *Nature, Lond.*, 1954, **174** (4426), 404

ALLAN, I. R. H., ALABASTER, J. S. and HERBERT, D. W. M. Recent Studies on Toxicity and Stream Pollution. *Wat. Sanit. Engr*, 1954, **5** (3), 109–112

ALLEN, L. A. Faecal Bacteria in Polluted Water. *Proc. Soc. Wat. Treatment and Exam.*, 1953, **2**, 94–110

ALLEN, L. A., COOPER, A. H., and ROSE, J. N. Microbiological Changes in Carbohydrate Media: Effect of Aeration on pH Value and on Oxidation and Assimilation. *J. appl. Bact.*, 1954, **17** (1), 57–69

ALLEN, L. A., PIERCE, M. A. F., and SMITH, H. M. Enumeration of *Streptococcus faecalis*, With Particular Reference to Polluted Waters. *J. Hyg., Camb.*, 1953, **51** (4), 458–467

ALLEN, L. A., and SMITH, H. M. Effect of Treatment of Domestic Sewage in Small Plants on the Counts of Faecal Bacteria. W.H.O. Monograph, "Design and Operation of Septic Tanks", Geneva, 1953, pp. 75–83

BRIGGS, R., KNOWLES, G., and SCRAGG, L. J. A Continuous Recorder for Dissolved Oxygen. *Wat. Sanit. Engr.*, 1954, 5 (1), 24–25

CHILDS, E., and ALLEN, L. A. Improved Methods for Determining the Most Probable Number of *Bacterium coli* and *Streptococcus faecalis*, *J. Hyg., Camb.*, 1953, **51** (4), 468–477

DOWNING, A. L., WHEATLAND, A. B., and EDEN, G. E. Observations on the Removal of Radio-isotopes During the Treatment of Domestic Water Supplies. II. Radio-strontium. *J. Instn Wat. Engrs.*, 1953, **7** (7), 555–572

DOWNING, K. M. The Influence of Dissolved Oxygen Concentration on the Toxicity of Potassium Cyanide to Rainbow Trout. *J. exp. Biol.*, 1954, **31** (2), 161–164

EDEN, G. E., ELKINS, G. H. J., and TRUESDALE, G. A. Removal of Radioactive Substances from Water by Biological Treatment Processes. *Atomics*, 1954, **5** (5), 133–142, 158

GAMESON, A. L. H. L'auto-épuration Dans les Estuaires. *Bull. Centre belge Et. Document. Eaux*, 1954, No. 24, 71–77

HERBERT, D. W. M. Measurement of the Toxicity of Substances to Fish. *J. Inst. Sew. Purif.*, 1952, Part 1, 60–68

JONES, E. E., and MURDOCH, J. C. Polluting Character of Silage Effluent. *Wat. Sanit. Engr.*, 1954, **5** (2), 54–56

KNOWLES, G., and WHEATLAND, A. B. Analytical Problems of River Pollution. *Chem. Age, Lond.*, 1954, **70** (1806), 465–469

PAINTER, H. A. Factors Affecting the Growth of Some Fungi Associated with Sewage Purification. *J. gen. Microbiol.*, 1954, **10** (1), 177–190

PETTET, A. E. J., and JONES, E. E. Treatment of Domestic Sewage in Plants Serving Small Groups of Houses. W.H.O. Monograph, "Design and Operation of Septic Tanks", Geneva, 1953, pp. 57–73

PETTET, A. E. J., and MILLS, E. V. Biological Treatment of Cyanides With and Without Sewage. *J. appl. Chem.*, 1954, **4** (8), 434–444

PREDDY, W. S. The Mixing and Movement of Water in the Estuary of the Thames. *J. Mar. biol. Ass. U.K.*, 1954, **33**, (3), 645–662

SCRAGG, L. J., BRIGGS, R., and KNOWLES, G. A Submersible Photoelectric Absorptiometer. *J. sci. Instrum.*, 1954, **31** (3), 75–77

SOUTHGATE, B. A. Treatment and Disposal of Waste Waters from Dairies. *Dairy Sci. Abstr.*, 1954, **16** (6), 428–441

SOUTHGATE, B. A. Treatment of Waste Waters from Tanneries. *J. Soc. Leath. Tr. Chem.*, 1953, **37**, 393–399

SPENCER, E. A., and KNOWLES, G. Clear Water for Hydraulic Research. *Wat. and Wat. Engng.*, 1954, **58** (702), 350–354

TOMLINSON, T. G., and HALL, H. Treatment of Sewage by Alternating Double Filtration With and Without Settlement of Primary Effluent. *J. Instn. munic. Engrs.*, 1953, **80** (4), 227–231

TRUESDALE, G. A. Measurement of Sewage Flow Using Radioactive Tracers. *J. Instn. munic. Engrs.*, 1953, **80** (4), 232–240

TRUESDALE, G. A., and DOWNING, A. L. Solubility of Oxygen in Water. *Nature, Lond.*, 1954, **173** (4417), 1236

WHEATLAND, A. B. Factors Affecting the Formation and Oxidation of Sulphides in a Polluted Estuary. *J. Hyg., Camb.*, 1954, **52** (2), 194–210

WILKINSON, R. An Automatic Sampler for Intermittent Flows of Water. *Instrum. Pract.*, 1954, **8** (5), 414–415

(B) LIST OF RESEARCH ASSOCIATION PUBLICATIONS

ISSUED DURING THE YEAR (INCLUDING PAPERS PUBLISHED IN JOURNALS)

(NOTE: *Copies of these papers are not available from D.S.I.R.*)

BRITISH BAKING INDUSTRIES RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

COOKSON, M. A., COPPOCK, J. B. M. and SCHNURMANN, R. Ultra-violet Spectrophotometric Estimation of the Quality of Mineral Oils Extracted from Bread. *The Analyst*, 1953, **78** (933), 695–703

COOKSON, M. A., and COPPOCK, J. R. M. The Role of Glycerides in Baking. Part I: The Effects of Added Glycerinated Fats in Bread and Flour Confectionery. *J. Sci. Fd Agric.*, 1954, **5** (1), 8–26

COPPOCK, J. B. M., COOKSON, M. A., LANEY, D. H. The Role of Glycerides in Baking. Part II: The Influence of Flour Oils on the Behaviour of Glycerinated Fats in Baking, and the Effect of Natural Monoglycerides present in Flour Oils and Baking Fats on the Pharmacological Desirability of using Glycerinated Fats in Baked Products. *J. Sci. Fd Agric.*, 1954, **5** (1), 8–26

COOKSON, M. A. and LANEY, D. H. A Technique for Analysis by Counter-current Extraction. *Chem. and Ind., (Rev)* 1954, 450–452

COPPOCK, J. B. M. Food Hygiene and Food Preparation in the Home and Kitchen. (a) Some Factors Affecting the Structure of the Kitchen and Larder. *J. R. Sanit. Inst.*, 1954, **74** (7)

FARMILOE, F. J., CORNFORD, S. J., COPPOCK, J. B. M. and INGRAM, M. The Survival of Bacillus Subtilis Spores in the Baking of Bread. *J. Sci. Fd Agric.*, 1954, **5**, 292–304

TEMPLETON, W. H. and CARPENTER, B. E. The Lipase Activity of Certain Cereal Products. *The Analyst*, 1953, **78**, (933), 726–727

TEMPLETON, W. H., COPPOCK, J. B. M. and GREER, E. N. Cereals and Cereal Products. *Rep. Progs Appl. Chem.*, 1953

THE BRITISH BOOT, SHOE AND ALLIED TRADES RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

ALLWOOD, M. J. and BURRY, H. S. The Effect of Local Temperature on Blood Flow in the Human Foot. *J. Physiology*, 1954, **124** (2), 345–357

BAILEY, F. G. An Account of the Work on Comparative Productivity Measurement carried out by the British Boot, Shoe and Allied Trades Research Association. O.E.E.C. Report and Papers on E.P.A. Project No. 230: Productivity Measurement in the European Boot and Shoe Industry. (EPA/EC/961)

BAILEY, F. G. Productivity Comparisons between Factories making Veldt Sandals. *J. Brit. Boot and Shoe Instn.*, 1953, **5**, (II), 422–426

BAILEY, F. G. Satra Seat Bedding and Assembling Machine. *J. Brit. Boot and Shoe Instn.*, February 1954, **6** (1), pp. 24–27

BRADLEY, H. Footwear Research—Principles and Programme. *Engineering Inspection*, 1954, **18** (1), pp. 10–13

HALL, E. F. Adhesives for Bottom Attachment. *J. Brit. Boot and Shoe Instn*, 1954, **6** (5), pp. 194–200

OTHER PUBLICATIONS

BOOTH, W. E. Plastics in the Shoe Industry. *Plastics Progress*, 1953, pp. 381–412. (Report of the Second British Plastics Convention, June 1953, published Iliffe & Sons, Ltd., London)

BRADLEY, H. Comparative Performance Records as a Tool for Management. (Paper to British Institute of Management Conference, Harrogate, November, 1953)

BRITISH CAST IRON RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

ANGUS, H. T. and TOGHILL, E. C. Cast Iron Brake Drums: Developments in Design and Materials. *Auto. Engr*, 1953, **43**, 409–418

BACH, B. B., DAWSON, J. V. and SMITH, L. W. L. Determination of Oxygen, Hydrogen and Nitrogen in Cast Iron. *J. Iron St. Inst.*, March 1954, **176**, 257–263

BACH, B. B., DAWSON, J. V., SMITH, L. W. L. Preparation of Ammoniacal Cuprous Chloride. *Chem. and Ind. (Rev.)*, 1953, (48), 1279–1280

GITTUS, J. H. Method of Analysing Flow of Granular Materials such as Sand. *Nature, Lond.*, 1953, **172**, 364

GITTUS, J. H. Flow Properties of Foundry Sand: Significance of the Bond Energy Ratio *Iron and Steel*, 1953, **26**, October, 475–478, November, 501–506, December, 551–553

GRANT, J. M. Growth Characteristics of Ingot Mould Irons in Air and Vacuum. *Proc. Inst. Brit. Foundrym.*, 1953, **46**, A110–A127; discussion, A128–130

MORROGH, H. The Solidification of Nodular Iron. *J. Iron St. Inst.*, April, 1954, **176**, 378–382

MORROGH, H. and TUTSCH, P. H. The Solidification of Iron-Phosphorus-Carbon Alloys. *J. Iron St. Inst.*, April 1954, **176**, 382–384

MORROGH, H. and WILLIAMS, W. J. Undercooled Graphite in Cast Irons and Related Alloys. *J. Iron St. Inst.*, April 1954, **176**, 375–378

PEARCE, J. G. Achievements of the British Cast Iron Research Association. *F.B.I. Review*, 1954, 29–31

PEARCE, J. G. The British Cast Iron Research Association. *Metallurgia*, October 1953, **48**, 175–177

PEARCE, J. G. Leaders of the Industry. *Found. Tr. J.*, February 1954, **96**, 117

PEARCE, J. G. Two Eastern Tea Kettles. *Found. Tr. J.*, February 1954, **96**, 118

PRICE, W. J. Spectrographic Analysis of Complex Oxides with Particular Reference to Slags and Ores. *Spectrochim. Acta*, 1953, **6**, 26–28

SMITH, L. W. L., BACH, B. B. and DAWSON, J. V. Estimation and Influence of the Gaseous Elements in Cast Iron. *Found. Tr. J.*, 4th March 1954, **96**, 233–238; 11th March 1954, **96**, 275–280; 18th March, 303–306; discussion, 303–308

WHITE, W. H. and LAWRIE, W. B. Application of External Dust Control to a Standard 24 in. Pedestal Grinder. *Proc. Inst. Brit. Foundrym.*, 1953, **46**, A247–A253; discussion, A253–A259

WOODWARD, G. R. Cast Iron. *Rep. Progr. appl. Chem.*, 1952, **37**, 306–315

Issued by the Association in their Journal of Research and Development

BACH, B. B. The Association's Work on Gases in Cast Iron. 1953, 5 (2), 38–40

BACH, B. B. Gas Analyses of Cast Iron Produced at Various Foundries. 1953, 5 (2), 45–70

BAMFORD, W. D. Booth Ventilation for Swing Frame Grinders. 1954, 5 (6), 331–351

BAMFORD, W. D., SHAW, F. M., and BRIGHT, J. Sand Cooling and Dust Control. 1954, 5 (7), 367–374

EVANS, E. R. Carbon Equivalent and Fluidity. 1953, 5 (3), 118–123

EVANS, E. R. Temperature Cycles of Enamelled Castings during the Process of Enamel Fusing. 1953, 5 (2), 78–92

EVANS, E. R. and WEBSTER, D. Mck. A Cause of Cracking in Bath Castings. 1954, 5 (4), 145–159

GILBERT, G. N. J. The Ductility of Whiteheart Malleable Iron. 1954, 5 (4), 160–172

GILBERT, G. N. J. Fatigue Properties of Cast Iron. 1953, 5 (3), 94–108

GILBERT, G. N. J. Galvanizing Embrittlement of Blackheart Malleable Iron. 1953, 5 (3), 124–131

GILBERT, G. N. J. Impact Properties of Flake Graphite Cast Irons. 1954, 5 (6), 298–317

GILBERT, G. N. J. Temper Embrittlement in Blackheart Malleable and Nodular Cast Irons. 1954, 5 (5), 249–263

GILBERT, G. N. J. and PALMER, K. B. The Influence of Surface Rolling on the Fatigue Strength of Cast Iron. 1953, 5 (2), 71–77

GITTUS, J. H. Factors Governing the Surface Finish of Iron Castings. 1954, 5 (7), 375–389

GITTUS, J. H. The Influence of Grain Size Distribution on Some Properties of Sand. 1954, 5 (6), 318–330

GITTUS, J. H. The Influence of Mould Factors on Casting Defects. 1954, 5 (5), 264–277

GODDING, R. G. and REW, R. Behaviour of Sand Mixtures under Load at Room and Elevated Temperatures. 1954, 5 (5), 278–295

HIGGINS, R. I. Possibilities of Reducing the Phosphorus Content of Cast Iron. 1954, 5 (7), 390–413

HILLMAN, M. H. The Magnetic and Electrical Properties of Cast Iron. 1954, 5 (5), 188–248

JOLLY, R. Segregation of Manganese Sulphide Type Inclusions in Grey Cast Iron. 1954, 5 (4), 180–186

PALMER, K. B. Comprehensive Mechanical Tests on an Acicular Cast Iron. 1953, 5 (3), 109–117
SMITH, L. W. L. Oxygen in Malleable Iron. 1954, 5 (4), 173–179
WILLIAMS, W. J. The Influence of Casting Temperature on Chill and Mottle Formation. 1954, 5 (4), 136–144
WILLIAMS, W. J. Oxidized Iron. 1953, 5 (2), 41–44
WILLIAMS, W. J. A Relationship of Microstructure to the Mechanical Properties of White Irons. 1953, 5 (3), 132–134

Issued in the B.C.I.R.A. Bulletin and Foundry Abstract

Aluminium in Cast Iron. 1953, **12** (3), 129–132
Behaviour of Cast Iron in Sea-Water. 1953, **12** (1), 8–14
British Standard Specifications Referring to Cast Iron and Related Subjects. Part 2. 1953, **12** (2), 75–77
The Carbon Dioxide Curing Process. 1954, **12** (6), 279–281
32nd Annual Report of the B.C.I.R.A. Council, 1952–1953. B.C.I.R.A., November, 1953
Index to Journal of Research and Development, v, 4, August, 1951–June, 1953
Index to Bulletin and Foundry Abstracts, v. 11, July, 1951–May, 1953
Open Days, 7th and 8th July, 1954. Descriptive Booklet

OTHER PUBLICATIONS

ANGUS, H. T. Dust and Carbon Monoxide Hazards in the Foundry: The Work of the British Cast Iron Research Association. *Proc. of a Conference on Making the Ironfoundry Safer.* Council of Iron Foundry Associations, 1954, p. 45–59
BACH, B. B. Theoretical Aspects of Oxygen in Cast Iron. Paper contributed to the 1954 Annual Conference of the Inst. Paper No. 1096
EVANS, E. R. Defects in Vitreous Enamelled Iron Castings. Paper contributed to the 1954 Conference of the Inst. Brit. Foundrym. Paper No. 1096
GILBERT, G. N. J. L'essai de Résilience des Fontes á Graphite Lamellaire. Paper No. CI/10 presented to the International Foundry Congress, Paris, September, 1953. (Printed only in this form)

BRITISH CERAMIC RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

BEECH, D. G. and HOLDRIDGE, D. A. Some Aspects of the Testing of Clays for the Pottery Industry. *Trans. Brit. Ceram. Soc.*, 1954, **53**, 103
BENNETT, H. The Solubility of Lead Glazes, Part V, *Trans. Brit. Ceram. Soc.*, 1954, **53**, 203
BENNETT, H. and VAUGHAN, F. The Solubility of Lead Glazes, Part IV. *Trans. Brit. Ceram. Soc.*, 1953, **52**, 578
CLEMENTS, J. F. and RIGBY, G. R. Some Factors Affecting the Crushing Strength of Porous Refractory Bodies. *Trans. Brit. Ceram. Soc.*, 1953, **52**, 565
CLEMENTS, J. F. and VYSE, J. A New Thermal Conductivity Apparatus for Refractory Materials. *Trans. Brit. Ceram. Soc.*, 1954, **53**, 134
CLEMENTS, J. F., WATSON, A. F., and VYSE, J. A Co-operative Test on Thermal Conductivity. *Trans. Brit. Ceram. Soc.*, 1953, **53**, 156
DAVIS, W. R. and RIGBY, G. R. The Dissociation of Carbon Monoxide by Iron Compounds. *Trans. Brit. Ceram. Soc.*, 1954, **53**, 511
DINSDALE, A. The Effect of Heat on Plaster. *Trans. Brit. Ceram. Soc.*, 1953, **52**, 614
DODD, A. E. The British Ceramic Research Association. *Metallurgia, Manchr.*, 1953, **48**, 180
DODD, A. E. Refractories, 1950–1953. *J. Iron St. Inst.*, 1953, **26** (155), 312
DODD, A. E. The British Ceramic Research Association. *Metallurgia, Manchr.*, 1954, **50**, 174
GREEN, A. T. Craftsmanship Aided by Research. *The Financial Times*, 1st March, 1954, p. 5
GREEN, A. T. Progress in Pottery Research. *Fed. Brit. Ind. Rev.*, April, 1954, No. 49, 29
JAMES, W. A New Method of Improving Furnace Temperature Control. *J. sci. Instrum.*, 1954, **31**, 23
KEELING, P. S. Cornish Stone. A Method of Quantitive Mineralogical Analysis. *Trans. Brit. Ceram. Soc.*, 1954, **53**, 67
KEELING, P. S. The Geology of Fireclays. *Trans. Brit. Ceram. Soc.*, 1954, **53**, 362
RICHARDSON, H. M., BALL, F., and RIGBY, G. R. The Preparation and Properties of Vanadium Spinels. *Trans. Brit. Ceram. Soc.*, 1954, **53**, 376
RICHARDSON, H. M. and BANKS, W. Investigation on Taphole Clays and Taphole Practice. *J. Iron St. Inst.*, 1954, **178**, 138
RIGBY, G. R. and WHITE, R. P. The Thermal Expansion Properties of Compositions Containing Lithia, Alumina and Silica. *Trans. Brit. Ceram. Soc.*, 1954, **53**, 324

ROWDEN, E. Fuel Utilisation in the Heavy Clay and Refractories Industries. *Fed. Brit. Ind. Fuel Econ. Rev.*, January 1954, 32

WORRALL, W. E. and GREEN, C. V. The Organic Matter in Ball Clays. *Trans. Brit. Ceram. Soc.*, 1953, **52**, 528

ISSUED BY THE ASSOCIATION

RIGBY, G. R. The Thin Section Mineralogy of Ceramic Materials. 2nd Edition. 1953. Published by British Ceramic Research Association. Price 32*s.* 6*d.*

OTHER PUBLICATIONS

BEECH, D. G. Testing in the Pottery Industry. Ceramics: A Symposium, 1953. Pubd by British Ceramic Society

CLEMENTS, J. F. The Thermal Properties of Ceramic Products. Ceramics: A Symposium, 1953. Pubd by British Ceramic Society

CLEMENTS, J. F. Testing Refractory Materials. Ceramics: A Symposium, 1953. Pubd by British Ceramic Society

CLEMENTS, J. F., WATSON, A. F., and VYSE, J. A. A Co-operative Test on Thermal Conductivity. 44th Report of the Joint Refractories Committee, Gas Council Publication. GC 10

CLEMENTS, J. F. and VYSE, J. Shrinkage of Bricks in Furnace Walls. 44th Report Joint Refractories Committee, Gas Council Publication, GC 10

CLEWS, F. H. Fireclay and Alumina—Silicate Refractories in the 20th Century. Ceramics: A Symposium, 1953. Pubd by British Ceramic Society

LAMING, J. Vertical Growth of a Setting of Intermittent Vertical Retorts. 44th Report of the Joint Refractories Committee, Gas Council Publication, GC 10

NOBLE, W. The Heavy-clay Industry, 1900–1950. Ceramics: A Symposium, 1953. Pubd by British Ceramic Society

RICHARDSON, H. M. X-rays and Ceramics. Ceramics: A Symposium, 1953. Pubd by British Ceramic Society.

RIGBY, G. R. Spinels and their Relation to Chrome Ores. Ceramics: A Symposium, 1953. Pubd by the British Ceramic Society

ROWDEN, E. Firing in the Heavy Clay and Refractories Industries, 1900–1950. Ceramics: A Symposium, 1953. Pubd by British Ceramic Society

BRITISH COAL UTILISATION RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

BARBER, R., JACKSON, R., LAND, T., and THURLOW, G. G. A Suction Pyrometer for Measuring Gas Exit Temperatures for the Combustion Chambers of Water-Tube Boilers. *J. Inst. Fuel*, 1954, **27**, 408–416

BILLINGTON, A. H. The Reduction of the Caking, Swelling and Smoke-Producing Properties of Coal by Chemical Pre-treatment. *Fuel, Lond.*, 1954, **33**, 295–301.

BOND, R. L. A Two-Stage Phenomenon in the Breakage of Coal. *Fuel, Lond.*, 1954, **33**, 249–250

BROADBENT, S. R. Some Uses of the Nomogram in Statistics. *Appl. Statist.*, 1954, **3**, 33–43

BROWN, R. L. Mixing of Granular Materials. *Research, Lond.*, 1953, **6**, 57S–58S

BROWN, R. L. Physics of Coal. Problems of Breakage and Structure. *Times Review of Science*, Winter, 1953

BROWN, R. L. and HAWKSLEY, P. G. W. Particle Mechanics: The Science of Granular Solids and Suspensions. *Times Review of Science*, Summer, 1954

GODRIDGE, A. M. and THURLOW, G. G. A Water Separating Cyclone. *J. sci. Instrum.*, 1954, **31**, 258–259

GUNN, D. C. Furnace Tube Baffles and Retarders, *Fuel Effi. News*, 1954, 3–5

GUNN, D. C. Efficient Industrial Steam Generation. *Engineering, Lond.*, 1954, **178**, 335–338

HALES, J. S. Room Heating for Comfort. *The Ironmonger*, 1954

HALES, J. S. Efficiency in Domestic Heating. *Coke and Gas*, 1953, **15**, 450–456

HALES, J. S. and GUNN, D. C. Heat for Horticulture. *Mechanism in Horticulture*, 1954, 61–68

KEAR, R. W. The Effect of HCl on the Corrosive Nature of Combustion Gases Containing SO_3. *Fuel, Lond.*, 1954, **33**, 119

NELSON, J. B. X-ray Studies of the Ultra-Fine Structure of Coal. Part I. The Low Angle Scattering of Vitrinite from Coals of Differing Rank. *Fuel, Lond.*, 1954, **33**, 153

TOWNEND, D. T. A. The New Education Scheme of the Institute of Fuel. *J. Inst. Fuel*, 1954, **27**, 353–362

TOWNEND, D. T. A. 2nd Hodsman Memorial Lecture: Science and Coal. *Chem. and Ind. (Rev.)*, 1954 (27), 766–774; *Gas J.*, 1954, **277**, 593–602

TOWNEND, D. T. A. Science and Coal. *F.B.I. Rev.*, 1954, No. 53, 29–33

WHITTINGHAM, G. The Corrosive Nature of Combustion Gases. *Corrosion Technology*, 1954, I (6), 182–188

ISSUED BY THE ASSOCIATION

Annual Report, 1953 Price 7s. 6d.
Quarterly Gazette Price 2s. 6d. each
Monthly Bulletin (not available to non-members until six months after publication) Price 7s. 6d. each

The following are the titles of the Reviews published in the Monthly Bulletins during the period October, 1953 to September, 1954:—

September/October, 1953—Part II—" Determination of the Weight and Size of Molecules in Solution ", by P. H. Given, S. M. Rybicka and W. F. Wyss
November, 1953—" Recent Advances in Infra-Red Spectroscopy ", by J. K. Brown
December, 1953—" Operational Research ", by F. Fereday
January, 1954—" Some Properties of Gas Mixtures ", by A. M. Godridge
February/March, 1954—Part I—" Physical and Chemical Factors in the Early Stages of Coke Formation ", by I. G. C. Dryden and M. Griffith
April, 1954—" Analogies for Matter, Heat and Momentum Transfer ", by R. L. Brown
May, 1954—" The Small Underfeed Stoker ", by W. D. Smith
June, 1954—" The Rapid Carbonisation of Coal ", by R. A. Kirby
July, 1954—" Physics of Particle Size Analysis: Review of papers presented at a Conference convened by the Institute of Physics and held at Nottingham University on 6–9th April, 1954 ", by B. B. Morgan and S. Badzioch
August, 1954—" The Cyclone Furnace ", by G. C. H. Sharpe
September, 1954—" Surface Diffusion ", by R. L. Bond and A. R. Murnaghan

BRITISH COKE RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

BATTYE, T., JOHNSON, R. and WILKINSON, H. C. Use of Bromine Water in the Determination of Sulphur in Coal or Coke by the Eschka process. *J. appl. Chem.*, 4th March, 1954, 119–123
BLAYDEN, H. E. G. Some Recent Work of the Northern Coke Research Laboratory. *Gas World—Coking Section*, 1954, **45**, 9–13
MOTT, R. A. Effect of Physical and Chemical Properties of Coke on its Combustion. *Coke and Gas*, 16th May, 1954, 189–194
MOTT, R. A. Recent Developments in the Analysis of Coal and Coke. *Chem. Age*, 1954, **70**, 1143–1146
STADLER, H. P. The Crystal Structure of Flavanthrone. *Acta Cryst. Camb.*, 1953, **6**, 540–542

ISSUED BY THE ASSOCIATION

Coke Review. A Bibliographical Guide to Published Material of Interest to the Coking Industry. No. 4, July–December 1953, No. 5 January–June, 1954
Fundamental Studies of Carbon and Coke. The Sixth Conference of the British Coke Research Association, 1954

THE BRITISH COTTON INDUSTRY RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

AXSON, M. Observations of the Traveller During Spinning. *J. Text. Inst.*, 1954, **45** (4), T368–T370
BILSBURY, M. M., MARTIN, J. T. and STANDING, H. A. The Absorption of Chrysophenine G by Cotton and Acidic Oxycelluloses. *J. Text. Inst.*, 1954, **45** (1) T1–T20
BRADBURY, E. and WORTHINGTON, A. P. The Crossing of Threads in Shedding. *J. Text. Inst.*, 1954, **45**, (6) T421–T437
CAVANEY, B., and FOSTER, G. A. R. Some Observations on the Drafting Forces of Cotton and Rayon-staple Slivers. *J. Text. Inst.*, 1954, **45** (5), T390–T404
CLIBBENS, D. A. Cellulose Chemistry and the Textile Industry. *J. Text. Inst.*, 1954, **45**, (5), 173–193
DAKIN, G., FOSTER, G. A. R. and LOCKE, J. Roller Slip and the Irregularity of Cotton and Rayon-staple Drawframe Slivers, Part 1—Practical and Experimental. *J. Text. Inst.*, 1954, **44** (11), T544–T569
DAVIDSON, G. F. The Dissociation Constant of Chlorous Acid. *J. Chem. Soc.*, 1954, p. 1649.
DERRY, R. L. and HIGGINBOTHAM, R. S. The Flow Properties of Textile Printing Pastes. *J. Soc. Dy. Col.*, 1953, **69** (13), 569
DONOGHUE, J. K. and MACK, C. The Reduction in Apparent Particle Concentration with multiple Strokes of the Owens Jet Dust Counter. *Brit. J. appl. Phys.*, 1953, **4** (10), 316
DRUMMOND, D. G., HAMLIN, MARY, DONOGHUE, J. K. and BROWNSETT, F. The Effect of Oiling the Cotton on the Airborne Contamination in Cardrooms. *Brit. J. industr. Med.*, 1954, **11** (2), 151–155

FARGHER, R. G. The Occurrence and Prevention of the Biological Attack of Cellulosic Textile Fibres. *Biochem. J.*, 1953, **54**, 71

FORD, J. E., and ROFF, W. J. Identification of Textile and Related Fibres. *J. Text. Inst.*, 1954, **45** (8), T580–T623

FOSTER, G. A. R. Roller Slip and the Irregularity of Cotton and Rayon-staple Drawframe Slivers. Part II—The Nature of Roller Slip and the Theory of Draft Distribution. *J. Text. Inst.*, 1954, **44** (11), T570–T579.

GREGORY, J. Cotton Yarn Structure—Part IV. The Strength of Twisted Yarn Elements in Relation to the Properties of the Constituent Fibres. *J. Text. Inst.*, 1953, **44** (11), T499–T514

GREGORY, J. Cotton Yarn Structure—Part IV. The Relation Between Strength Measurements Made on Fibres, Fibre Bundles, Yarns and Cloth. *J. Text. Inst.*, 1953, **44**, T515–T533

HAMLIN, A. G. and BATHER, J. M. Two Improved Control Systems for Horizontal Microburettes. *Analyst*, **79**, (943), 655

HAMLIN, A. G. The Determination of Small Amounts of Chromium in Textiles by Means of Diphenylcarbaside. *J. Text. Inst.*, 1954, **45** (1), T44–T54

HAMLIN, MARY. Finishes for Cellulosic Textiles Giving Permanent Protection Against Microbiological Attack—a Survey of the Literature. *J. Text. Inst.*, 1953, **44** (11), T745–P753

HARLAND, W. G. The Degree of Polymerisation and its Distribution in Cellulose Rayons. Part I and II. *J. Text. Inst.*, 1954, **45**, T678–T695

HEAD, FRANK, S. H., and HUGHES, G. The Oxidation of Cellulose with Periodate. *J. Chem. Soc.*, 1954, 603–606

HENRY, P. S. H. Survey of Generation and Dissipation of Static Electricity. *Brit. J. appl. Phys.*, 1953, Supplement 2, S6–S11

HOLDEN, R. Detection of Free Hydroxyl Radicals During the Oxidation of Cellulose in Air. *Nature, Lond.*, 1954, **173**, 539

LORD, J. and TAYLOR, H. M. The Bubble Pressure Test for the Measurement of Bore Size of Fabrics. Part I—The Development of the Test. *J. Text. Inst.*, 1954, **45**, T371–T379

LORD, J. The Bubble Pressure Test for the Measurement of the Pore Size of Fabrics. Part II—The Application of the Bubble Pressure Test to a Study of the Sealing of Close Cotton Cloths when Wetted. *J. Text. Inst.*, 1954, **45** (5), T380–T389

MACK, C. Theoretical Study of Ring and Cap Spinning Balloon Curves (With and Without Air Drag). *J. Text. Inst.*, 1953, **44** (11), T483–T498

MACK, C. and SMART, E. J. L. Measurements of the Air Drag of Textile Threads. *J. Text. Inst.*, 1954, **45**, (4), T348–T362

MARTIN, J. T. and NORRISH, R. G. W. The Photochemical Decomposition of t-butyl Hydroperoxide in Solution. *Proc. roy. Soc., A.*, 220, No. 1142, 322–339

MEREDITH, R. Measurements of Orientation in Cotton Fibres using Polarized Light. *Brit. J. appl. Phys.*, **4**, 369–373

MEREDITH, R. Relaxation of Stress in Stretched Cellulose Fibres. *J. Text. Inst.*, 1954, **45** (6), T438–T461

MEREDITH, R. The Torsional Rigidity of Textile Fibres. *J. Text. Inst.*, 1954, (7), T489–T503

MEREDITH, R. The Effect of Rate of Extension on the Tensile Behaviour of Viscose and Acetate rayons, silk and nylon. *J. Text. Inst.*, 1954, **45** (1), T30–T43

PARISH, C. J. A relay Operated Unit for the Measurement of the Relative Slip Between Two Rollers. *Electron. Engng*, 1953, **26** (313), 112

PEAKE, R. E. Planning and Experiment in a Cotton Spinning Mill. *Applied Statistics*, 1953, **213**, 184

ROFF, W. J. A Colour Test for Nylon 66 and Terylene. *Analyst*, 1954, **79** (938), 306–307

STANDING, H. A. The Direct Dyeing of Cellulose. A Method for the Analysis of Equilibrium Absorption Data in Terms of Current Quantitative Theories. *J. Text. Inst.*, 1954, **45** (1), T21–T29

TIPTON, H. Birefringence and Strain in Textile Filaments. *J. Text. Inst.*, 1954, **44** (12), T657

TIPPETT, L. H. C. Quality Control in Cotton Spinning. *Text. Wkly*, 1954, **53**, pp. 168, 170, 172, 174

URQUHART, A. R. Cellulose Acetate as a Raw Material for Rayon Production. *J. app. Chem.*, 4, p. 195–203

VINCENT, J. J. The Flight of the Shuttle. *J. Hudders. Text. Soc.* 1952–53, p. 29

WARWICKER, J. O. The Crystal Structure of Silk Fibroin. *Acta cryst.*, 7 (8–9), p. 565

WARWICKER, J. O. Structures of Native and Mercerised Celluloses. *Nature, Lond.*, 1954, **174** (4420), 135

ISSUED BY THE ASSOCIATION

Shirley Institute Test Leaflet, CHEM. 20, "A Semi-micro Method for Determination of Formaldehyde in Viscose or Cuprammonium Rayon Treated with Formaldehyde, or with Urea—or Melamine—Formaldehyde. Price 2s. 0d.

Shirley Institute Text Leaflet, CHEM. 21, "Determination of Titanium in Textiles." Price 2s. 0d.

CUTLERY RESEARCH COUNCIL

ISSUED BY THE ASSOCIATION

Cutlery Research Council Bulletin (issued quarterly)
Research Note RN/1—Surface defects in Stainless Steel Knife Blades
" " RN/2—Knife Handles
" " RN/3—Vapour Phase Inhibitors
" " RN/4—Induction Heating
" " RN/5—Application of Electrolytic Polishing to Stainless Steel Table Knives
Research Paper CRC/RC/54/1—Heat Treatment and Properties of Stainless Cutlery Steels

THE BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

BACON, F. T. Research into the Properties of the Hydrogen-Oxygen Cell. *Beama. J.*, 1954, **61**, 6–12; *Engineer*, 1954, **198**, 226–228
BATES, L. F. The Domain Structure of Ferromagnetic Materials. *J. Inst. Met.*, 1954, **82**, 417–425
BATES, L. F. and WILSON, G. W. Bitter Figures on Single Crystals of Nickel and Nickel Iron. *Proc. phys. Soc. Lond.*, 1953, **66**, 819–822
BAXTER, H. W. Heavy-Duty Contactor Contacts—Present Knowledge and Need for Research *Elect. Times*, 1954, **125**, 90–94
BAXTER, H. W. Multiple Arcing in Fuse-Wires. *Elect. Times*, 1954, **125**, 574
BETT, K. E., HAYES, P. F. and NEWITT, D. N. The Construction Operation and Performance of a Primary Standard Mercury Column for the Measurement of High Pressures. *Phil. Trans.*, 1954, **247**, 59–100
BRUCE, C. E. R. Long Spark Discharges. *Elect. Rev., Lond.*, **153**, 1203–1207
BUSEMANN, F. The Magnetic Compass Error Caused by D.C. Single-Core Sea Cables. *Direct Current*, 1954, **1**, 208–213
BUSEMANN, F. H.V. D.C. Inverter Stations: Comparison of Cost of Supplying Reactive Volt-Amperes by Various Methods. *Direct Current*, 1954, **2**, 8–15
CANHAM, A. E. Artificial Lighting for Glass-house Crops. *Worcs. agric. Chron.*, 1954, **22** (2), 85
CANHAM, A. E. Artificial Lighting for Plant Growth. *Trans. Illum. Engng Soc., N.Y.*, 1954, **19** (8), 235–254
CASSIE, A. M. Aspects of H.V. D.C. Technique. The Manchester Lecture on High Voltage Direct Current Power Transmission at the Manchester College of Technology, October–November, 1953. *Direct Current*, 1953, **1**, 173
CASSIE, A. M. The Supply of Selenium. *Beama J.*, 1953, **60**, 223–227
CROSS, L. E. and NICHOLSON, B. J. Ferroelectricity and Anti-ferroelectricity in Sodium Niobate. *Research*, 1954, **7**, S36–S38
DANIEL, V. Physical Principles in Human Co-operation. *Sociological Review*, 1952, **44**, 107–134
DANIEL, V. The Physics of Long-Chain Crystals. *Advances in Physics*, 1953, **2**, 450–494
DANIEL, V. The Thermodynamic Approach to Solid Structure. *Brit. J. appl. Phys.*, 1954, **5**, 305 to 311
DANIEL, V. and TURNER, C. Dielectric Effects of Nucleation. *Phil. Mag.*, 1953, **44**, 1371–1391
DEVONSHIRE, A. F. Theory of Ferroelectrics. *Advances in Physics*, 1954, **3**, 85–130
FRANCIS, G. and VON ENGEL, A. The Growth of the High-Frequency Electrodeless Discharge. *Phil. Trans.* A, 1953, **246**, 143–180
FINN-KELCEY, P. G. and DOW, J. A. Le Sechage des Grains par l'Electricite. *Bulletin d'Informations Pratiques*, 1954, No. 165, pp. 33–35
FROHLICH, H. Electrons in Lattice Fields. *Advances in Physics*, 1954, **3**, 325–361
GOLDENBERG, H. Complex Roots of a Transcendental Equation. *Math. Gaz.*, 1954, **38**, 161–165
GOLDENBERG, H. Maximum Arc Energy Liberated during the First Current Loop in a Series A.C. Circuit. *Engineer*, 1954, **196**, 597–598
GOLDENBERG, H. Calculation of Transient Heating in the Dielectric of Single Core Cables. *Engineer*, 1954 **197**, 779–780
GOLDING, E. W. Local Energy Sources for Underdeveloped Areas. *Impact Sci. Soc., Paris*, 1954, **5**, 27–46
GOLDING, E. W. Wind-generated Electricity for the Farm. *Agriculture*, 1954, **61** (1), 15–18
GOLDING, E. W. Wind-Generated Electricity for Desert Areas. *Sci. Counsel*, 1953, **16** (2), 44–46

GOLDING, E. W. The Prospects for Electricity Generation by Wind Power. *Elektrizitatsverw.*, 1953, **28**, 168–171
GOLDING, E. W. Harnessing the Wind. *Discovery*, 1953, **14**, 373–378
GOSLAND, L. Aspects of H.V. D.C. Technique. The Manchester Lecture on High Voltage Direct Current Power Transmission at the Manchester College of Technology, October–November 1953. *Direct Current*, 1953, **1**, 173
HARTSHORN, L., PARRY, J. V. L., and RUSHTON, E. The Dielectric Losses in Some Representative Insulating Materials. *Proc. Instn. elect. Engrs.*, 1953, **100**, part IIA, 23–37
HOWARD, P. R. Surge Puncture Characteristics of High-voltage Mass-impregnated Paper Cables. *Proc. Instn. elect. Engrs.*, 1953, **100**, Part II, 315–318
HUTCHINGS, E. E. Impedance of Earth Continuity Conductors. *Elect. Times*, 1954, **125**, 841–844
LITTLE, P. F. and VON ENGEL, A. The Hollow Cathode Effect and the Theory of Glow Discharges. *Proc. roy. Soc. A.*, 1954, **224**, 209–227
MARTIN, D. H. Ferromagnetic Domain Processes in Single Crystals of Silicon Iron. *Proc. phys. Soc., Lond.*, 1953, **66**, 712–714
MASON, F. O. Series Breaks in Circuit Breakers: A Technique for the Measurement of Voltage Distribution. *Engineer*, 1954, **197**, 882–885
NEEDHAM, J. C. and HULL, W. G. Self-adjusting Welding Arcs. *British Welding Journal*, 1954, **1**, 304–306
NEEDHAM, J. C. Self-Adjusting Welding Arcs. *British Welding J.*, 1954, **1**, 71–77
NEEDHAM, J. C., HULL, W. G. and ORTON, L. H. The Self-Adjusting Arc—Improved Power Sources. *Weld. Res.*, 1953, **7**, 100r–102r
OWEN, V. M. Electricity from Water Power. *Fm. Mechaniz.*, May 1954, 177–179
RIDLEY, R. W. Creep Properties of Steels Utilized in High Pressure and High Temperature Superheater and Steam Pipe Practice. Part III. Revision of Long Time Creep Data for a Carbon Steel Header and a Carbon-Molybdenum Steel Pipe. *Proc. Instn. mech. Engrs., Lond.*, 1952–1953, **1 B**, (11) 511–516
STARK, K. H. A Mould for Pressing Plastic Discs. *J. sci. Instrum.*, 1953, **30**, 341
STODHART, A. H. Wind Power and Its Uses. *Electrical Machinery*, 1953, **3**, 23–25
STODHART, A. H. Cooking by the Sun. *Discovery*, 1954, **15** (9), 348–349
WATERS, M. The Measurement and Calculation of Axial Electromagnetic Forces in Concentric Transformer Windings. *Proc. Instn. elect. Engrs.*, 1954, **101**, Part II, 35–46
WATSON, R. G. H. Fuel Cells. *J. Instn. Heat & Vent. Engrs.*, 1954, **22**, 120–121
WATSON, R. G. H. Electrochemical Generation of Electricity. *Research*, 1954, **7**, 34–40
WHITEHEAD, S. Recent Progress in Dielectrics. Report of Section A of the British Association, Liverpool, September 1953. *Nature, Lond.*, 1953, **172**, 563–564
WHITEHEAD, S. Research and Development in Power Supply. *Times Elect. Supp.*, December 1953, p. 18
WHITEHEAD, S. The Organization and Work of the Electrical Research Association. *F.B.I. Rev.*, 1953, No. 45, pp. 26, 29 and 31
WHITEHEAD, S. Progress in Dielectrics. *Elect. Rev., Lond.*, 1953, **153**, 1309–1313

ISSUED BY THE ASSOCIATION

	Price
CHURCH, H. F. Oriented Polystyrene Film Capacitors. A Major Cause of Premature Breakdown. Report Ref. L/T289	7*s.* 6*d.*
CRAIG, R. D. Gas Temperature in Argon Spark Channels. Report Ref. L/T318	
DANIEL, V. and TURNER, C. Effects of Contamination on Structure and Properties with Special Reference to Long-Chain Ketones. Report Ref. L/T281	6*s.* 0*d.*
DAY, A. G. Water Sorption in Polystyrene and Cellulose Triacetate. Report Ref. L/T309	12*s.* 6*d.*
DEVONSHIRE, A. F. Review of Ferroelectricity and Anti-ferroelectricity in the Perovskites. Report Ref. L/T298	10*s.* 6*d.*
EASTWELL, B. A. *In Situ* Methods of Measuring Soil Moisture Content: A Critical Résumé. Report Ref. W/T27	15*s.* 0*d.*
FINN-KELCEY, P. The Operation of a Barn Hay Drying Installation. Report Ref. W/T28	15*s.* 0*d.*
GAUNT, H. M. and CRAGGS, J. D. Some Experiments on D.C. Positive Point-to-Plane Corona Discharges. Report Ref. L/T294	15*s.* 0*d.*
GOLDENBERG, H. The General Solution of a Special Case of a Non-Linear Differential Equation. Report Ref. Z/T88	4*s.* 6*d.*
GOLDING, E. W. and STODHART, A. H. The Use of Wind Power in Denmark. Report Ref. C/T112	15*s.* 0*d.*
HUDSON, A. A. Gas-Blast Circuit-Breakers. Effect of Arcing on the Mass-flow of Air through the Nozzle and on Nozzle Pressure (Third Progress Report). Report Ref. G/T275	12*s.* 6*d.*
KAY, H. F. and MILES, J. L. Growing of Perovskite-Type Crystals. Report Ref. L/T303	7*s.* 6*d.*
NETHERCOT, W. and REHFISCH, T. J. The Oscillographic Study of the Spark Arising from the Interruption of a Current in an Inductive Circuit with Particular Reference to Intrinsic Safety. Report Ref. G/T217	18*s.* 0*d.*
MARRIOTT, J. W. and CRAGGS, J. D. Negative Ion Formation in Gases of High Dielectric Strength. Report Ref. L/T301	24*s.* 0*d.*
MARRIOTT, J. W. and CRAGGS, J. D. Negative Ion Formation in Gases of High Dielectric Strength. Part II—The Lozier Apparatus. Report Ref. L/T308	15*s.* 0*d.*
MASON, J. H. Breakdown of Solid Dielectrics in Divergent Fields. Report Ref. L/T310	—
MEGSON, N. J. L. and YARSLEY, V. E. Behaviour of Cellulose Acetate Films under Tropical Conditions. Report Ref. A/T141	—
MOLE, G. A Note on the Use of Electrode Potentials for the Estimation of Corrosion due to Dissimilar Metal Contact. Report Ref. O/T11	7*s.* 6*d.*
MOLE, G. Deposits on Overhead Line Insulators Exposed to Wind-Borne Salt Spray. Report Ref. O/T12	12*s* 0*d.*
PARANJAPE, B. V. Internal Friction of Single-Metal Crystals at High Frequencies Report Ref. L/T288	6*s.* 0*d.*
PELZER, H. Polarization of Dielectrics by Slow Particles. 111. Report Ref. L/T316	7*s.* 6*d.*
PROWSE, W. A., LAVERICK, E. and JASINSKI, W. The Onset of Breakdown in Gases Subject to Superposed Microwave and Unidirectional Electric Fields. Report Ref. T/295	7*s.* 6*d.*
ROBINSON, G. C. An Investigation on Aluminium Electrolytic Capacitors and the Development of a New Type of Aluminium Oxide Capacitor. Report Ref. L/T305	15*s.* 0*d.*
ROBINSON, H. and WILLIAMS, H. L. Flameproof Electrical Apparatus: Flanged Joints, One Inch and One Half-Inch in Radial Breadth, in Atmospheres of Pentane Vapour and Air. Report Ref. G/T291	10*s.* 6*d.*
RUSHTON, E. The Dielectric Properties of Ketone Resins. Report Ref. L/T302	12*s.* 6*d.*
RUSHTON, E. The Dielectric Properties of Methyl Methacrylate Resins. Report Ref. L/T315	12*s.* 6*d.*
RUSHTON, E. and PARRY, J. V. L. The Dielectric Properties of Silicone Liquids and Greases—III. Report Ref. L/T296	7*s.* 6*d.*
SHOTTER, G. F. Meter and Instrument Jewels and Pivots. Fourth Interim Report. Report Ref. T/T48	30*s.* 0*d.*
SHOTTER, G. F. and ELLIOTT, N. Testing of Earth-Continuity Conductors. Report Ref. V/T114	10*s.* 0*d.*
STODHART, A. H. The Economic Value of Hydrogen Produced by Wind Power. Report Ref. C/T111	9*s.* 0*d.*
THOMAS, A. MORRIS. Altitude Correction Factors for Spark over Voltages of Insulators and Rod Gaps. Report Ref. L/T311	
THOMAS, A. MORRIS. Nomograms and Line Charts for Humidity Correction Factors Applicable to Flashover Tests on Insulators. Report Ref. L/T313	—
THOMAS, A. MORRIS. The Case for the Adoption of the British Plastic Yield Test as the I.E.C. Standard. Report Ref. L/T314	—

Price

WHITE, E. L. and BROWN, T. J. Surge Voltage Distribution in a Continuous Single-Disk Winding with Open-Circuited Sections as Occasioned by Various Arrangements of Voltage-Regulating Tappings. Report Ref. S/T72 18*s.* 0*d.*

YARSLEY, V. E., GRANT, W. J. and IVES, G. C. Thermal Decomposition of Organic Insulating Materials in Relation to the Mechanism of Tracking. Report Ref. L/T274 12*s.* 0*d.*

ZIENAU, S. On the Motion of Slow Electrons in Polar Materials. Report Ref. L/T299 12*s.* 6*d.*

—— Development of a Specification for a Discharge ("Ozone") Resistance Test for Rubber Insulated Cables. Report Ref. F/T180 7*s.* 6*d.*

—— Corrosion of Buried Copper and Ferrous Strip in Natural and Salted Soils. Report Ref. V/T110 10*s.* 5*d.*

—— The E.R.A. Network Analyser. March 1954. Report Ref. V/T122 9*s.* 0*d.*

OTHER PUBLICATIONS

BRUCE, C. E. R. Electrical Discharges in Relation to Circuit-Breaking. Chapter 4 of "Circuit Breaking"—Book published by Butterworths, 1953

CASSIE, A. M. Introduction to the Theory of Circuit Interruption. Chapter 2 of "Circuit Breaking"—Book published by Butterworths, 1953

EASTWELL, B. A. The Measurement of Soil Moisture by Electrical Methods. Chapter IV of "Plant Climate and Irrigation", Book edited by S. A. Searle and published by Chichester Press Ltd., 1954

GOSLAND, L. Circuit Constants in Relation to Circuit Breaking. Chapter 3 of "Circuit Breaking"—Book published by Butterworths, 1953

GOSLAND, L. and VOSPER, J. S. Present and Prospective Restriking Voltage Conditions on the British 132 kV and 275 kV Networks. "C.I.G.R.E." Paper No. 135, 1954

HUTCHINGS, E. E. Electrical Earthing and Accident Prevention. Book edited by M. G. Say, published by George Newnes Ltd., 1954. Section 2—Earthing Regulations, by E. E. Hutchings

MASON, F. O. Electrical Methods and Techniques in Circuit Breaker Research. Chapter 5 of "Circuit Breaking"—Book published by Butterworths

MOLE, G. The E.R.A. Portable Discharge Detector. Annexe I to C.I.G.R.E. Report No. 105, 1954

RIDDLESTONE, J. The Variation with Current and Inductance of Metal Transfer between Platinum Contacts. I.E.E. Monograph No. 103, 1954

TRENCHAM, H. The Impact of E.R.A. Research on Circuit-Breaking Practice. Chapter 6 of "Circuit Breaking"—Book published by Butterworths, 1953

WHITEHEAD, S. Research in Manufacture. *Financial Times Survey*, entitled The Electrical Industry, p. 19, 15th March, 1954

WHITNEY, W. B. Aims, Achievements and Problems of the E.R.A.'s Work. Chapter 1 of "Circuit Breaking"—Book published by Butterworths, 1953

THE BRITISH HAT AND ALLIED FELTMAKERS' RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

BAINES, A. The Physical Properties of Felt. Part I. Felt Structure, Extention and Recovery. *J. Text. Inst.*, 1953, **44** (12), T645–T656

BARR, T. and WATT, J. A. C. An Investigation into the Carrotting of Hatters' Fur. *Hatters' Gaz.*, 1954, **78**, 50–52

FREEDLAND, V. D. Industry, Information and Research. *ASLIB Proc.* 1954, 6 (2), 111–116

HAIGH, D. Ribbon Shrinkage: Effect on Hat Size and Shape. *Millinery and Hatting Year Book.* 1954, 103, 105, 107, 109

WATT, J. A. C. Scientific Instruments can Assist Feltmaking. *Fibres*, 1954, **15** (4), 130–140

THE RESEARCH ASSOCIATION OF BRITISH FLOUR MILLERS

PUBLISHED IN JOURNALS

HINTON, J. J. C., PEERS, F. G. and SHAW, B. The B-Vitamins in Wheat: The Unique Aleurone Layer. *Nature, Lond.*, 1953, **172**, 998

HITCHINSON, J. B., KENT, N. L. and MARTIN, H. F. The Kernel Content of Oats. II. Comparisons of Kernel, Content and 1,000 Kernel Weight for the Winter and Spring Varieties. *J. nat. Inst. agric. Bot.*, 1953, 6, 443

KENT, N. L. Combating the Rodent Menace on the Farm. *J. Inst. Corn Merch.*, 1954, 6, 110

KENT, N. L. Wastage on the Farm: Staddles for Corn Stacks. *Fmg. News Glasg.*, 1953, **195**, 10; *Ulster Fmr.*, 1953, **53**, 10, 24, 26

THE BRITISH FOOD MANUFACTURING INDUSTRIES RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

BANFIELD, F. H. Open Pack Cured Meats. *Food Tech., Aust.*, 1954 **6** (5), 245, 247, 249
HARVEY, H. G. Basic Considerations in Regard to Flavour Assessment. *Chem. and Ind. (Rev.)*, 1953, 1163–1167
HINTON, C. L. The Melting Point of Cocoa Butter. *Int. Choc. Rev.*, 1954, **9** (6), 161–164

OTHER PUBLICATIONS

HINTON, C. L. Summary of the Overseas Food Standards and Regulations. Food Directory 1954; published by Tothill Press Ltd.

FRUIT AND VEGETABLE CANNING AND QUICK FREEZING RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

DICKINSON, D. The Purification of Cannery Waste Waters in Biological Filters. *J. Sci. Fd. Agric.*, 1954, **5**, 94
DICKINSON, D. and HOLT, R. The Determination of Tin in Canned Foods. *Analyst*, 1954. **79**, 104
HOLT, R. Fluorine and Chromium Contents of Treated Aluminium Surfaces *J. Sci. Fd. Agric.*, 1954, **5**, 173
GILLESPY, T. G. Estimation of Sterilizing Values of Processes as Applied to Canned Foods: II—Packs Heating by Conduction:
Complex Processing Conditions and Value of Coming-up Time of Retort. *J. Sci. Fd. Agric.*, 1953, **4**, 553
GILLESPY, T. G. Modern Trends in Fruit and Vegetable Canning. *La Revue de la Conserve*, 1953, **8**, 35

ISSUED BY THE ASSOCIATION

Research and Development 1953—Interim Report
Scientific Bulletin No. 1. Chemical Laboratory Handbook for the Fruit and Vegetable Cannery, by D. Dickinson and R. Holt
Research Leaflet No. 1. Thermophilic Spoilage in Canned Vegetables, November 1953, by T. G. Gillespy
Technical Memorandum No. 3. Discoloration of Canned Celery, October 1953, by W. B. Adam and D. Dickinson
No. 4. Experiments with the Tenderometer at Maturometer, 1953, November 1953 by W. B. Adam and R. Holt
No. 5. Suggestions for a New Code of Practice for Canned Fruit and Vegetables, November 1953, by W. B. Adam
Booklet—Campden Research Station
Statistical Review, 1953, compiled by W. B. Adam and M. Darvill

OTHER PUBLICATIONS

ADAM, W. B. Developments in the Canning and Quick Freezing of Fruits. *Report of the Empire Fruit Producers' Conference*, June 1953

RESEARCH AND INFORMATION COMMITTEE OF THE FURNITURE DEVELOPMENT COUNCIL

ISSUED BY THE ASSOCIATION

Information Report No. 6. Dermatitis, Causes and Prevention, by I. Jones, Price 2*s.* 6d.
" " No. 7. Uses for Woodwaste, by I. Jones, Price 5*s.* 0*d.*
" " No. 8. Electrical Resistance Heating for Setting Adhesives, by I. Jones, Price 5*s.* 0*d.*
" " No. 9. Finishing Methods used in the European Furniture Industry.

BRITISH GELATINE AND GLUE RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

EASTOE, J. E. and EASTOE, B. The Organic Constituents of Mammalian Compact Bone. *Biochem., J.* 1954, **57**, 453

EASTOE, J. E. Separation and Estimation of Chitosamine and Chondrosamine in Complex Hydrolysates. *Nature, Lond.*, 1954, **173**, 540

FYSH, D. The Use of Preservatives for Animal Glue. *Adhesives and Resins*, 1954, **2**, 30

FYSH, D. Standard Jelly Strength Measurements of Animal Glues. *Adhesives and Resins*, 1953, **1**, 153

SAUNDERS, P. R. and WARD, A. G. The Colour and Clarity of Gelatin and Glue Solutions. *J. Sci. Fd. Agric.*, 1953, **11**, 523–527

SAUNDERS, P. R. and WARD, A. G. An Absolute Method for the Rigidity of Gelatin Gels. *Proc. Sec. Int. Congr. Rheology*, 1953, 284–290

STAINSBY, G. What Determines Jelly Strength? *Adhesives and Resins* 1953, **1**, 222

STAINSBY, G. Seventh Research Panel Meeting. *Nature, Lond.*, 1954, **173**, 342

STAINSBY, G. SAUNDERS, P. R. and WARD, A. G. The Preparation and Properties of Some Gelatin Fractions. *J. Poly. Sci.* 1954, **12**, 325-335

WARD, A. G. The Physical Properties of Gelatin Solutions and Gels. *Brit. J. appl. Phys.*, 1954, **5**, 85–90

WARD, A. G. The British Gelatin and Glue Research Association, *Chem. and Ind. (Rev.)*, 1953, 1372–1374

WARD, A. G. Recent Advances in Gelatin Research, *Chem. and Ind. (Rev.)*, 1954, 502

BRITISH INTERNAL COMBUSTION ENGINE RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

BICERA Demonstration. *Engineer*, 1953, **196** (5100), 534–535, *Engineering*, 1953, **176** (4580), 607, *Oil Engine*, 23rd November, 1953, **21**, 256–259, *Gas and Oil Power*, November, 1953, **48**, 258–259, 273, *Mechanical World*, November, 1953, **133**, 492–495, *Automobile Engineer*, March, 1954, **43**, 115–121, *Design News*, December, 1953, **8**, 5 and January, 1954, **9**, 3

LYN, W. T. An Experimental Investigation into the Effect of Fuel Addition to Intake Air or the Performance of a Compression-Ignition Engine. *Proc. Instn. Mech. Engr*, 1954, **168** (9), *Engineering*, 1954, **177** (4592), 144–145, *Engineer*, 1954, **197** (5112), 94–96 and 115, *Oil Engine*, 1954, **21**, 373–374

BRITISH IRON AND STEEL RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

Absorptiometric Determination of Cobalt in Iron and Steel. *J. Iron St. Inst.*, 1954, **176** (1), 63

A Combustion Method for the Determination of Sulphur in Slag. *J. Iron St. Inst.*, 1954, **177** (2), 233

An Investigation of the Combustion Method of Sulphur Determination in Ferro-Alloys and Complex Steels. *J. Iron St. Inst.*, 1954, **177** (2), 239

BAILEY, W. H. Non-contact D.C. Ammeter. *Elect. Rev.*, 21st August, 1953

BANKS, W. and RICHARDSON, H. M. Investigation on Taphole Clays and Taphole Practice. *J. Iron St. Inst.*, 1954, **178** (2), 138

BELL, E. B. and THOMAS, D. Radioactive Measurement of Valve Leakage, Infiltration and Blow-out in Open-Hearth Furnaces. *J. Iron St. Inst.*, 1954, **178** (2), 122

BERRY, R. W. Soaking Pits: A Review of Developments and Operating Results, 1941–53. *Iron Coal Tr. Rev.*, 1953, **167** (4462), 887

B.I.S.R.A.—Sheffield. *Metal Treatm.*, 1953, **20** (98), 48

B.I.S.R.A. Sketty Hall, Swansea. *J. Iron St. Inst.*, 1954, **177** (2), 229

BOCKRIS, J. O'M. and LOWE, D. C. An Electro-magnetic Viscometer for Molten Silicates at Temperatures up to 1800° C. *J. sci. Instrum.*, 1953, **30** (11), 403

BRANDT, D. J. O. and WILLIAMS, W. S. Steel Practice on a Small Scale. *Iron and Coal Trades Review*, 1954, **169** (4507), 516

BURGESS, H. J. Crane Mounted Weighers. *Iron and Steel*, 1954, **27** (4), 125

BURNS, C. Stereoscopic Photography in the Study of Particle Motion in Blast Furnace. *Journal of Photographic Science*, 1954, **2** (1), 26

BURTON, E. J. and WEEKS, D. J. Progress Review No. 27, Temperature Measurement. *J. Inst. Fuel*, 1953, **26** (154), 260

CARLISLE, S. S. Automatic Control in the Iron and Steel Industry. *Trans. Soc. Instrum. Tech.*, 1954, **6** (2), 46

CARLISLE, S. S. and SPENCER, J. R. A New Method of Electrical Recording Suitable for Multi-Channel Working. *Trans. Soc. Instrum. Tech.*, 1953, **5** (3), 105

CARRIER, A. G. E. Grabs: A Survey of Literature. *Mech. Handl.*, 1953, **40** (12), 952

CASHMORE, W. P. and THRING, M. W. Experiments on Flame Radiation in an Empty Open-Hearth Furnace. *J. Iron St. Inst.*, 1953, **175** (2), 177

COLE, D. G., FELTHAM, P. and GILLAM, E. On the Mechanism of Grain Growth in Metals, with Special Reference to Steel. *Proc. phys. Soc. Lond., B*, 1954, **67** (2), 131

COOK, R. M. and SPEIGHT, G. E. A Carbon-Resistance Furnace for the Determination of Gases in Steel by the Vacuum-Fusion Method. *J. Iron St. Inst.*, 1954, **176**, Part 3, 252

CUDE, A. L. The Length of Oil and Gas Flames: Extension of Free Flame Relationships to Practical Conditions. *J. Iron St. Inst.*, 1954, **176** (3), 270

CUDE, A. L. The Length of Gas Flames. *J. Iron St. Inst.*, 1953, **173** (3), 304

DAWS, L. F. The Emissivity of a Groove. *Brit. J. appl. Phys.*, 1954, **5** (5) 182

DEAN, S. K. An Accelerometer for Recording Accelerations of 0–0·5 g. *Instrum. Pract.*, 1953, **7** (12), 969

DEAN, S. K., JENKINS, W. N., GLEDHILL, P. K. and BLANCHARD, A. J. A Method of Automatic Control for Sinter Plant Feeder Tables. *J. Iron St. Inst.*, 1954, **177**, Part 2, 220

DENNIS, W. E. A Graphite Tube Resistance Furnace and Voltage Regulator for Equilibrium Studies in the Temperature Range 1500–1800° C. *J. sci. Instrum.*, 1953, **30** (12), 453

DENNIS, W. E. and RICHARDSON, F. D. The Equilibrium Controlling the Decarburisation of Iron-Chromium-Carbon Melts. *J. Iron St. Inst.*, 1953, **175** (3), 264

Determination of Silica in Blast Furnace Slags. *J. Iron St. Inst.*, 1954, **177** (2), 243

Determination of Tin. *J. Iron St. Inst.*, 1954, **176** (2), 156

Determination of Aluminium in Iron and Steel. *J. Iron St. Inst.*, 1954, **176** (3), 263

Determination of Copper in Iron and Steel. Methods of Analysis Committee, B.I.S.R.A. *J. Iron St. Inst.*, 1953, **174** (4), 335

EDDISON, R. T. and OWEN, D. G. Discharging Iron Ore. *Operat. Res. Quart.*, 1953, **5** (3), 39

EVANS, E. LL. and SLOMAN, H. A. Studies in the Deoxidation of Iron: Deoxidation by Titanium. *J. Iron St. Inst.*, 1953, **174** (4), 318

FELTHAM, P. On the Transient Flow of Metals at High Temperatures. *Proceedings of the Second International Congress on Rheology*, Oxford, July, 1953, 266

FELTHAM, P. The Plastic Flow of Iron and Plain Carbon Steels above the A_3-Point. *Proc. phys. Soc., Lond., B*, 1953, **66** (406), 865

FINCHAM, C. J. B. and RICHARDSON, F. D. The Behaviour of Sulphur in Silicate and Aluminate Melts. *Proc. roy. Soc.*, A, 1954, **223**, 40

Flame Radiation Research Joint Committee: Reports of Burner Trials at Ijmuiden. *J. Inst. Fuel*, 1953, **26** (153), 189

FORD, H. Problems of the Control of Dimensions, Shape, and Finish in the Rolling of Sheet and Strip and in the Drawing of Wire. *J. Inst. Met.*, 1953–1954, **82** (7), 281

GILLAM, E. and COLE, D. G. On Monitoring a Geiger-Counter Spectrometer Beam. *J. sci. Instrum.*, 1954, **30** (11), 429

GLEDHILL, P. K. and ELY, C. F. Effect of Mineral Additions and Moisture Control on the Sintering of Sierra Leone Concentrates. *J. Iron St. Inst.*, 1953, **175** (3), 277

GOODEVE, SIR CHARLES. The Milling of Rail Ends and its Effect on Productivity. *Engineering, Lond.*, 1953, **176** (4571)

GOODEVE, SIR CHARLES and RIDLEY, G. R. A Survey of Operational Research in Great Britain. *Operat. Res. Quart.*, 1953, **4** (2), 21

GOODEVE, SIR CHARLES. Operational Research as a Science. *J. Operational Research Society of America*, 1953, **1** (4) and *Research*, 1953, **6**, 465

GREEN, A. P. The Plastic Yielding of Metal Junctions due to Combined Shear and Pressure. *J. of the Mechanics and Physics of Solids*, 1954, **2** (3), 197

GREEN, A. P. On the Use of Hodographs in Problems of Plane Plastic Strain. *J. of the Mechanics and Physics of Solids*, 1954, **2** (1), 73

HAYNES, R. and THOMAS, D. The Pitot Method of Measuring Gas Flow Rates in Ducts: An Investigation of Possible Errors. *Trans. Soc. Instrum. Tech.*, 1953, **5** (3), 121

Heat Treatment Practice in the Iron and Steel Industry. *Metal Treatm.*, 1953, **20** (94), 301

HERNE, H. The Theoretical Characteristics of Bichromatic Pyrometers. *Brit. J. appl. Phys.*, 1953, **4** (12), 374

HESSENBERG, W. C. F. and JENKINS, W. N. The Effects of Screw and Speed Selling Changes on Gauge, Speed, and Tension in Tandem Mills. *Research Correspondence*, 1954, **7** (8), *S* 45

HOPKINS, B. E. and TIPLER, H. R. Effect of Heat Treatment on the Brittleness of High-purity Iron-Nitrogen Alloys. *J. Iron St. Inst.*, 1954, **177** (1), 110

HUDSON, J. C. Protective Coatings for Ships and Marine Installations. *Chem. and Ind. (Rev.)*, 1954, (13), 640

HUDSON, J. C. and STANNERS, J. F. The Protection of Iron and Steel by Metallic and Non-Metallic Coatings—II. *J. Iron St. Inst.*, 1953, **175** (4), 381
HUGHES, M. L. and HUMPHREYS, R. The Recovery of Zinc from Galvanizers' Dross. *Sheet Metal Ind.*, 1953, **30** (319), 955
HUGHES, M. L. and MOSES, D. P. Hot Dip Aluminising. *Metallurgia, Manchr.*, 1953, **48** (287), 105
HUNDY, B. B. Plane Plasticity. *Metallurgia, Manchr.*, 1954, **49** (293), 109
HUNDY, B. B. Accelerated Strain Ageing of Mild Steel. *J. Iron St. Inst.*, 1954, **178** (1), 34
HUNDY, B. B. Elimination of 'Stretcher Strains' in Mild Steel. *J. Iron St. Inst.*, 1954, **178** (2), 127
HUNDY, B. B. The Accelerated Strain Ageing of Mild Steel. *Research, Lond.*, 1953, **6** (10), 54s
JENNINGS, R. F. The Rating of Sinter Plants for Economic Output. *J. Iron St. Inst.*, 1953, **175** (3), 248
JENNINGS, R. F., GLEDHILL, P. K., CARTER, G. C. and ELY, C. F. Sinter-Plant Assessment Trials at Dagenham and at Cleveland. *J. Iron St. Inst.*, 1953, **175** (3), 267
JOHNSON, T. W. and MEACHEN, D. Blast Furnace Exploration: Use of a Continuous Flow Counter. *Research, Lond.*, 1954, **7** (9), 356
JORDAN, F. and NEWBY, M. P. Measurement of Air Flow through the Strand in Sinter Plants. *J. Iron St. Inst.*, 1953, **175** (4), 360
LAY, J. O. The Electrolytic Deposition of Iron as an Analytical Technique. *Metallurgia, Manchr.*, 1953, **48** (290), 313
LEAKE, L. E. A Glass Solenoid Pump. *J. sci. Instrum.*, 1953, **30** (11), 434
LEE, J. G. Rail Transport: Wagon Shuting Machines. *Engineer, Lond.*, 1954, **197** (5126), 612; **197** (5127), 651
LEYS, J. A. A Water-Cooled Pitot Tube for Hot Gases. *J. Iron St. Inst.*, 1953, **174** (3), 228
LEYS, J. A. Flame Lengths: Estimation for Coke Oven Gas and for Oil. *Iron and Steel, Lond.*, 1954, **27** (3), 93
LOIZOU, N. and SIMS, R. B. The Yield Stress of Pure Lead in Compression. *J. Mechanics and Physics of Solids*, 1953, **1** (4), 234
MAYNE, J. E. O. and MENTER, J. W. The Mechanism of Inhibition of the Corrosion by Solutions of Sodium Phosphate, Borate and Carbonate. *J. chem. Soc.*, 1954, p. 103
MAYNE, J. E. O. Effect of Rust and Environment on Inhibition by Zinc-Rich Paints. *J. Iron St. Inst.*, 1954, **176** (2), 140
MAYNE, J. E. O. Atmospheric Exposure Tests with Zinc-Rich Polystyrene Paints. *J. Iron St. Inst.*, 1954, **176** (2), 143
MAYNE, J. E. O. and MENTER, J. W. The Mechanism of Inhibition of the Corrosion of Iron by Sodium Hydroxide Solution, Part II. *J. chem. Soc.*, 1954, p. 99
MAYORCAS, R. and THOMAS, D. Method of Measuring Flame Radiation and Emissivity Continuously in Open-Hearth Furnaces. *J. Iron St. Inst.*, 1953, **175** (4), 359
MCCALLUM, N. and BARRETT, L. R. Some Aspects of the Corrosion of Refractories. *Trans. ceram. Soc.*, 1952, **51** (11), 523
MCCRUM, A. W. and GAYDON, F. A. A Theoretical Investigation of the Yield Point Loading of a Square Plate with a Central Circular Hole. *J. Mechanics and Physics of Solids*, 1954, **2** (2), 156
Mercury-Cathode Electrolysis and its Application to Steel Analysis. *J. Iron St. Inst.*, 1954, **176** (1), 29
MORGAN, D. W. and KITCHENER, J. A. Solutions in Liquid Iron, Part 3, Diffusion of Cobalt and Carbon. *Trans. Faraday Soc.*, 1954, **50**, Part 1, (373), 51
MILLS, H. R. and LEE, J. G. Mechanical Trimmers for Ships Carrying Iron Ore. *Mech. Handl.*, 1954, **41** (6), 350
NETTELL, D. F. and HEARN, P. J. A Simple Timing Device Pulsing at Mains Frequency. *Instrum. Pract.*, 1954, **8** (2), 142
PEARSON, J. and TURKDOGAN, E. T. Activity Coefficients of Oxygen and Phosphorous in Iron-Oxygen-Phosphorus Melts. *J. Iron St. Inst.*, 1954, **176** (1), 19
PEARSON, J., TURKDOGAN, E. T. and FENN, E. M. The Free Energy of Formation of Manganous Orthophosphate. *J. Iron St. Inst.*, 1954, **176** (4), 441
PEARSON, J. Metal-Slag Reactions in Steelmaking. *Iron Coal Tr. Rev.*, 1954, **168** (4484), 685
REES, W. P., HOPKINS, B. E. and TIPLER, H. R. Tensile and Impact Properties of Fe-Si, Fe-Ni, Fe-Cr, and Fe-Mo Alloys of High Purity. *J. Iron St. Inst.*, 1954, **177** (1), 93
Research and Development in Electric Overhead Travelling Cranes for Steelworks. *Brit. Steemkr*, 1954, **20** (3), 96
RICHARDSON, F. D. The Thermodynamics of Metallurgical Carbides and of Carbon in Iron. *J. Iron St. Inst.*, 1953, **175** (1), 33
RICHARDSON, F. D. and DENNIS, W. E. Effect of Chromium on the Thermodynamic Activity of Carbon in Liquid Iron. *J. Iron St. Inst.*, 1953, **175** (3), 257
RICHARDSON, F. D. and FINCHAM, C. J. B. Sulphur in Silicate and Aluminate Slags. *J. Iron St. Inst.*, 1954, **178** (1), 4
RIDGION, J. M., COHEN, E. and LANG, C. The Development of a Pelletizing Process for Fine Iron Ores. *J. Iron St. Inst.*, 1954, **177** (1), 43

SAGE, A. M. Steels for Steam Power Plant. *Proc. Inst mech. Engrs, Lond. A.*, 1953, **167** (4), 414

SHANAHAN, C. E. A. and COOKE, F. A Simple Carbon Resistor Furnace for Fusion Point Determination. *Chem. and Ind. (Rev.)*, 1953, (40), 1050

SHEARS, E. C. and ARCHIBALD, W. A. Alumino-Silicate Refractories: Some Observations on their Chemistry. *Iron and Steel, Lond.*, 1954, **27** (1), 26 and **27** (2), 61

SIMONS, J. P., BURTON, A. J. and HAMSTEAD, C. G. The Tungsten/Molybdenum Thermocouple for Immersion Pyrometry. *J. Iron St. Inst.*, 1953, **175** (4), 402

SIMS, R. B. Calculation of Roll Force and Torque in Hot Rolling Mills. *Proc. Instn mech. Engrs, Lond., A*, 1953, **167** (4), 371

SIMS, R. B. Calculation of Roll Force and Torque in Cold Rolling by Graphical and Experimental Methods. *J. Iron St. Inst.*, 1954, **178** (1), 19

SIMS, R. B. and BRIGGS, P. R. A. The Control of Strip Thickness in Hot and Cold Rolling by Automatic Screwdown. *Sheet Metal Ind.*, 1954, **31** (323), 181

SIMS, R. B. and PLACE, J. A. The Stresses in the Reels of Cold Reduction Mills. *Brit. J. appl. Phys.*, 1953, **4** (17), 213

Some Factors Affecting the Wear of Graphite Electrodes in the Electric Arc Furnace. *J. Iron St. Inst.*, 1954, **176** (2), 159

STEVENS, C. G. and TURKDOGAN, E. T. The Heats and Formation of Trimanganous Phosphate and Trimagnesium Phosphate. *Trans. Faraday Soc.*, 1954, **50** (376) Part 4, 270

STILL, J. E. DAUNCEY, L. A., and CHIRNSIDE, R. C. Conductimetric Determination of Carbon in Metals. *The Analyst*, 1954, **79** (934), 4

TERRINGTON, J. S. and HAWKES, J. M. Crane Gantry Girders for Steelworks. *Struct. Engr*, 1953, **31** (10), 268

THOMAS, W. R. and LEAK, G. M. The Diffusion of Nitrogen in Alpha Iron. *Phil. Mag.*, 1954, **45** (365) 656

THRING, M. W. The British Iron and Steel Research Association. Physics in Iron and Steel Manufacture. *Bull. Inst. Physics*, 1953, No. 46, 103

THRING, M. W. and NEWBY, M. P. Combustion Length of Enclosed Turbulent Jet Flames. *Proceedings of the Conference on Combustion held at the Massachusetts Institute of Technology*, September, 1952, p. 789

Tool Steels. *Mon. Statist. Bull. Brit. Iron St. Fed.*, 1954, **29** (5), 5

TURKDOGAN, E. T. and PEARSON, J. Activities on Constituents of Iron- and Steel-making Slags. Part II—Manganous Oxide. *J. Iron St. Inst.*, 1953, **175** (4), 393

TURKDOGAN, E. T. and PEARSON, J. Activities of Constituents of Iron- and Steel-making Slags. Part III—Phosphorous Pentoxide. *J. Iron St. Inst.*, 1953, **175** (4), 398

TURKDOGAN, E. T. and PEARSON, J. Reaction Equilibria between Metal and Slag in Acid and Basic Open-Hearth Steelmaking. *J. Iron St. Inst.*, 1953, **176** (1), 59

TURKDOGAN, E. T. and PEARSON, J. Thermodynamic Functions of Elements and Entropies of Inorganic Substances. *J. appl. Chem.*, 1953, **3**, 495

WINTON, D. A. Roll Pass Design for Beams. *J. Iron St. Inst.*, 1954, **176** (1), 3

WISE, D. A. Application and Rating of Mill-Type Motors in Steelworks. *Iron Coal Tr. Rev.*, 1953, **167** (4453), 347

ISSUED BY THE ASSOCIATION

B.I.S.R.A. Annual Report, 1953

BISRA. SURVEY, 1954

Summary No. 45. Spectrographic Analysis of Low-Alloy Steels

Summary No. 48. Determination of Iron in Ores, Slags and Refractories

Summary No. 50. Waterline Corrosion

Summary No. 55. The Interaction of Oxygen and Phosphorus in Molten Iron

Summary No. 56. Mechanical Trimmers for Ships Carrying Iron Ore. B.I.S.R.A. Information Services. Ref. INF/3/54

Catalogue of Irons and Steels for Research Purposes (Second Edition). Ref. MG/226/53

OTHER PUBLICATIONS

GOODEVE, SIR CHARLES. Operational Research—A New Approach to Complex Social Problems.—Case Institute of Technology Diamond Jubilee Convocation, Ohio, April, 1953

HUDSON, J. C. Steel Structures Painting Council. Specifications for Cleaning and Painting Steel Structures. Report Ref. MG/B/32/53

LOXLEY, E. M. and WHITELEY, F. The Application of the Sachs Boring Method to the Measurement and Detection of Residual Stresses in Cold Drawn Tubes. Report Ref. MW/E/53/53

OLDFIELD, J. H. The Design and Construction of a Photomultiplier Tube Adaptor for Prism Spectrograph. Report Ref. MG/DD/162/54

PEARSON, J. and ENDE, U. J. The Thermodynamics of Metal Nitrides and of Nitrogen in Iron and Steel. Report Ref. CP/9/2

Diamond Die Profiloscope. Longworth Scientific Instrument Co. Ltd., Abingdon, Berks. Manufacturers' descriptive pamphlet

PERRY, K. P. Heat Transfer by Convection from a Hot Gas Jet to a Plane Surface. Preprint issued by the Institute of Mechanical Engineers

SMITH, E. J. D. and ARCHIBALD, W. A. Super Refractories. A Symposium. Published by the British Ceramic Society

WILLIS, J. Deep Drawing: A Review of Professor H. W. Swift's Researches. Butterworths Scientific Publications. Price 25s. net

THE BRITISH JUTE TRADE RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

SOUTAR, T. H. and HAMPTON, E. Structural Changes in Boiling Solutions of Sugar with Reference to Chromatography of Carbohydrates. *Nature, Lond.*, 1954, **174** (4434), 801–802

BRITISH LAUNDERERS' RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

AUDIGIER, V. N. Targets for Production (Quality Production, with Profit). *Laundry R.*, 1954, **84** (9), 69–77, and **84** (10), 63–65

AUDIGIER, V. N. The Pros and Cons of Automatic Washing. *J. Instn Brit. Laund.*, 1953, **34** (11), 452–455

HARWOOD, F. COURTNEY. Modern Detergency. *J. Text. Inst.*, 1953, **44**, 105–113

HARWOOD, F. COURTNEY. Is Laundry Research Worthwhile? *Laundry R.*, 1954, **84** (10), 59–63

HARWOOD, F. COURTNEY. The Importance of Laundering in Hospital Services. *Laundry J.*, 1954, No. 3080, 7–8

PERDUE, G. R. and KIRK, G. E. Laundering and Dry Cleaning. *Rev. Text. Progr.*, **4**, 1952

STANLEY, J. S. The Effect of Paraffin Chain Salts on the Charge on Textile Fibres. *J. Phys. Chem.*, 1954, **58**, 533–536

WAGG, R. E. The Evaluation of Detergents. *J. Text. Inst.*, 1953, **44**, T658

WAGG, R. E. Testing the Qualities of a Detergent (How the Laboratory Tests for Detergent Efficiency). *Laundry Rec.*, 1954, **84** (10), 79–87

ISSUED BY THE ASSOCIATION

Laundry Productivity. Published jointly by British Launderers' Research Association and Institution of British Launderers Ltd. Price £3 3*s.* 0*d.*

The B.L.R.A. Short Washing Process. B.L.R.A. Report No. 96, 1954.

B.L.R.A. Bulletin, 1953, **5** (13)

BRITISH LEATHER MANUFACTURERS' RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

BOWES, J. H. and MOSS, J. A. The Reaction of Fluorodinitrobenzene with the α- and β-amino Groups of Collagen. *Biochem. J.*, 1953, **55**, 735

BRAYBROOKS, W. E. and MITTON, R. G. Oak Bark Tonnage: Effects of Variations in Layering. *J. Soc. Leath. Tr. Chem.*, 1954, **38**, 233

CACHIA, G. P., INNES, R. F. and MITTON, R. G. Durability of Upholstery Leather from Split Hides, Part III. *J. Soc. Leath. Tr. Chem.*, 1954, **38**, 74

DEMPSEY, M., FURLONG, J. R. and KNEW, E. An Experiment on the Curing of Sudanese Sheepskins. *Colon. Pl. Anim. Prod.*, 1952–53, **3**, 320

DEMPSEY, M., INNES, R. F. and MITTON, R. G. Comparison of the Paraffin and Pressure Degreasing Processes: The Effect on Distribution of the Residual Grease and the Properties of the Leather. *J. Soc. Leath. Tr. Chem.*, 1954, **38**, 265

ELLIS, S. C. and PANKHURST, K. G. A. Monolayers of Collagen. *Trans. Faraday Soc.*, 1954, **50**, 82

GREEN, G. H. Influence of "Breaking Over" Sun-dried Sheepskins During Soaking on Water Uptake. *J. Soc. Leath. Tr. Chem.*, 1954, **38**, 183

HAINES, B. M. Putrefaction in Calfskins. *J. Soc. Leath. Tr. Chem.*, 1953, **37**, 363

INNES, R. F., MAYER, M. H. and MITTON, R. G. Durability of Upholstery Leather from Split Hides, Part II. *J. Soc. Leath. Tr. Chem.*, 1953, **37**, 384

MITTON, R. G. Measurement of the Real Volume of Leather by Gas Displacement. *J. Soc. Leath. Tr. Chem.*, 1954, **38**, 2

MITTON, R. G. and PANKHURST, K. G. A. Comparison of White Spirit and Paraffin for Degreasing Sheepskins for Chrome Gloving Leather. *J. Soc. Leath. Tr. Chem.*, 1953, **37**, 331

PANKHURST, K. G. A. The Action of Large Ions on Collagen and Gelatin. *J. Soc. Leath. Tr. Chem.*, 1953, **37**, 312

PHILLIPS, H. The British Leather Manufacturers' Research Association. *Chem. and Ind. (Rev.)*, 1954, 294

PHILLIPS, H. Chemistry of Leather. Three Cantor Lectures. *J. R. Soc. Arts*, 17th September, 1954

PHILLIPS, H. Developments in the Tanning of Chrome Side Upper Leather. *Shoe and Leath. Rec.*, 30th May, 1954

OTHER PUBLICATIONS

ARMSTRONG, D. M. G. Study of Diffusion Processes in Tanning. *Faraday Soc.* Discussion, 1954, No. 16

ELLIS, S. C. and PANKHURST, K. G. A. Interaction of Tanning Materials with Collagen Monolayers. *Faraday Soc.* Discussion, 1954, No. 16

PHILLIPS, H. Leather Research. *Times Weekly Review, Survey of the Leather Industry*, 24th September, 1953

PHILLIPS, H. The British Leather Manufacturers' Research Association. *Text. Rec., Exhibition Handbook*, October, 1953

LINEN INDUSTRY RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

TURNER, A. J. The Future of the Natural Fibres. *J. Text. Inst.*, 1954, **45** (7), 317–327

THE PARSONS AND MARINE ENGINEERING TURBINE RESEARCH AND DEVELOPMENT ASSOCIATION

PUBLISHED IN JOURNALS

BROWN, T. W. F. High Temperature Turbine Machinery for Marine Propulsion. *Oil Eng.*, 1954, **22** (248), 395; *Engineer, Lond.*, 1954, **197** (5113), 122–127 and **197** (5114), 158–161 and **197** (5115), 194–196; *Shipb. Shipp. Rec.*, **83** (4), 119–121 and **83** (5), 151–153; *J. Comm. Shipb. Engng Edn*, 21st January, 1954, p. 1 and 28th January, 1954, p. 4; *Shipp. World*, 27th January, 1954, p. 136 and 3rd February, 1954, p. 158; *Engineering, Lond.*, 177 (4592), 148–149; *Elec. Rev., Lond.*, 29th January, 1954, p. 188; *Mot. Ship*, **34** (407), 498–499; *Mar. Engr, Lond.*, **77** (928), 145–148 and **77** (929), 183–184 and **77** (931), 257–262

BROWN, T. W. F. The Long Life Internal Combustion Turbine. *Engineering, Lond.*, **177** (4610), 717–724

DARLING, R. F. Fuel Systems and Controls for Marine Gas Turbine. *Shipbuilder, Lond.*, **61** (550), 303–305

FREDERICK, S. H. and EDEN, T. F. Corrosion Aspects of the Vanadium Problem in Gas Turbines. *Iron and Steel, Lond.*, February, 1954, p. 67; *Shipbuilder, Lond.*, **61** (550), 305–309

FOWLER, H. S. and WALKER, V. Fluid-flow in Turbo-machinery. *Shipbuilder, Lond.*, **61** (550), 292–295

HIMS, H. E. C. An Improvized Balancing Operation. *Mach. Mkt*, 9th April, 1954; *J. Comm. Shipb. Engng Edn.*, 22nd April, 1954

TERRELL, B. J. The Influence of Thermal Effects on the Manoeuvrability of Marine Turbine Machinery. *Shipbuilder, Lond.*, **61** (550), 295–298; *J. Comm. Shipb. Engng Edn*, 19th November, 1954, p. 4

YATES, H. G. Thermal Straightening of Turbine Rotors. *Mach. Mkt*, 16th April, 1954, 389; *Shipb. Shipp. Rec.*, **83** (23), 743–745

YATES, H. G. The Development of a Marine Steam Turbine Design. *Man. Engr., Lond.*, **76** (923), 512–520

OTHER PUBLICATIONS

CONN, R. B. and HARE, J. Some Electronic Instruments for Marine Turbine Research. *Lloyds List*, 1st September, 1954

MOTOR INDUSTRY RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

BRISTOW, J. R. New Laboratory of the Motor Industry Research Association. *Nature, Lond.*, 1954, 173 (4415), 1117–1119

ISSUED BY THE ASSOCIATION

Report No.	
1946/T1	Technical and Scientific Information: Classification Scheme for the Motor Industry
1946/R1	Wear and Cracking of Tin-Base and Lead-Base Bearings
1946/R2	Durability of Gears: The Effect of Oil Viscosity on Gear Scuffing
1946/R3	Deep-Drawing Research: Ironing of Metal Cups: Effects of Die Angle and Wall Thickness. Fourteenth Report on Work in the Engineering Department of Sheffield University under the direction of Professor H. W. Swift
1946/R4	Deep-Drawing Research: Stresses and Strains in Cylindrical Drawing Operations Fifteenth Report on Work in the Engineering Department of Sheffield University under the direction of Professor H. W. Swift
1946/R5	Deep-Drawing Research: Plastic Strain in an Isotropic Strain-Hardening Material. Sixteenth Report on Work in the Engineering Department of Sheffield University under the direction of Professor H. W. Swift
1946/R6	Fuel Injection in Spark-Ignition Engines: Review of Information. First Report on the Investigation in progress at Queen Mary College under the supervision of Professor E. Giffen
1946/R7	Torsional Stiffness of Vehicle Structures: First Report—Tests on a Motor-Car Frame
1947/R1	Development of Equipment for Measuring Stresses in Vehicle Structures: First Report—Measurement of Dynamic Stresses in a Large Passenger Car
1947/R2	Durability of Gears: The Effect of Temperatures, Speed and Type of Oil on Gear Scuffing
1947/R3	Deep-Drawing Research: Bending and Friction over the Die Radius. Seventeenth Report on Work in the Engineering Department of Sheffield University under the direction of Professor H. W. Swift
1947/R4	Deep-Drawing Research: Ironing of Thick-Walled Cups. Eighteenth Report on Work in the Engineering Department of Sheffield University under the direction of Professor H. W. Swift
1947/R5	Deep-Drawing Research: Shearing of Metal Bars. Nineteenth Report on Work in the Engineering Department of Sheffield University under the direction of Professor H. W. Swift
1947/R6	Fuel Injection in Internal-Combustion Engines. Fuel Spray Phenomena: Review of Information. Second Report on the Investigation in progress at Queen Mary College under the supervision of Professor E. Giffen
1947/R7	The Bearing Characteristics of Two Magnesium Alloys: Final Report on Work on Light Alloy Bearings
1947/R8	A Capacity-Type Torquemeter and a Review of Some Recent Electrical Torquemeters
1947/R9	Torsional Stiffness of Vehicle Structures: Second Report—Tests on a Motor-Car Body and Frame Unit
1947/R10	Cast Crankshafts: A Survey of Published Information
1947/R11	Fatigue Strength of Cast Crankshafts: Effect of Proportions and Size on Bending Fatigue Strength
1947/R12	Piston Ring Movement during Blow-By in High-Speed Petrol Engines
1948/1	Some Experiments on Scale-Model Vehicles with particular reference to Dust Entry
1948/2	The Effect of Some Design Variables on Temperatures of the Exhaust Valve, Valve Guide and Valve Seat
1948/3	Torsional Stiffness of Vehicle Structures: Third Report—Tests on a Complete Car
1948/4	Fuel Injection in Internal-Combustion Engines: The Measurement of Atomisation in Fuel Sprays
1948/5	Fuel Injection in Internal-Combustion Engines: Atomisation of Low-Pressure Fuel Sprays
1948/6	Development of Equipment for Measuring Stresses in Vehicle Structures: Second Report—Measurement of Dynamic and Static Stresses in a Commercial Vehicle
1948/7	An Examination of Various Methods of Testing Partial Flow Oil Filters for Motor Vehicle Engines, with an Appendix on the Determination of Total Solids in Used Lubricating Oil
1949/1	Pressure-Backed Piston Rings: First Report

Report No.	
1949/2	Deep-Drawing Research: An Experimental Crank Press. Twentieth Report on the Work in the Engineering Department of Sheffield University under the direction of Professor H. W. Swift
1949/3	Deep-Drawing Research: Shearing of Metal Bars, II. Twenty-first Report on Work in the Engineering Department of Sheffield University under the direction of Professor H. W. Swift
1949/4	A Hydraulic Fatigue Testing Machine for Gear Teeth
1949/5	Dynamic Strain Recording Equipment for Measurements on Vehicle Structures under Operating Conditions
1949/6	The Guttering Failure of Automobile Engine Exhaust Valves with Fuels of High Lead Content
1949/7	Durability of Gears: Bending Fatigue Strength of Gear Teeth—Preliminary Report
1949/8	Durability of Gears: The Effect of Material and Heat Treatment on Gear Scuffing
1950/2	Fatigue Strength of Cast Crankshafts. First Report on the Influence of the Crankshaft Material on Bending Fatigue Strength
1950/3	Some Experiments on Noise in Vehicles
1950/4	A Comparison of Some Exhaust Valve Materials Operating with Fuels of High Lead Content
1950/5	Some Observations on Flow in Spray Nozzles
1950/6	Torsional Stiffness of Vehicle Structures: Fourth Report. Recommended Procedure for Measuring the Torsional Stiffness of Car Structures
1950/7	Bending Fatigue Strength of Gear Teeth: A Comparison of Some Typical Gear Steels
1950/8	Factors Influencing the Scuffing of Gears: A Summary of the Results of Work Done on Gear Scuffing by M.I.R.A. and the I.A.E. Research Department
1950/9	The Fatigue Strength of Steels: with particular reference to the influence of material condition and surface treatment. A Survey of Information
1950/10	An Investigation of the Stresses in P.S.V. Type Wheels. First Report—Stresses Due to Static Loading
1951/1	The Experimental Determination of Static and Dynamic Stresses in a Double-deck Public Service Vehicle
1951/2	Fatigue Strength of Cast Crankshafts. The influence of some special design features on bending fatigue strength
1951/3	Some Experiments on Ventilation and Heating of a Double-deck Public Service Vehicle. A description of work carried out for the Association by Professor T. R. Cave-Browne-Cave, Southampton University College
1951/4	Some Experiments on Spray Atomisation with Swirl Atomisers. Sixth Report on the Investigation in Progress at Queen Mary College, under the personal supervision of Professor E. Giffen
1951/5	Comfort and Fatigue in Vehicle Riding. A survey of Investigations into the effects on driver and passenger of vehicle riding qualities
1951/6	A Torsional Fatigue Machine with Torque Control
1951/7	Further Experiments on Noise in Vehicles: A Detailed Comparison of Three Cars
1951/8	The Failure of Gears by Pitting: A Comparison of some Typical Gear Steels
1951/9	An Investigation of the Stresses in P.S.V. Type Wheels. Second Report—Stresses Due to Dynamic Loading
1951/10	Brake Fade: A Brake Lining Testing Machine, and some Preliminary Results
1951/11	Development of a Test Procedure for Lubricating Oils for British Road Vehicle I.C. Engines. Interim Report
1951/12	The Experimental Stress Analysis of a Small Saloon Car of Unitary Construction. First Report—Stresses Due to Static Loading.
1951/13	Pressure-backed Piston Rings. Second and Final Report on the Extra-Mural Research carried out at the Cambridge University Engineering Laboratory
1951/14	The Influence of Crankshaft Material on Bending Fatigue Strength. Second Report: Four Cast Steels
1951/15	M.I.R.A. Four-Channel Dynamic Strain Recorder (Mark II)
1952/1	The Influence of Crankshaft Material on Bending Fatigue Strength. Third Report: Four Nodular Graphite Irons
1952/2	The Experimental Stress Analysis of a Small Saloon Car of Unitary Construction. Second Report: Stresses Due to Dynamic Loading
1952/3	The Influence of Shot Peening and Cold Rolling on the Bending Fatigue Strength of Cast Crankshafts
1952/4	Brake Fade. Second Report
1952/5	Bending Strength of Gear Teeth: a Comparison of some Carburising steels
1953/1	Torsional Fatigue Strength of Cast Crankshafts: A Comparison of Four Materials
1953/2	Oil Consumption in I.C. Engines

THE BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

BAILEY, G. L. J. Alloys (1953 Cantor Lectures). *J. R. Soc. Arts*, 1954, **102**, 227–276

BAILEY, G. L. J. Attitude of the Co-operative Research Association. *Research, Lond.*, 1954, 7 (10) 415–417

BAILEY, G. L. J. Research Associations. V.—The British Non-Ferrous Metals Research Association. *Bull. Inst. Physics*, March, 1954, No. 51, 41–48

BAKER, W. A. The British Non-Ferrous Metals Research Association. *Bull. Instn. Metall.*, 1953, 4 (4), 10–19

CIBULA, A. Grain-Refining Additions for Cast Copper Alloys. *J. Inst. Met.*, 1953–1954, **82** (11), 513–524

EDWARDS, J. The B.N.F. Jet Test on Organic Bright Nickel Deposits. *Bull. Inst. Met. Finishing*, Spring, 1954, 4 (1), 33–46, *Trans. Inst. Met. Finishing*, 1954, **30**

GILBERT, P. T. The Resistance to Failure of Condenser and Heat Exchanger Tubes in Marine Service. *Trans. Inst. Mar. Engrs*, 1954, **66** (1), 1–20

GILBERT, P. T. and HADDEN, S. E. Behaviour of Galvanized Steel in Sodium Benzoate Solution, *J. appl. Chem.*, 1953, 3 (12), 545–548

GILBERT, P. T. and LAQUE, F. L. Jet Impingement Tests. *J. Electrochem. Soc.*, 1954, **101** (9), 448–455

HALL, W. L. and MANTLE, E. C. The Economical Use of Metals *Bull. Inst. Met.*, 1953, 2 (4), 50–53

HESSENBERG, W. C. F. and MANTLE, E. C. The Bright Annealing of Copper and Its Alloys. *Metal Ind., Lond.*, 1953, **83** (14–16, 18, 19), 279–281, 301–303, 323–324, 363–364, 377–380

HOPKIN, L. M. T. and THWAITES, C. J. The Effects of Some Constitutional Factors on the Creep and Fatigue Properties of Lead and Lead Alloys. *J. Inst. Met.*, 1953–54, **82** (4), 181–196

LUSHEY, R. S. D. and MCKEOWN, J. Stress-Rupture Time Properties of Copper-Tube Materials. *Engineer, Lond.*, 1954, **197**, 811–813

MCKEOWN, J. Fatigue of Lead and Lead Alloys. *Metal Ind., Lond.*, 1954, **85** (15), 305–306

MCKEOWN, J., EBORALL, R. J. L. and LUSHEY, R. D. S. Creep Properties of 99·8 per cent. Purity Aluminium at 20–80°C and at 250 and 450°C. *Metallurgia, Manchr.*, 1954, **50** (297), 13–15

MARSH, K. J. Some Observations on the Anelastic Properties of Copper and Tin Bronzes. *Acta Metallurgica*, 1954, 2 (3), 530–545

OLLARD, E. A. The Production of Printing Rollers by Electro-Deposition. *J. Soc. Dy. Col., Bradford*, 1953, **69**, 529–537

PHILLIPS, V. A. Stretcher-Strain Markings in Aluminium Alloys and Methods for Their Elimination, with Particular Reference to 3 to 4 per cent. Magnesium Alloys. *Sheet Metal Ind.*, 1953, 30 (319,320), 977–985, 1048–1054

RUDDLE, R. W. The Running and Feeding of Castings. *Metallurgia, Manchr.*, 1954, **49** 294; *Found. Tr. J.*, 1954, **96**, 489–497

RUTHERFORD, N. B. A Note on the Nature of " Black Spots " on Work Hot-Dip Galvanized in Baths Containing Aluminium. *Sheet Metal Ind.*, 1953, **30** (320), 1070

RUTHERFORD, N. B. Observations on the Loss of Aluminium from Galvanizing Baths. *Met. Treatm.*, 1954, **21** (105), 261–267

RUTHERFORD, N. B. Pinhole Porosity in Brass and Gunmetal Castings. *Found. Tr. J.*, 1954, **97**, 13–20; *Metal Ind., Lond.*, 1954, **85** (1), 5–8

WHITAKER, M. E. The Oxidation of Aluminium-Magnesium Alloys by Steam: A Contribution to Research on Mould Reaction. *J. Inst. Met.*, 1953–54, **82** (3), 107–116

OTHER PUBLICATIONS

BAILEY, G. L. J. The Influence of " Joint Design " on " Solderability ". *Sheet and Strip Metal Users' Tech. Assoc. Advance Copy*, Annual Conference, Dec., 2–4, 1953

EBORALL, R. J. L. An Approach to the Problem of Intercrystalline Fracture. *National Physical Laboratory Symposium on Creep and Fracture of Metals at High Temperatures*, 31*st May*, 1*st and* 2*nd June*, 1954. *Paper No.* 17, 13*pp*

GILBERT, P. T. Chemical Properties and Corrosion Resistance of Copper and Copper Alloys. Chapter 18 (pp. 379–409) of book " Copper: The Science and Technology of the Metal, Its Alloys and Compounds ". Ed. by A. Butts. (Reinhold, June, 1954, 936 pp.)

GILBERT, P. T. The Protection of Steel Against Atmospheric Corrosion by Metallic Coatings. *Preprint* of paper presented at Joint Meeting of Society of Chemical Industry and Commission No. 4 of the Association Belge pour l'Etude l'Essai et l'Emploi des Materiaux (to be published in *Industr. chim. belge.*), June, 1954, 8 pp

HISCOCK, S. A. The Sources and Control of Dross Formation in Hot-Dip Galvanizing. Oxford International Conference on Hot Dip Galvanizing *Preprint*. No. 14, July, 1954, 25 pp

RUTHERFORD, N. B. Pinhole Porosity in Brass and Gunmetal Castings. *Inst. Brit. Foundrymen Paper No.* 1100, June, 1954

THE RESEARCH ASSOCIATION OF BRITISH PAINT COLOUR AND VARNISH MANUFACTURERS

PUBLISHED IN JOURNALS

AHLERS, N. H. E., DENNISON, A. C., and O'NEILL, L. A. The Spectroscopic Examination of Punicic Acid. *Nature, Lond.*, 1954, **173** (4413), 1045–1046

AHLERS, N. H. E., DENNISON, A. C., and O'NEILL, L. A. Constitution of Mamala Oil. *Chem. and Ind. (Rev.)*, 1954. (26), 756–757

AHLERS, N. H. E., and MCTAGGART, N. G. The Spectroscopic Examination of Pomegranate Seed Oil. *J. Sci. Fd. Agric.*, 1954, **5** (2), 75–79

AHLERS, N. H. E., and MCTAGGART, N. G. The Determination of Hydroxyl, Ketone and Ester in Autoxidised Fatty Esters and Related Compounds by Infra-Red Spectroscopy. *Analyst*, 1954, **79** (933), 70–76

AHLERS, N. H. E., and O'NEILL, L. A. Structure of Oils and Resins-Spectroscopy. *Chem. and Ind. (Rev.)*, 1953 (47), 1256–1257; *Chem. Ass.*, 1954, **37** (412), 533–559

JORDAN, L. A. The Paint Research Station. *Chem. and Ind. (Rev.)*, 1954 (21), 584–592

RUSHMAN, D. F., and SIMPSON, E. Semi-Micro Molecular Still for Quantitative Use. *J. Oil. Col. Chem. Ass.*, 1954 (408), 319–322

ISSUED BY THE ASSOCIATION

REVIEW OF CURRENT LITERATURE

No. 156 November–December, 1953
No. 157 January–February, 1954
No. 158 March–April, 1954
No. 159 May–June, 1954
No. 160 July–August, 1954
No. 161 September–October, 1954

Annual subscription, £4 10*s.* 0*d.* (Inland) and £5 10*s.* 0*d.* (Overseas). Orders may be placed with Messrs. Chorley & Pickersgill, Amberley House, Norfolk Street, Strand, London, W.C.2. Single copies may be obtained from the Paint Research Station at 15*s.* 0*d.* (Inland) and 18*s.* 6*d.* (Overseas)

THE BRITISH PAPER AND BOARD INDUSTRY RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

ALLISON, E. C. and MILLER, D. J. B. Technical Enquiries at the British Paper and Board Industry Research Association. *Technical Bulletin*, 1953, **30** (5) and *Indian Pulp and Paper Magazine*, 1954, **8** (10)

EMERTON, H. W. Methods of Studying the Surface Topography of Papermaking Fibres. *J. R. mic. Soc.*, June, 1954, 35–41

EMERTON, H. W. A Method of Indicating the Scale of Reflection Electron Micrographs. *Research, Lond.*, 1954, **7** (10)

EMERTON, H. W., MATTOCKS, R. E. and BLANCHARD, D. M. W. A Direct Comparison of the Silvering and Permeability Methods of Determining Specific External Surface. *Tappi*, February, 1954, 55–56

HOOD, N. R. Searching for Better Methods. *Financial Times Supplement Paper and Board*, November, 1953, 4

HOOD, N. R. The British Paper and Board Industry Research Association. *Chem. and Ind. (Rev.)*, 1953, 1322–1324 and *J. Inst. Public Supply Officers*, 1954, **5** (4), 116

HOWARD, E. The Micro-biological Problems of the Paper and Board Industry. *J. Soc. of appl. Bact.*, 1953, **17** (2), 219–229

SIMPSON, A. and BLANCHARD, D. M. W. A Vacuum Cell for Use with a Light Microscope. *Research, Lond.*, 1954, **7** (7), 541–544

WATTS, J., EMERTON, H. W. and AMBOSS, K. A Brief Contribution to the Conference on Electron Microscopy held in London. *Brit. J. appl. Phys.*, 1954, **5** (5), 164

WATTS, J. and EMERTON, H. W. Interpretation of Electron Micrographs. *Procs. Technical Section*, **35** (2), 303–318

THE PRINTING, PACKAGING AND ALLIED TRADES RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

ADAMS, R. A. C. Phosphorus-Nickel Alloys for Lithography. *Penrose Annu.*, 1954, 124–126
BANKS, W. H. and COLLEDGE, R. W. Uses of Glue and Gelatine in Industry. *Bull. Brit. Glue and Gel. Mftrs, R.A.*, 1954, **5** (1), 3–8
BANKS, W. H. and MILL, C. C. Some Observations on the Behaviour of Liquids Between Rotating Rollers. *Proc. roy. Soc., A*, 1954, **223** (1154), 414–419
COUPE, R. R. "Acid" Papers and Ink Drying. *Penrose Annu.*, 1954, 113–115
COUPE, R. R. The Influence of Chemical Residues in Paper on Printability. *Int. Bull. Printing and Allied Trades*, 1954, (67), 42–47
CRONEY, R. G. W. Studies in Letterpress Printing with Particular Reference to Makeready. *Proc. of First Tech. Conference on Makeready and Premakeready*. 4th–5th December, 1952, 1953, pp. 20–23
FOSTER, J. H. Patra in Action. *Print. Rev.*, 1954, **18** (65), 29–30
FOSTER, J. H. Any Packaging Problems? Then Patra Can Help You. *J. Edinburgh Chamber of Commerce*, 1954, **36** (1), 20–21
HARRISON, V. G. W. Gloss Measurements: The Design of Glossmeters. *J. Oil and Col. Chem. Ass.*, 1953, **36** (400), 569–579
HARRISON, V. G. W. The Optical Properties of Paper. *Int. Bull. Printing and Allied Trades*, 1954, (67), 31–34
HARRISON, V. G. W. Progress in Photomechanical Processes, 1948–54. *J. Photogr. Sci.*, 1954, **2**, 39–44
HARRISON, V. G. W. and POULTER, S. R. C. Gloss Measurement of High-Gloss Papers. *Research, Lond.*, 1954, **7** (4), pp. 128–186
MILL, C. C. and GATES, E. R. Temperature Effects in a Rotation Viscometer. *Analyt. Chem.*, 1953, **25** (9), 1390–1393
PAINE, F. A. What Goes into a Package. *Brit. Trade J. and Export World*, 1954, **100** (1097), 133–134
PAINE, F. A. Packaging for Export. *Eng. Industries Bull.*, 1954, No. 123, 112–113
POULTER, A. C. Packaging Research Improves Product Quality. *Mass Prod.*, 1954, **30** (7), 130–139
POULTER, S. R. C. A Review of Printability Work. *Int. Bull. Printing and Allied Trades*, 1954, No. 67, 6–10
RIDDELL, G. L. The Printing, Packaging and Allied Trades Research Association. *Chem. and Ind. (Rev.)*, 1953, No. 48, 1266–1269
RIDDELL, G. L. Science: An Aid to Packaging. *F.B.I. Rev.*, 1954, No. 51, 39–43
RIDDELL, G. L. The Quality of Paper and Board in Relation to Its Usage—Packaging. *Proc. Tech. Sect. Brit. Paper and Board Makers' Assoc.* 1954, 35 (2), 213–231
STRASBURGER, H. Adhesives Research at Patra. *Adhesives and Resins*, **1** (9), 274–277

PRODUCTION ENGINEERING RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

GALLOWAY, D. F. Some Practical Aspects of Cutting Tool Nomenclature Arising from Recent Research. *Proc. Instn mech. Engrs, Lond.*, 1954, **168** (1), 67–88
GALLOWAY, D. F. Practical Applications of Production Engineering Research. *J. Instn Prod. Engrs*, 1954, **33** (7), 374–397

THE BRITISH RAYON RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

BOLLAND, J. L. and COOPER, H. R. The Photo-sensitized Oxidation of Ethanol. *Proc. roy. Soc., A*, 1954, **225**, 405–426
CHARNLEY, F. Processing Fibre-blends. *Text. Dig.*, 1954, **15** (2), 124–133
CORBETT, W. M. and KENNER, J. Trans-esterification as a Means of Halide Esterification under Neutral Conditions. *J. chem. Soc.*, 1953, (717), 3572–3575
CORBETT, W. M. and KENNER, J. The Degradation of Carbohydrates by Alkali. Part V. Lactulose, Maltose and Maltulose. *J. chem. Soc.*, 1954, (5055), 1789–1791
FAUST, R. C. The Determination of the Refractive Indices of Inhomogeneous Solids by Interference Microscopy. *Proc. phys. Soc., B*, 1954, 67, 138–148
HOWELL, H. G. The Friction of a Fibre Round a Cylinder and its Dependence upon Cylinder Radius. *J. Text. Inst.*, 1954, **45** (8), T575–T579
KENNER, J. and RICHARDS, G. N. The Degradation of Carbohydrates by Alkali. Part III. 3-0 Methyl Derivatives of Glucose and Fructose. *J. chem. Soc.*, 1954, (4671), 278–282

KENNER, J. and RICHARDS, G. N. The Degradation of Carbohydrates by Alkali. Part IV. 1-0 Methylfructose, Glucose, and Fructose. *J. chem. Soc.*, 1954, (5054), 1784–1789
LODGE, A. S. and HOWELL, H. G. Friction of an Elastic Solid. *Proc. phys. Soc., B*, 1954, 67, 89–97
MAJURY, T. G. The Dyeing of Cellulose Acetate with Non-Ionic Dyes. Parts I and II. *J. Soc. Dy. Col.*, 1954, **70** (10), 442–447
MAJURY, T. G. The Dyeing of Cellulose Acetate from the Vapour Phase. *J. Soc. Dy. Col.*, 1954, **70** (10), 448
MARRINAN, H. J. and MANN, J. A Study of Infra-Red Spectroscopy of Hydrogen Bonding in Cellulose. *J. appl. Chem.*, 1954, **4** (4), 204–211
REID, J. B. Weathering of Cellulose Acetate. *J. Text. Inst.*, 1954, **45** (9), T665–T677
SACK, R. A. Transverse Oscillations in Travelling Strings. *Brit. J. appl. Phys.*, 1954, **5**, 224–226
SHARPLES, A. The Hydrolysis of Cellulose. Part I. The Fine Structure of Egyptian Cotton. *J. Polym. Sci.*, 1954, **13**, 393–401
SHARPLES, A. The Hydrolysis of Cellulose. Part II. Acid Sensitive Linkages in Egyptian Cotton. *J. Polym. Sci.*, 1954, **14**, 95–104
TAYLOR, J. B. Sorption of Water by Soda-Boiled Cotton at Low Humidities. *J. Text. Inst.*, 1954, **45** (8), T642–T664
TRELOAR, L. R. G. The Photoelastic Properties of Short-chain Molecular Networks. *Trans. Faraday Soc.*, 1954, **50** (8), 881–896
WELLARD, H. J. Variation in the Lattice Spacing of Cellulose. *J. Polym. Sci.*, 1954, **13**, 471–476
WELLARD, H. J. Cellulose Unit Cells. *Nature, Lond.*, 1954, **174** (4420), 135–136
WOOD, C. Dynamic Friction of Viscose Fibres and Relative Humidity. *J. Text. Inst.*, 1954, **45** (10), T794–T802
WOOD, C. A Laboratory Pump for Closed Circulation of Humidified Air. *J. sci. Instrum.*, 1954, **31** (10), 386–387
WHISTLER, R. L. (Purdue University, Indiana) and MCGILVRAY, D. I. Chemistry of the Carbohydrates. *Annu. Rev. of Biochem.*, 1954, **23**, 79–98

PUBLISHED BY THE ASSOCIATION

BUTLER, K. J., COWHIG, W. T. and THOMPSON, R. A Loom Stoppage Recorder. B.R.R.A. Private Publication No. 2
COWHIG, W. T. and MORRIS, W. J. Tests on Yarn Tension Devices in Pirn Winding. B.R.R.A. Private Publication No. 1
LODGE, A. S. Some Finite Strain Generalizations of Boltzman's Equations. *Proceedings Second International Congress on Rheology*, July, 1954, Butterworths Scientific Press, 229–235
MEITNER, W. and TAYLOR, J. E. Fugitive Tinting. *J. Text. Inst.*, 1954, **45** (8), P369–P379. *Proceedings Joint Conference of Text. Inst. and Soc. Dy. Col.*, 1954

RESEARCH ASSOCIATION OF BRITISH RUBBER MANUFACTURERS

PUBLISHED IN JOURNALS

AUDSLEY, A., GROSS, F. R. and PANTONY, D. A. Relationship between the Molecular Volume Refraction and Polarisation of the Tri-n-alkyl-methanes. *J. Inst. Petrol*, 1954, **40**, 45–49
BANKS, G. L., CHALK, A. J., DAWSON, J. E. and SMITH, J. F. Catalysis of Olefin Autoxidation by Heavy Ions in Non-polar Media. *Nature, Lond.*, 1954, **174**, 274–275
CHALLENGER, F. and PANTONY, D. A. Synthesis and Properties of Tertiary Methanes. *J. Inst. Petrol*, 1954, **40**, 38–45
MESSENGER, T. J. New Tools for Research. *J. Ind. Rubb.*, 1953, **125**, 989–990, 992, 994, 996, 1002
SCOTT, J. R. Co-operative Research in the Rubber Industry. *Engng. Insp.*, 1954, **19**, 30–39.
SCOTT, J. R. Croydon to Shawbury. Re-establishing R.A.B.R.M. in its new Home. *J. Ind. Rubb.*, 1953, **125**, 1004–1006, 1008
SCOTT, J. R. Rubber Test Methods; 1953 Meeting of the I.S.O. Committee. *Proc. I.R.I.*, 1954, **1**, 56–65
WALLACE, G. L. Rubber in the Guianas. Old Documents with a Topical Interest. *J. Ind. Rubb.*, 1953, **125**, 955
WALLACE, G. L. Who has the Oldest Rubber Trade Directory? *J. Ind. Rubb.*, 1953, **125**, 981
WAKE, W. C. Wear in Double Texture Garments. *I.R.I. Trans.*, 1953, **30**, 3–15
WAKE, W. C. The end of " Croydon ", *J. Ind. Rubb.*, 1953, **126**, 692
WAKE, W. C Interaction of Fibre and Rubber in Rubber-to-Fabric Adhesion. *Rev. gen. Caoutch.*, 1953, **31**, 299–302
WHORLOW, R. W. Rheology of Unmasticated and Masticated Smoked Sheet. *Rubb. Chem Technol.* 1953, **27**, 20–35

OTHER PUBLICATIONS

BIERTON, E. F. and REDFERN, C. J. Historical and Statistical Review. *Ann. Rept. on the Progress of Rubb. Tech.*, 1953

GARDNER, E. R., HERBERT, A. E. and WAKE, W. C. Abraded Filament Type Cords. *Third Rubber Technology Conference*, 1954, Preprint 31, p. 11

MOAKES, R. C. Testing and Equipment and Specifications other than for Latex. *Ann. Rept. on the Progress of Rubb. Tech.* 1953

PAYNE, A. R. Non-linearity in the Dynamic Properties of Rubber. *Third Rubber Technology Conference.* Preprint 59, p. 24

WAKE, W. C. Chemistry and Physics of Vulcanised Rubber. *Annual Report of the Progress of Rubber Technology*, 1953

THE BRITISH SHIPBUILDING RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

BROWN, J. and FERGUSON, J. M. Tests on Launching Greases. *Trans. Instn. Nav. Archit., Lond.*, 1954, **96** (2), 89

JOHNSON, A. J. and MARWOOD, W. J. Vibration Tests on an Up-river Collier with Special Reference to the Influence of Depth of Water. *Trans. N.E. Cst. Instn. Engrs. Shipb.*, 1954, **70** (3), 193

THOMSON, A. S. T., SCOTT, A. W., FERGUSON, W. and MCBROOM, H. C. Some Factors in the Design and Lubrication of Journal Bearings. *Trans. N.E. Cst. Instn. Engrs. Shipb.*, 1953–54, **97** (4), 257

THOMSON, A. S. T., FERGUSON, W., STABLER, G. V. and SCOTT, A. W. Investigations on Surface Finish of Steel Shafts. *Trans. Instn. Engrs. Shipb., Scot.*, 1953–54, **97** (7), 549

BRITISH STEEL CASTINGS RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

B.S.C.R.A. Radiographic Exposure Calculator. *Iron and Steel, Lond.*, 1953, **26** (11), 470

HOAR, T. P. Metal Penetration and Sand Burn-on in Steel Castings. *West of Scotland Iron and Steel Institute J.*, 1952–1953, **60**, 28–50

HOLT, P. F. and YATES, D. M. Studies on the Nature of Silicosis: the Polymerization of Silicic Acid Sols in Vivo. *Brit. J. of exp. Path.*, 1954, **35** (1), 52–59

Rotary Metal Sampling Device. *Found. Tr. J.*, 1953, **95** (1938) 498

THE COAL TAR RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

BRIGGS, D. K. H. and POPPER, F. Thermal Conductivity of Coal Tar Pitch. *Fuel, Lond.*, 1954, **33**, 222–229

DEAN, R. E., WHITE, E. N. and MCNEIL, D. The Production and Commercial Possibilities of Diphenic Acid. *J. appl. Chem.*, 1953, **3**, 469–476

GREENHOW, E. J., WHITE, E. N. and MCNEIL, D. The Chemistry of Fluorene. Part III. The Condensation of 9-fluorenyl-sodium with Acid Chlorides and Anhydrides. *J. Chem. Soc.*, 1953, 3099–3105

GREENHOW, E. J., HARRIS, A. S. and WHITE, E. N. The Chemistry of Fluorene. Part IV. Some New Caloro- and Nitro- derivatives. *J. Chem. Soc.*, 1954, 3116–3121

HARRIS, A. S., WHITE, E. N. and MCNEIL, D. The Chemical Composition of High-boiling Fractions of Coal Tar. I. Retort Soft Pitch. *J. appl. Chem.*, 1953, **3**, 443–451

SHELMERDINE, J., POPPER, F. and MCNEIL, D. The Production of Phthalic Anhydride by the Oxidation of Tar Oils. *J. appl. Chem.*, 1953, **3**, 513–521

ISSUED BY THE ASSOCIATION

Review of Coal Tar Technology, **5** (1 and 2), 7*s.* 6*d.*

Coal Tar Data Book (Loose-leaf), 3 guineas each

OTHER PUBLICATIONS

MCNEIL, D. and VAUGHAN, G. A. Composition of Coal Tars. Institution of Coal Tars Institution of Gas Engineers Copyright Publication No. 438

BRITISH WELDING RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

BAKER, J. F. and HORNE, M. R. New Methods in the Analysis and Design of Structures in the Plastic Range. *British Welding Journal*, 1954, **1** (7), 307–315

COTTRELL, C. L. M. Effect of Hydrogen on the Continuous Cooling Transformation Diagram for a Manganese Molybdenum Steel. *J. Iron St. Inst.*, 1954, **176** (3), 232–282

COTTRELL, C. L. M. and BRADSTREET, B. J. Vanadium as Replacement for Molybdenum. *British Welding Journal*, 1954, **1** (2), 82–86

COTTRELL, C. L. M. Weldability of Mn-Mo Steel Related to Properties of the Heat-Affected Zone. *British Welding Journal*, 1954, **1** (4), 177–186

COTTRELL, C. L. M. Hydrogen—Barrier to Welding Progress. *British Welding Journal*, 1954, **1** (4), 167–176

COTTRELL, C. L. M. Weldability of a B-Mo Steel Related to Properties of the Heat-Affected Zone. *British Welding Journal*, 1954, **1** (7), 315–321

COTTRELL, C. L. M. and BRADSTREET, B. J. Cooling Rates in Typical Arc-Welded Joints. *British Welding Journal*, 1954, **1** (7), 322–326

COTTRELL, C. L. M. Transformation Temperature of Alloy Steels Related to Weldability with Low-Hydrogen Electrodes. *British Welding Journal*, 1954, **1** (9), 409–412

DIXON, H. E. and ROBERTS, J. E. Some Simple Statistical Methods for Resistance Welding Investigations. *British Welding Journal*, 1954, **1** (6), 276–286

DIXON, H. E. and ROBERTS, J. E. Spot Welding of High-Strength Aluminium Alloys. *British Welding Journal*, 1954, **1** (8), 351–370

DIXON, H. E. The Fusion Welding of Aluminium Alloys. *British Welding Journal*, 1954, **1** (10), 455–457

DIXON, H. E. A Survey of Published Information on the Fusion Welding of Heat-Treatable Aluminium Alloys. *British Welding Journal*, 1954, **1** (10), 458–464

DIXON, H. E. Spot Welding of Aluminium Alloys. *Welding and Metal Fabrication*, 1954, **22** (9), 350–353

HORNE, M. R. Collapse Load Factor for a Rigid Frame Structure. *Engineering, Lond.*, 1954, **177** (4594), 210–212

HOULDCROFT, P. T. The Use of Self-Adjusting Arc Equipment for Welding a Light-Alloy Deckhouse. *British Welding Journal*, 1954, **1** (1), 36–44

HOULDCROFT, P. T. Dilution and Uniformity in Aluminium Alloy Weld Beads. *British Welding Journal*, 1954, **1** (10), 468–472

HULL, W. G. The Use of Gas Shielded Arc Processes for Cutting Non-Ferrous Materials. *Welding and Metal Fabrication*, 1954, **22** (5), 188–191

HULL, W. G. and ADAMS, D. Review of Published Information on Weld Cracking in Aluminium Alloys, with Particular Reference to Al-Mg-Si Alloys. *British Welding Journal*, 1954, **1** (10), 464–467

NEEDHAM, J. C. and HULL, W. G. Self-Adjusting Welding Arcs. *British Welding Journal*, 1954, **1** (2), 71–77

ROBERTS, J. E. and DIXON, H. E. Effect of Steel Quality on Spot-Welding Properties. *British Welding Journal*, 1954, **1** (1), 27–35

ROBERTS, J. E. Resistance Spot Welding of $\frac{3}{16}$ in. and $\frac{1}{4}$ in. Mild Steel. *British Welding Journal*, 1954, **1** (3), 136–140

ROBERTS, J. E. Resistance Welding of Coated Steels: A Review of Information. *British Welding Journal*, 1954, **1** (5), 233–237

RODERICK, J. W. The Load-Deflection Relationship for a Partially Plastic Rolled-Steel Joist. *British Welding Journal*, 1954, **1** (2), 78–82

RODERICK, J. W. and PRATLEY, H. H. L. Behaviour of Rolled-Steel Joists in the Plastic Range. *British Welding Journal*, 1954, **1** (6), 261–275

TAYLOR, H. G. History of Work of the British Welding Research Association. *F.B.I. Review*, 1954, October, 46–51.

TYLECOTE, R. F. Investigations on Pressure Welding. *British Welding Journal*, 1954, **1** (3), 117–135

WINTERTON, K. Recent Researches on Steel Welding. *Coke and Gas*, 1954, January

WINTERTON, K. Nitrogen-Arc Welding of Copper. *British Welding Journal*, 1954, **1** (2), 87–90

WINTERTON, K. Evolution of Hydrogen from Weld Metal. *Metallurgia*, 1954, **49** (291), 3–7

WINTERTON, K. The British Welding Research Association (Review of Progress of the Work). *Metallurgia*, 1954, **50** (300), 169–174

LM. 7 Committee of B.W.R.A. Protection from Radiation of Personnel Engaged in Inert Gas Metal-Arc Welding. *Welding and Metal Fabrication*, 1954, **22** (5), 183

The Formative Years—A Review of Progress from March, 1946 to April, 1953. *Weld. Res.*, 1953, **7** (6), 118r–154r

ISSUED BY THE ASSOCIATION

Annual Report of the Welding Research Association, 1953–1954

Welding Research for Industry, 1954

Projection Welding of Mild Steel, 1954 (Ref. T30) Price 3*s.* 6*d.*

WOOL INDUSTRIES RESEARCH ASSOCIATION

PUBLISHED IN JOURNALS

ANDERSON, S. L. The Air Flow Method of Measuring Wool Fibre Fineness. *J. Text. Inst.*, 1954, **45**, 312–316

ANDERSON, S. L. A Simple Method of Comparing the Breaking Loads of Two Yarns. *J. Text. Inst.*, 1954, **45**, 472–479

APPLEYARD, H. M. and DYMOKE, C. M. Effect of Ortho-chlorophenol on Wool. *J. Text. Inst.*, 1954, **45**, 480–482

BENSON, F., MILLER, J. G. and TOWNSEND, M. W. H. Machine Interference: A Solution of Some Work-load Problems Arising When an Operative has Charge of More than one Machine. *J. Text. Inst.*, 1953, **44**, T619–644

BLACKBURN, S. and LEE, G. R. The Chromatographic Separation of the Diastereoisomerides of Lanthionine. Determination of Lanthionine. *Chem. and Ind., (Rev.)*. 1954, No. 41, 1252

BLACKBURN, S. and LEE, G. R. The Terminal Carboxyl Groups of Wool Keratin. *J. Text. Inst.*, 1954, **45**, T487–488

BOND, F. and WRIGHT, M. L. The Preparation of Films by a Mechanical Method. *J. sci. Instrum.*, 1954, **31**, 70

BREARLEY, A. Variations in Woollen Carding—A Rapid Practical Test for Mill Use. *Wool Rec.*, 1954, **85**, 867–868

BREARLEY, A. Textile Testing—How to Use the Results. *Fibres*, 1954, **15**, 303–304

BURNS, M. The Development of the Fleece and Follicle Population in Herdwick sheep. *J. Agric. Sci.*, 1954, **44**, 443–464

BURNS, M. Observations on the Development of the Fleece and Follicle Population in Suffolk Sheep. *J. Agric. Sci.*, 1954, **44**, 86–99

BURNS, M. Observations on the Follicle Population of Blackface Sheep. *J. Agric. Sci.*, 1953, **43**, 422–431

CASSIE, A. B. D. Raper Autoleveller. *J. Text. Inst.*, 1954, **45**, 14

CASSIE, A. B. D. The Wool Industries Research Association. *Norsk Tekstiltidende*, 1954, **35**, 359–362, 365

CASSIE, A. B. D. Research Associations. IV. The Wool Industries Research Association, Leeds. *Inst. of Physics Bull.*, 1954, (49), 2–10

CASSIE, A. B. D. How Research is Helping the Cloth and Clothing Trades. *The Clothing Institute J.*, 1954, **2** (3), 61–66

CASSIE, A. B. D. The Scientific Approach in the Wool Textile Industry. *Yorks. Observer Trade Review*, 1953, 10

CASSIE, A. B. D. The Wool Industries Research Association. *Chem. and Ind. (Rev.)*, 1953, **43**, 1138–1143

CORFIELD, M. C. and ROBSON, A. The Amino-acid Composition of Salmine. *Biochem. J.*, 1953, **55**, 517–522

CORFIELD, M. C., HOWITT, F. O. and ROBSON, A. Basic Amino-acids of Silk Fibroin. *Nature, Lond.*, 1954, **174**, 603–604

DAVIDSON, A. N. The Relaxation Shrinkage of Woven Wool Fabrics During Soaking in Water and Hoffman Pressing. *J. Text. Inst.*, 1954, **45**, T323–347

DAVIDSON, A. W. and PRESTON, R. A Method for the Estimation of Fibrolane BX or Viscose Rayon in Blends with Wool. *J. Text. Inst.*, 1954, **45**, T142–146

DILWORTH, S. and APPLEYARD, H. M. A Sharpening Machine for a New Type of Microtone Knife. *Quart. J. Micr. Sci.*, 1954, **95**, 11–16

ELSWORTH, F. F. and BARRITT, J. Determination of the Fatty Matter in Wool by Extraction with Diethyl Ether. *J. Text. Inst.*, 1953, **44**, 754–759

GREEN, T., HARKER, R. P. and HOWITT, F. O. Use of Adsorption Columns in the Analysis of Emulsions Stabilized with Non-ionic Detergents. *Nature, Lond.*, 1954, **174**, 659

HARKER, R. P., HEAPS, J. M. and HORNER, J. L. Use of Adsorption Columns in the Analysis of Soap and Detergent-stabilized Emulsions. *Nature, Lond.*, 1954, **173**, 634–635

HORNER, J. L. The Combination of Wool Keratin with Alkali. *Trans. Faraday Soc.*, 1954, **50**, 1000–1010

HOWITT, F. O. Non-cellulose Textile Chemistry. *Rep. Progr. Appl. Chem.*, 1952, **37**, 744–763

KING, G. and WARBURTON, F. L. Reversible Twist and Bending Relaxation Phenomena in Keratin Fibres. *J. Text. Inst.*, 1954, **45**, T412–418

LEES, K. and ELSWORTH, F. F. The Solubility of Wool in Urea-bisulphite Solution and its use as a Measure of Fibre Modification. *J. Soc. Dy. & Col.*, 1954, **70**, 354–355

LEMON, H. From Hand Spinning to the Raper Autoleveller. *Texture*, 1954, **1**, 209–213

LINCOLN, B. The Frictional Properties of the Wool Fibre. *J. Text. Inst.*, 1954, **45**, 92–107

MEDLEY, J. A. The Electrostatic Charging of Some Polymers by Mercury. *Brit. J. appl. Phys., Suppl.* No. 2, 1953, S28–30

MEDLEY, F. A. The Dissipation of Electrical Charges Generated by Rollers. *Brit. J. appl. Phys., Suppl.* No. 2, 1953, S23–27

MEDLEY, J. A. The Discharge of Electrified Textiles. *J. Text. Inst.*, 1954, **45**, T123–141
MEDLEY, J. A. Static Electrification in an Externally Applied Field. *Research Correspondence*, 1954, **7**, S33–34
MILLER, J. G. and TOWNSEND, M. W. H. Machine Interference. *J. Text. Inst.*, 1954, **45**, T419
PERYMAN, R. B. Effect on Wool of Boiling in Aqueous Solutions. I. *J. Soc. Dy. & Col.*, 1954, **70**, 83–92
POOLE, E. J. D. The Textile Recorder Exhibition—Weaving Machinery. *J. Text. Inst.*, 1953, **44**, 763–765
ROBSON, A. Radioactive Isotopes in Wool Research. *Fibres*, 1954, **15**, 91–93, and *Atomics*, 1953, **4**, 320–324, 330
RYDER, M. L. and AUBER, L. Abnormal Growths Associated with Wool Follicles in Sheep. *Nature, Lond.*, 1954, **174**, 743–744
RYDER, M. L. An Adjustable Cutting-stage for a Freezing Microtome. *The Microscope*, 1953, **9**, 273–274
TAYLOR, D. S. Some Observations on the Movement of Fibres During Drafting. *J. Text. Inst.*, 1954, **45**, T310–322
Testing and Measuring Instruments Devised in Wool Industries Research Association Laboratories. *Fibres*, 1954, **15**, 123–125
The W.I.R.A. Autocount. *Wool Rec.*, 1954, **86**, 736, 738, 918
THORNDIKE, G. H. and BREARLEY, A. Possibilities for Systematic Control in Wool Yarn Production, *J. Text. Inst.*, 1953, **44**, 794–805
TRANTER, T. C. The Crystal Structure of Glycyl-L-Alanine Hydrobromide. *Nature, Lond.*, 1954, **173**, 221–222
TRANTER, T. C. Unit-cell Dimensions and Space Groups of Synthetic Peptides, II. *Acta Crys. Camb.*, 1953, **6**, 805–806
WARBURTON, F. L. Variations in Normal Colour Vision in Relation to Practical Colour Matching. *Proc. Phys. Soc. B*, 1954, **67**, 477–484
W.I.R.A. Wool Textile Research Underlying the Development of Methods and Machinery. *Text. Mfr. Text. Machinery Exhibition Suppl.*, 1953, 6–9, 24
WRIGHT, M. L. Membrane Potentials for Keratin and Cellophane and the Meyer-Teorell Theory. *J. Phys. Chem.*, 1953, **58**, 50–53
WRIGHT, M. L. The Self-diffusion of a Dye in a Polar Polymer Membrane. *Discussions of the Faraday Soc.*, 1954 (16), 58–65
WRIGHT, M. L. Interaction of Ions with Keratin, II. *Trans. Faraday Soc.*, 1954, **50**, 89–96
WRIGHT, M. L. The Electrical Resistance of Wool and Other Textile Materials. *J. Soc. Dy. & Col.*, 1954, **70**, 120

OTHER PUBLICATIONS

W.I.R.A. Recent Developments in Wool Textile Research. *Text. Rec. Annual Book of the Year*, 1953, 130–135

(30582) Wt. 1323—634 K22 3/55 D.L.