Department of Scientific and Industrial Research

REPORT FOR THE YEAR 1952-53

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by Command of Her Majesty
March 1954

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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)

(*b*) RESEARCH ASSOCIATIONS—*continued*

(*c*) OTHER GRANT-AIDED ORGANIZATIONS

APPENDICES

REPORT OF THE COMMITTEE OF THE PRIVY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH FOR THE YEAR 1952–53

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-Eighth Report of our proceedings, covering the period from 1st October, 1952, to 30th September, 1953. We subjoin the Thirty-Eighth 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 learned with great pleasure that Your Majesty had been graciously pleased to confer the honour of Knighthood on Mr. A. H. S. Hinchliffe, D.L., J.P., a member of our Advisory Council.

We appointed 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., and Sir Philip Johnson to be members of the Advisory Council from 1st October, 1952.

Mr. E. Fletcher retired from the Advisory Council on 30th September, 1953, on completion of his term of office. We wish to record our appreciation of the valuable services he rendered during his membership.

RESEARCH BOARDS

Sir William Halcrow, M.I.C.E., M.I.Mech.E., retired from the Chairmanship of the Hydraulics Research Board on 31st March, 1953. He had been Chairman of the Board since its inception in 1946, and we consider ourselves fortunate in having had the benefit of his knowledge and experience during the formative period of the new Hydraulics Research Organization.

To succeed Sir William Halcrow, we appointed Mr. W. P. Shepherd-Barron, M.C., T.D., M.I.C.E., M.I.Mech.E., to be Chairman of the Hydraulics Research Board from 1st April, 1953.

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

INTERNATIONAL CONGRESSES AND FOREIGN VISITS

During the year a number of officers of the Department made visits abroad to take part in international conferences and to obtain information on recent scientific and technical advances in other countries.

RESEARCH ASSOCIATIONS

We learned with great pleasure that Your Majesty had been graciously pleased to appoint Mr. J. E. Hirst, Chairman of the Council of the British Cast Iron Research Association, and Mr. D. R. H. Williams, who was for many years Chairman of the Research Control Committee of the Wool Industries Research Association, to be Commanders of the Most Excellent Order of the British Empire.

On 17th October, 1952, the first post-war building programme of the Wool Industries Research Association was completed, when the new buildings were opened by the Rt. Hon. Viscount Swinton, P.C., G.B.E., C.H., M.C., then Chancellor of the Duchy of Lancaster and Minister of Materials.

We were also pleased to learn that the Nobel Prize for Chemistry for 1952 had been awarded to Dr. A. J. P. Martin and Dr. R. L. M. Synge, two former members of the staff of the Wool Industries Research Association, in recognition of their pioneer work on partition chromatography as part of the Association's research programme; and that the Medal of the Society of Chemical Industry for 1953 had been awarded to Dr. L. A. Jordan, C.B.E., A.R.C.S., F.R.I.C., M.I.Chem.E., Director of Research of the Research Association of British Paint, Colour and Varnish Manufacturers.

No new Research Associations have been formed since we last reported. The Linoleum Research Council was wound up as from 23rd February, 1953, and grant has been terminated.

New or revised terms of grant have been accepted by eleven Research Associations, research organizations, and other bodies. Special grants for capital projects have been offered to two Research Associations. Further particulars will be found in the Report of the Advisory Council (pp. 18 and 19) and in the Summary of Work (p. 116 et seq.).

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Following a number of international meetings, Your Majesty's Government in the United Kingdom have agreed to participate in arrangements for collaboration with a number of European countries in fundamental research in that part of the field of nuclear physics which is concerned with very high energy particles. In July, 1953, the Secretary of the Department, on behalf of Your Majesty's Government in the United Kingdom, signed a Convention for the establishment of the European Organization for Nuclear Research. The United Kingdom's contribution to the Organization will be borne on the Department's vote.

PATENTS

During the year 43 British and, in certain cases, corresponding Colonial and foreign patent applications have been filed and 34 British patents have been allowed to lapse. Eleven British patent applications were abandoned and 46 foreign patents and patent applications were allowed to lapse or were abandoned.

EXPANSION OF THE DEPARTMENT

In our last Report we recorded steps we had reluctantly taken, in the economic position of 1951-52, to arrest the planned expansion of the Department's activities and to make some adjustments in the distribution of the resources available to us. During 1952-53 we received from our Advisory Council and many of the Research Boards of the Department strong representations in favour of the provision of increased resources and we were glad to be able to arrange with the Lords Commissioners of Your Majesty's Treasury for the presentation to Parliament of Estimates for 1953-54 which contained some additional financial provision, including especially provision for additional staff needed for the new Mechanical Engineering Research Laboratory at East Kilbride and the Hydraulics Research Laboratory at

Wallingford. The Estimates, as approved, provide for a net expenditure of £5,688,821, an increase of £245,271 over the provision for 1952-53, and for 80 additional staff, industrial and non-industrial.

Following these decisions, which were reached early in 1953, we considered further the strong representations of our Advisory Council for the resumption of the general planned expansion of the Department. The Council had emphasized to us the need not only for increased resources for this purpose, but also for their being assured, so far as might be constitutionally possible, over a period of years. We have been glad to be 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 schemes for the steady growth over the next five years, 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. We have accordingly authorized detailed planning for that period on the basis of these schemes, of which some further details are given in the Report of our Advisory Council.

STAFF

The total number of staff of all grades, industrial as well as non-industrial, employed in the Department on the 1st October, 1953, was 4,073 (including 159 part-time), an increase of 38 compared with the previous year. In addition, 22 members of the permanent staff were serving in Your Majesty's Forces, and three were on loan to other Departments.

EXPENDITURE

The net expenditure of the Department during the year ended 31st March, 1953, was £5,207,455 as compared with £4,956,819 in the preceding year. Details may be found in Appendix V.

SALISBURY,
Lord President of the Council.

B. LOCKSPEISER,
Secretary.
19*th February*, 1954.

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

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ADVISORY COUNCIL

(1952-53)

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.

E. FLETCHER, Esq.

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.

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 1952–53

MAY IT PLEASE YOUR LORDSHIPS

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

With great pleasure we record that His Royal Highness the Duke of Edinburgh, who had previously visited several of the Department's Research Establishments, accorded us the signal honour of his presence at our meeting on 17th December, 1952. The Most Hon. the Marquess of Salisbury, who had lately taken office as Lord President of the Council, accompanied him. In the course of a general survey of the many problems arising in the Department's work, we were greatly heartened by His Royal Highness's lively interest in all that we are endeavouring to do, and particularly in the crucial problem of reducing the lag between the acquisition of scientific knowledge and its use in industry. We return to this problem in the section of this Report on the Intelligence and Information Division (p. 21).

During the year we have again had to carry on our work under the shadow of a difficult economic situation, and with the handicap that the resources available to the Department, both in money and in staff, remained far less than we believe to be necessary for its manifold purposes. We pressed strongly for some increase in the Department's resources for the year beginning 1st April, 1953, and for ways and means to be found for ensuring a resumption of progress towards the fulfilment of the approved post-war plans that we had submitted to your Lordships in 1945. We are glad to record that your Lordships were able to agree with the Chancellor of the Exchequer to present to Parliament Estimates for 1953-54 which, unlike those for the preceding year, allowed for some slight expansion of resources; and it gave us much greater satisfaction to learn, towards the end of the year under review, that your Lordships had also been able to agree to a plan for substantial growth of D.S.I.R. over the next five years. Although this plan is subject to annual confirmation by Government and the voting of the necessary funds by Parliament, it affords us firm ground on which to advise how best to allocate the resources we may expect to be made available, and on which to base forward policy with reasonable assurance that our recommendations will not be stultified by lack of the means with which to carry them to fulfilment. In the following pages we shall find it necessary to record difficulties arising from the exiguity of current resources which came to our notice during the year. For this reason we defer to the end of this Report further reference to the problems of resources and the means now to be adopted for their solution.

D.S.I.R. ESTABLISHMENTS

Following what is now our standard practice, we have visited three Establishments during the year, namely, the National Physical Laboratory, the Chemical Research Laboratory and the Hydraulics Research Station. On each occasion we have been able, not only to see something of the work of the Establishment, and of the facilities available, but also to discuss major aspects of the programme and any special needs with the Chairman of the Advisory Board and the Director of Research. We have also received and discussed the Annual Reports for 1952 of all the fourteen Research Boards

and Directors of Research, and in two cases, Mechanical Engineering Research and Fire Research, we had the benefit during these discussions of the presence of the Chairman of the Board and the Director of Research. In all these visits and discussions we have been impressed on the one hand with both the high quality and the practical value, immediate and potential, of the work in progress, and on the other hand with the strength of the representations made to us that resources were sadly insufficient for all that ought to be done and was being pressed for.

NATIONAL PHYSICAL LABORATORY

When we visited the National Physical Laboratory, we had the benefit of a discussion with several members of the Executive Committee, of which our Secretary, Sir Ben Lockspeiser, is Chairman, and the Director, Sir Edward Bullard.

The National Physical Laboratory differs in several ways from the other D.S.I.R. Establishments, and we wish to comment upon two of them which, in our view, make the handling of its work particularly complex and difficult. These are its size—it is by far the largest of the Establishments—and the diversity of its activities. The Laboratory was founded at the beginning of the present century, and shares with the still older Geological Survey of Great Britain the distinction of being older than the Department of which it is now part. It began under the control of the Royal Society, with which it still has especially close relationships through its General Board and Executive Committee. Its objectives were formally defined, at its inception, as "the standardization and verification of instruments, the testing of materials and the determination of physical constants", but it is noteworthy that, in opening the Laboratory, His Royal Highness the Prince of Wales, later His Majesty King George V, said, "The object of the scheme is, I understand, to bring scientific knowledge to bear practically upon our everyday industrial and commercial life: to break down the barrier between theory and practice: to effect a union between science and commerce". The present functions, not only of the Laboratory, but of the whole Department, could hardly be more succinctly defined. Since 1902 the growth in scientific knowledge and technological achievement has been enormous, probably far exceeding the imaginings of those far-seeing men who helped to found the Laboratory a bare half-century ago. With the passage of time, and notably during the first world war, the scope of the Laboratory's work has widened to include many fields of research; while the growth of national needs has from time to time resulted in work being transferred from the Laboratory to become the basis of new institutions. Thus, on the one hand new Divisions for Light and Mathematics have been established since 1939, and such specialized branches of work as control mechanisms, electronics and ultrasonics have been taken up; on the other hand, building and road-making materials have long since become the responsibility of the Building Research Station and the Road Research Laboratory, while two of the Laboratory's Divisions, Radio and Engineering, have more recently been detached to become independent research directorates. The Laboratory at present comprises Divisions for Aerodynamics, Electricity, Light, Mathematics, Metallurgy, Metrology, Physics (mainly heat, sound and radiation) and Ship Design and Propulsion, as well as Sections for Electronics and Test Work. We mention these changes to illustrate the fact that the National Physical Laboratory is in no sense a static organization, with fixed responsibilities and limited scope; on the contrary, its field of work is ever-changing and must continue to change as the boundaries of scientific knowledge extend, new forms of manufacture arise and new uses are found for

national resources. It must be stressed too that while some of the Laboratory's work (e.g., in the Aerodynamics and Ship Divisions) is directed primarily to the scientific needs of particular manufacturing and user fields, a very large part of it is not, but is undertaken to meet the basic needs of industry in general and of the public. All industry increasingly depends on the maintenance of increasingly accurate standards of measurement over an increasingly wide range of requirements from such basic ones as length, mass and temperature to such modern ones as the high-frequency electrical oscillations of hundreds of millions of cycles per second used in radio and radar. With every advance in technology the scope and difficulty of this work increases, and it is to the N.P.L. that Government and industry alike look for that ultimate precision without which the less precise, but still very accurate, tools of industry could not be produced. Yet this remains but a relatively small part of the Laboratory's field of work as a whole.

The Laboratory has recently measured the speed of light to a high degree of accuracy by a method which seemed deceptively simple by comparison with older experiments. The frequency of resonance of radio waves in an accurately measured resonant chamber was the basis of the measurement, and it combined the special skills of a number of sections of the Laboratory. The value obtained was higher than that previously accepted, but it is now confirmed as being more accurate. At one time only of academic interest, the speed of light is now a constant of such fundamental importance in science that an accurate determination of it is of the utmost value.

During the last few years the Light Division of the National Physical Laboratory has been developing a new method of producing diffraction gratings suggested by Sir Thomas Merton. To further these researches a unique lathe has been acquired, capable of generating helices of from 80 to 30,000 turns per inch. From the lathe-cut thread a corrected helix is made, free from periodic errors, by the use of a flexible nut controlling the ruling tool, and from this plane gratings are then produced by a replica process. Gratings made in this way have already proved very valuable in the field of infra-red spectrometry, where they are being used for rapid chemical analysis and the automatic control of processes. Methods have also been devised for using the gratings for accurate linear measurement and for the control of machine tools. The various Merton-NPL processes are protected by a number of patents and two British firms have been licensed to use them.

As the speed of aircraft increases, the designer is faced with entirely new problems of the behaviour of bodies moving in air at speeds greater than that of sound. The Aerodynamics Division of the National Physical Laboratory is a pioneer in exploring this frontier of knowledge. By feeling the way with theoretical studies and small-scale experiments in wind tunnels, the nature of the problems to be faced is gradually defined, and the designer of high-speed aircraft is provided eventually with data on which he can realize the new types of machines with which the British aircraft industry is able to lead the whole world.

In the theoretical studies of high-speed flight, and in a wide range of other investigations, mathematical problems of great complexity have already been solved with the help of the Automatic Computing Engine which has been designed and built at the Laboratory with the help of industry. This machine operates so quickly that it is possible with it to carry out calculations hitherto not attempted because of their complexity. The first machine has already proved itself a powerful research tool, and further improvements in design are being made to increase its usefulness.

It is some years since we referred at length to the National Physical Laboratory, and our visit has led us to do so for two reasons. In the first place, we were deeply impressed with the value, and indeed the necessity, of the work it is doing. Secondly, we are convinced that the process of organic change that has seen the Laboratory grow from small beginnings 50 years ago to its present size and reputation, shedding now and again branches of activity that have become so large and important as to justify and require independent resources and control, will and must continue.

HYDRAULICS RESEARCH STATION

On our visit to the Hydraulics Research Station we met Mr. W. P. Shepherd-Barron, who had recently succeeded Sir William Halcrow as Chairman of the Hydraulics Research Board, Mr. C. H. Dobbie, a member of the Board, and Sir Claude Inglis, the Director of Research. The visit was of special interest to us, since this is one of the research establishments created in accordance with the post-war plans that we submitted to your Lordships. We recorded in our Report for the year 1947–48 that an establishment on the scale of expenditure of £45,000 a year (1946 prices) had been recommended and approved. The growing recognition of the importance of the problems with which the Station is intended to deal, as witnessed, for example, by those arising from the disastrous North Sea floods of 1953, is beginning to call in question the sufficiency of work on this scale even after increasing it to allow for the lower purchasing power of the pound. Even so, no more than some three-quarters of the original plan, in terms of staff, has yet been fulfilled and much of that only within the last year. As in other cases, great difficulties have been experienced in finding and acquiring a suitable site and in getting the necessary building erected, and they have been increased by the need to build on a larger scale than had at first been foreseen, in order to take advantage of the recent experience of similar organizations abroad. The site eventually chosen was at Howbery Park on the Thames near Wallingford, and it appears to meet most of the exacting requirements, especially the need for an ample supply of water. A large house on the site has been refurbished to provide the necessary office and some laboratory, drawing-office and similar accommodation, and large-scale flumes, waveponds, etc., and a workshop have been completed. The main hall in which large-scale models of rivers, estuaries and so on can be constructed is in course of erection, and should provide a floor area for this purpose of the order of 60,000 square feet by early in 1955. By that time over £500,000 will have been expended on the purchase of the site and the provision of buildings.

The accommodation already provided has made it possible to make a good beginning with the substantial programme of research to be centred at the Station, which includes experimental studies with models of river estuaries and harbours, more theoretical studies of the movement of materials by the action of waves, coast erosion and the development of instruments. An example of the Station's work which was completed during the year was the study of the changes in the bed of Morecambe Bay. It was carried out at the request of the Railway Executive, who feared that the changes would make the approaches to Heysham Harbour unnavigable. The Station was able to show, from a study of surveys of the Bay over the past 100 years, that the changes occur cyclically, and that the present deterioration of the channel would not be permanent.

Work is in progress on behalf of the Lyttleton Harbour Board, New Zealand, on the problems caused by the penetration of waves from the open sea into the inlet on which the harbour is situated. This, and

associated problems such as siltation, are being studied by means of two models, one of the inlet and another, on a larger scale, of the harbour and its immediate approaches.

In contrast to these *ad hoc* problems, one of general interest, particularly to an island community like ours, is the Station's study of coast erosion. This is being tackled in two ways, by a study in the laboratory of wave action in models, and by the work of a survey team at selected beaches. Both methods of approach will involve long-term studies, and progress so far has been mainly towards developing research techniques.

One of the Station's most urgent tasks has been to develop instruments and apparatus for its own use. Among the first was a pneumatic tide generator for use in models. The generator will produce tides of any given profile, and several generators have been built for models in use. Instruments have been made for measuring water velocity, river flow and wave heights and for other needs of model work and surveys.

Our visit to the Station satisfied us that it is already making significant contributions to this important branch of civil engineering. Requests for investigations and advice from the United Kingdom and Commonwealth are greater than the Station can meet now or for some time to come. It is most regrettable that, in the circumstances, some enquirers should have to get their investigations carried out abroad, and we look forward confidently to the Station's contribution increasing in scope and importance in a way which will fully justify the decision to create it.

CHEMICAL RESEARCH LABORATORY

The most noteworthy feature of our visit to the Chemical Research Laboratory, apart from the opportunity it gave us to meet the Chairman, Professor E. L. Hirst, and members of the Chemistry Research Board, and Dr. D. D. Pratt, the Director, was our first inspection of the recently completed and occupied radio-chemical building. This fine and well-equipped laboratory has been erected, with the assistance of the Ministry of Supply, for work which the Laboratory is doing on methods of analysing and concentrating radioactive materials. It incorporates all the necessary plant and devices for ensuring that the staff are adequately protected by elaborate ventilation systems and other means against any harmful concentration of radiation, and that no harmful materials are discharged from the Laboratory into the atmosphere or the sewers. We were also glad to find that excellent new accommodation, though of a temporary type, had been provided for the Laboratory's microbiological work. This work, which is taking an increasingly important place in the programme, has been gravely congested for some years.

The Laboratory's work is of high quality, and we are in no doubt of its importance in the national interest. The work on such topics as the corrosion of metals and the recovery of valuable constituents from waste materials or low-grade sources is of obvious economic value. Of no less, though less obvious, value is the work on such other subjects as the study of techniques for the purification of industrially important materials and the determination of the physical and physico-chemical constants of substances of special interest in chemical engineering. We are entirely satisfied that the accommodation and the staff should be expanded further as provided for in D.S.I.R.'s approved post-war plans to enable the Laboratory to cope adequately with a full programme.

MECHANICAL ENGINEERING RESEARCH

The most important topic of our discussion with Sir Andrew McCance, Chairman of the Mechanical Engineering Research Board, and Dr. Sopwith, Director of Mechanical Engineering Research, was the slow progress with the building of the new Laboratory at East Kilbride—due not to any failure on the part of the Ministry of Works but to lack of means—and with the staffing of this new research organization. We share the Board's view that progress has been much slower than the objectives warranted, for less than one-third of the Laboratory has been built and less than one-half of the staff recruited, and this despite the fact that the Department has devoted 40 per cent. of its post-war building allocation and 20 per cent. of its post-war staff increase to the purpose. There has nevertheless been solid achievement, for over £500,000 has now been expended on the purchase of the site and on buildings, and a staff of over 250 has been built up on the foundation of less than one-fifth of that number transferred from the National Physical Laboratory as its nucleus. We understand that it is now expected (following the plans for the next five years to which we refer later) that by 1959 the essential building programme should be completed at a cost of about £2m., and that by that time also the staff should have reached the approximate total, somewhere between 500 and 700, which was in the minds of the Committee on whose recommendation the new organization was established. We plan to visit the new Laboratory in 1954.

Notwithstanding the slow progress with building to which we have referred, the programme of work is being tackled with the utmost vigour, and significant advances are being made in all parts of the Laboratory's field, as reference to the Summary of Work (pp. 74-83) will show.

JOINT FIRE RESEARCH ORGANIZATION

This Organization's Report for 1952 included a review of the programme of work in the light of the experience of the first five years of its existence, and we welcomed the opportunity to discuss with the Chairman of the Fire Research Board, Sir George Burt, and the Director of Research, Mr. S. H. Clarke, the trend of events and the lessons for the future. The Organization is unique among those directly administered by the Department in that its basis is co-operation between Government and the Fire Offices' Committee, with the net cost equally shared between them. Co-operation in this form was something of an experiment, and it was especially interesting to form an opinion of its working. We were gratified to find that the Board, on which the Fire Offices' Committee is fully represented, considered that the experiment had been "completely satisfactory" and our discussion served only to confirm that conclusion.

We have further evidence of this in the excellent results that the Fire Research Station is producing. A systematic analysis of reports of fires is being carried out, which serves not only to indicate which are the most important problems for research, but also to show what practical steps can best be taken, in the light of existing knowledge, to prevent the occurrence of fires and to combat them when they do occur. Fire prevention begins with the design and construction of buildings. The experimental work at the Station on the fire resistance of elements of building construction, which is carried out in collaboration with the Building Research Station, is providing basic information that is being assimilated into modern practice. Investigations on fire-fighting methods and materials are showing how they can be used with greater effectiveness and economy. In all this work the close collaboration that the Station has established with Local Authorities

is proving of great mutual value. We should like to express our appreciation of the public spirit that the Fire Offices' Committee has shown throughout this collaboration.

ROAD RESEARCH LABORATORY

The Select Committee on Estimates of the House of Commons for the year 1952-53 appointed a Sub-Committee to review Government Estimates in relation to expenditure on Roads. The Department was asked to present evidence, written and oral, and on 12th February, 1953, the Secretary of the Department, Sir Ben Lockspeiser, appeared before the Sub-Committee, accompanied, in the absence of the Director of Road Research, by Dr. A. R. Lee and Dr. R. J. Smeed, the Deputy Directors. The upshot of their oral evidence was a request from the Sub-Committee for a further memorandum indicating more fully how and to what extent, in the Department's opinion, the work of the Laboratory could most usefully be expanded. The measures proposed in the memorandum were for the most part those included for the Laboratory in D.S.I.R.'s post-war plans. Since the memorandum has been published as an Appendix to the Committee's Report*, together with the full oral evidence, we do not propose to enlarge upon it, but we would record the great satisfaction it has given to us that the Sub-Committee expressed the view that "the one way in which any significant reduction in roads expenditure could be made—and the one way in which, in the present economic difficulties, anything could be done substantially to improve the condition of the roads—is by the use of new methods and machinery, such as it is the purpose of the Road Research Laboratory to elaborate". For this reason the Sub-Committee recommended that immediate consideration be given to the expansion of the Laboratory's work as well as consultation between the Department and the Ministry of Transport on means for improving the dissemination of knowledge of the results. We shall respond to the best of our ability to the Sub-Committee's desire to see the Laboratory's work expanded, though we must, of course, keep fairly in mind the important claims of many other branches of D.S.I.R.'s work on the total resources available.

WATER POLLUTION RESEARCH LABORATORY

We wish to conclude our comments on D.S.I.R. Establishments with a special reference to the Water Pollution Research Laboratory. This organization was first established in 1927 and for many years, in fact up to the outbreak of war in 1939, it had no laboratories of its own but farmed out its work or, as in its noteworthy surveys of the River Tees and the River Mersey, maintained small teams of workers in temporary local accommodation to deal over periods of months or years with special local problems. In 1939 plans for a new Laboratory, alongside the Building Research Station at Garston, Herts, were approved, but they were abandoned on the outbreak of war, and instead temporary premises were found in a large house at Watford, supplemented by a small amount of hutting at the Building Research Station. This was tolerable as a makeshift under war conditions, but utterly unsuitable as a permanent arrangement, and we put a new Water Pollution Research Laboratory in the forefront of the post-war building programme. We are glad to know that, after many delays, this building is now well under way on a site at Stevenage, Herts, and that it is expected to be ready for occupation about the middle of 1954.

We, and we believe our predecessors, have always been deeply impressed with the value of the results produced by this Laboratory, and with the

* Fifth Report from the Select Committee on Estimates, Session 1952–53, Roads, (1953), H.M.S.O., price 7*s.*

importance of the work that it does and, given greater resources, undoubtedly could do. Year by year the growth of the population and of industry increases the difficulties of finding and purifying adequate supplies of water and of preventing their contamination by sewage and industrial effluents; while the increasing variety of the effluents which industry must be able to dispose of, increases the difficulties of local authorities in treating sewage.

An outstanding example of such a problem is the condition of the Thames estuary, which is causing anxiety. The Laboratory is at present devoting a great part of its resources to studying the condition of the estuary and its causes. The River Thames, whether as a source of water for domestic or industrial use, as a means for the disposal of sewage and industrial effluents, or as a channel for navigation to one of the biggest ports in the world, not to mention its value to London as an amenity, is the focus of interests of great magnitude. Measures for improving its condition cannot but be costly and have far-reaching effects. This makes the need for accurate scientific knowledge, as a basis of action, all the greater, and places a great responsibility on the Laboratory. There is no doubt that the Water Pollution Research Laboratory, in this and other ways, has a great and important task to fulfil.

RESEARCH ASSOCIATIONS

The general policy governing the grants to Research Associations is designed to ensure that an Association shall attain an effective scale of operation as rapidly as possible, and shall thereafter grow steadily until it reaches an adequate size. The grants are made for five-year periods, and take the form of a block grant, payable against a fixed minimum sum to be raised by the industry, and an additional grant up to a certain maximum paid *pro rata* on industrial subscriptions in excess of the minimum. The additional grant is generally paid at a higher rate than the block grant, and thus forms a powerful incentive to expansion. As an Association develops, the value of its services to its members increases, and we expect them, when they apply for renewal of grant for a further quinquennium, to be willing to shoulder a substantially increased share of the cost.

In 1939 there were 21 grant-aided Research Associations with a total annual income of £480,000, of which £178,000 was grant from the Department. In 1952 there were 41 Associations with a total income of £4M., of which £1·3M. was grant. There has thus been a gratifying increase in the number of Associations and in the scale of their operations, even after full allowance has been made for the fall in the value of money. There is, however, still need for a substantial expansion of many of the existing Associations and, *prima facie*, for the creation of a number of new ones. These must be expected to call for a considerable expansion of resources. We have been gratified by the willingness of members to increase their subscriptions to meet the Associations' growing needs, and with this and the additional provision for grant included in the five-year financial plan for D.S.I.R. which we have already mentioned (p. 11), and to which we refer again later (p. 26), we may look forward to the future with reasonable confidence.

During the year our Industrial Grants Committee have considered applications for the revision or renewal of grants from seven Research Associations, viz., the British Cast Iron Research Association, the British Ceramic Research Association, the British Coal Utilisation Research Association, the Coal Tar Research Association, the British Gelatine and Glue Research Association, the British Hydromechanics Research Association, and the British Scientific Instruments Research Association, and from two analogous bodies, viz., the Research Committee of the Furniture Development Council, and the

Research Council of the British Whiting Federation. They have also considered applications for further grant from Aslib (Association of Special Libraries and Information Bureaux), and the Commonwealth Mycological Institute (in respect of the maintenance and expansion of a collection of fungi of industrial importance). Details of the grants made will be found in the Summary of Work (p. 116).

We have also considered two applications for special grants towards heavy capital expenditure. The first of these was from the British Electrical and Allied Industries Research Association, whose plans for a new laboratory at Leatherhead were referred to in the Department's Report for 1951-52 (p. 119). The cost is estimated at about £400,000, and approval has been given, on our recommendation, for a grant not exceeding £100,000 provided £100,000 is contributed from the Association's reserves and £200,000 by special contributions from industry.

The second application was from the British Coke Research Association in respect of the cost of a full-scale test-oven plant. Reserves of high-grade coking coals in this country are decreasing rapidly, and if supplies of coke for industrial, especially metallurgical, purposes are to be ensured, means must be found for utilizing lower-grade coals. Small-scale experiments in the laboratories of private companies, the Research Association and the Fuel Research Station have shown that there is real promise of being able to produce satisfactory coke from suitable blends which include coals that are individually unsuitable, and the project is designed to enable these possibilities to be fully investigated to the production stage. The estimated cost of the plant is about £400,000, and approval has been given, on our recommendation, for a grant not exceeding £100,000, provided that special contributions of not less than £300,000 are made by industry.

SCIENTIFIC GRANTS

MAINTENANCE ALLOWANCES

The rates of maintenance allowances to students for training in research were last fixed in 1948. Changes in the value of money since then have brought the adequacy of the rates into question, and in March, 1953, we received a report on the subject from our Scientific Grants Committee. The Committee had sought the views of a representative selection of supervisors of research students in Universities throughout Great Britain, and had received 39 replies, which included 28 specimen budgets of students. The enquiry left no doubt of the need to increase the rates. After carefully considering the issues involved, we endorsed our Scientific Grants Committee's recommendations that, from 1st October, 1953, the allowances be increased by £25 per annum; and that no deduction should be made from the allowances in respect of demonstrating fees up to a limit of £50 per annum, but that a deduction should be made of one-half of any excess over £50. These recommendations have been approved, and the rates of allowance from 1st October, 1953, are as follows:—

	Students in lodgings or at a college or hostel	*Students living with parents*
	£ per annum	£ per annum
Oxford, Cambridge and London ...	325	245
Other Universities	285	245

As hitherto, approved fees are payable in addition, but full deductions are made in respect of other awards, any private income and earnings other than fees for demonstrating.

The number of applications for allowances received last spring was 1,017; the number of new awards made was 415; and the total number of allowances now current is 1,009.

GRANTS FOR SPECIAL INVESTIGATIONS

In our last two Reports we have referred to the scheme for the erection by Manchester University, at Jodrell Bank, of a radio-telescope, and to the arrangements which had been made to proceed with it, the major part of the costs being met by grants from the Department and from the Nuffield Foundation. In May we received a report from our Scientific Grants Committee on an application from the University for a supplementary grant for the capital and running costs. Our original recommendation in 1951 was based on an estimated cost of £287,000, spread over five years. In the meantime rises in costs, including salaries and wages, coupled with closer determination of the final cost as a result of detailed design work, receipt of tenders, etc., led to a revised estimate of about £440,000, with some small margin of uncertainty still remaining about the ultimate cost of part of the telescope, particularly the driving system. In the circumstances, and after receiving from the University an undertaking to make a rather larger contribution to the running costs, we have recommended that the Department's grant be increased to a sum of the order of £230,000. With £200,000 to be contributed by the Nuffield Foundation and the University's own contribution to running costs this will, we hope, enable the scheme to be completed.

During the year we received 51 new applications for assistance, and were able to recommend 26 new awards totalling some £48,000.

NUCLEAR PHYSICS

As stated in our Report for 1950–51, the Department is continuing to give substantial support towards the capital and maintenance costs of nuclear physics research in a number of Universities in the United Kingdom during the quinquennium 1952–57. During the year we have been called upon to make revised recommendations for capital grants to Liverpool University for a synchro-cyclotron, and to Glasgow University for a synchrotron, and we have completed our recommendations for the full quinquennium for Oxford University, a part of whose proposals had been deferred at the general review we made last year. Particulars of the grants current now are included in Appendix VI.

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

An outstanding development during the year, which closely affects our responsibilities and those of our Nuclear Physics Committee, has been the Government's decision to join the proposed inter-governmental European Organization for Nuclear Research for which an interim Council had been planning since February, 1952. The United Kingdom had been closely, though unofficially, associated with the Council's work from the outset, and the Department had contributed to the cost of the preparatory work and had played a major part in advising on the many novel scientific and administrative problems involved.

In July, 1953, the Convention setting up the permanent Organization was signed by the Secretary of the Department on behalf of the Government of the United Kingdom and by the representatives of nine other European States. Provided that the necessary seven States ratify the Convention, the Organization is expected to commence work early in 1954.

The Convention provides for collaboration in fundamental research in that part of the field of nuclear physics concerned with very high energy particles, and the laboratory to be built near Geneva will be equipped with the latest types of accelerators for producing them. The United Kingdom will participate in the various research projects, and will have access to the costly research facilities for an expenditure of only some quarter of the sum it would have to spend in constructing similar apparatus for its exclusive use.

The Department will be the medium for official relations with the Organization, and will be responsible for co-ordinating United Kingdom policy on the scientific and administrative matters involved. The United Kingdom's contribution to the budget of the Organization is to be borne on the Department's Vote, and is expected to average some £350,000 per annum during the seven years while the Laboratory is being built, and some £180,000 per annum thereafter.

INTELLIGENCE AND INFORMATION DIVISION

In previous Reports we have commented frequently on the importance, and the difficulties, of securing the speedy application of scientific knowledge, new and old, in industry. All the Department's Establishments and all the Research Associations are deeply concerned with this objective and the problems to which it gives rise. One of the most difficult of these problems at the present time is that of applying all the energy and resources one can for the purpose, without at the same time entrenching beyond all reasonable bounds on the resources available for scientific and technical research and investigation. One of the post-war developments undertaken by the Department, on our recommendation, was the establishment of an enlarged central Intelligence and Information Division in the Headquarters Office, not in any way to supersede the activities of the Establishments and Research Associations in this field, but rather to study and deal with the more general questions involved, and to act as a central Departmental focus for them. Many problems arising within the Executive Departments of Government are of such a nature as to be of only fractional interest to each of several D.S.I.R. Establishments or Research Associations. Furthermore, many of these problems must be tackled jointly by the scientist and the economist. The Intelligence Division has a primary duty of identifying such problems, and of co-operating with the Department's Establishments, the Research Associations and industry in their solution. In 1950, it was decided to enlarge the functions of the Division, with a view to still further promoting the application of the results of research to industrial productivity. Its duties were redefined, in general terms, as follows:—

(i) To maintain touch with current economic and sociological affairs and Government policy in these fields with a view to ensuring that D.S.I.R. is kept informed of needs; and that the attention of Government Departments, and especially the central economic staff, is called to the implications of scientific and technical advances.

(ii) To keep watch on scientific progress and to call attention to advances that may be capable of industrial application.

(iii) To undertake particular scientific and technical surveys and enquiries as required.

(iv) To maintain the Headquarters Records, Library and Information Services.

(v) To organize and maintain liaison with overseas countries, especially within the Commonwealth and in Western Europe, in accordance with arrangements approved from time to time.

More recently the Division has taken over responsibility also for the publications and publicity work of the Department.

During the year we have received an account of the work of the Division for the years 1951 and 1952. We do not propose to comment on it at length since we have discussed special aspects of the Division's work in recent Reports and a section on it is included in the Summary of Work published with this Report (p. 70). We do, however, wish to refer briefly to one or two special aspects of it, and to express our satisfaction with what is being done and our conviction of its continuing importance.

During the last few years many complex problems have arisen in relation to the conservation and substitution of raw materials which were scarce or whose acquisition from abroad involved currency difficulties. Through its Establishments and the Research Associations, and with the Intelligence Division as its co-ordinating centre, the Department has undertaken much research in this field. The Division has worked closely with the Ministry of Materials, and has provided representatives to serve on the Ministry's Development Committee and the associated specialist Working Parties, and on the Natural Resources (Technical) Committee of the Lord President's Office. Among the questions dealt with in this field are the following.

Many industrial problems arising from the scarcity of sulphur have been investigated, and economic uses for waste sulphuric acid have been found in a number of instances. Economic assessments have been made of the long-term trends in the demand and supply of selenium, germanium and vanadium, and the possibilities of increasing supplies by technological improvement have been examined. In the case of vanadium, proposals have been made for applying to production practice known technical processes for the recovery of the metal from indigenous iron ore and steel scrap. Following a large increase in the number of pyrites roasting plants in this country as a consequence of the recent sulphur shortage, an investigation was made of the technical and economic possibilities of recovering non-ferrous materials from the resulting cinders. It included a survey to determine where a recovery plant could best be located in relation to pyrites burning plants, on the one hand, and existing iron-works which make use of high-grade iron-ore residue on the other. A report on the subject is at present being considered by industry.

INDUSTRIAL PRODUCTIVITY

Much of the Department's work has a direct bearing on levels of industrial productivity, and in the last few years preliminary studies have been made by the Department and other organizations on topics in the fields of industrial engineering, human factors and operational research, as we have mentioned in previous Reports. Special funds have lately become available from Conditional Aid* to enable the Department substantially to increase its activities in relation to productivity. In particular, a considerable and coherent programme of work is being started on the advice of the two Joint Committees of D.S.I.R. and the Medical Research Council whose appointment we referred to last year.

The Committee on Human Relations in Industry, working mainly through Sub-committees on particular facets of this general problem, has recommended the allocation of money for research projects, mainly in Universities, on subjects which include management organization, incentives to both

* " 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.

management and operatives, problems of resistance to technological change, and promotion and training, including the recruitment and use of university graduates in industry. The Committee on Individual Efficiency in Industry has recommended the support of work on the influence of the design of equipment and of working conditions on the efficiency of the operator, on industrial engineering techniques and on problems of training.

The Department has also been asked to undertake, with Conditional Aid funds, the supervision of a research programme on production economics, and we have appointed a Committee to make recommendations for suitable projects. Many of these will be undertaken in or on behalf of the Department's own Establishments and Research Associations. A preliminary survey by the Department has shown a great interest throughout British industry in the possibilities of adopting improved industrial engineering techniques, and the Intelligence Division is co-operating with numerous industrial and research organizations for this purpose. With the assistance of Conditional Aid funds this activity is to be strengthened by the creation of a small industrial engineering unit at Headquarters, which will work mainly through the Research Associations.

THE EXPLOITATION OF SCIENCE BY INDUSTRY

At our last meeting of the year under review we received with much interest the "Report on the Exploitation of Science by Industry" which constituted the sixth Annual Report of the Advisory Council for Scientific Policy (1952–53). We especially welcomed the Council's commendatory remarks on the value of Research Associations, and we wholeheartedly echo their hope that the Associations' "activities in the field of industrial productivity will be rapidly extended as a means of helping the smaller firms in particular". We have given many instances in earlier Reports of this type of work; we regard it as a valuable extension of the Associations' main task of scientific and technological research, and it will be our aim to give Associations every encouragement along this path, and to advance the aim of the further recommendation of the Report:

> "that extension of the use of research and development contracts, largely through existing organizations, offers great possibilities in the modernization of civilian industry and its exploitation of scientific discoveries. We hope that the appropriate authorities will give further, and urgent, consideration to the machinery necessary for this extension." (Paragraphs 25–28.)

We heartily welcome this further proposal for the better solution of the problem of the utilization of scientific discovery and invention, and one of our main tasks in the coming year will be to consider how to give it practical effect in the Department's field. Prompted by it, however, we should like to refer briefly to the many other ways in which the Research Associations already endeavour to attain the objective in view.

It is estimated that the present activities of the Research Associations amount to about one-tenth of the total research and development activities of civil industry. Many of the Associations therefore, and especially those associated with the larger and more scientific industries, apply much less direct effort to research and development than do their individual members, collectively, in their own laboratories and factories. Since the member firms themselves control the activities of each of the Associations, and are entitled to, and do in fact, receive full and continuous information about the work of the Association and its results, there is little more that can be done to make the member firms aware of the scientific information which their

Association can supply, and of the service which it is able to give. What is in much greater doubt is whether, in fact, the use made of the knowledge supplied by and through an Association is as widespread as it should be, and whether there are not obstacles that could be removed. There are often powerful factors operating to delay the application of the results of research—shortage of staff and funds for development, unwillingness to disturb current production and marketing arrangements. The Research Associations have these and similar issues under continuous review, and are already tackling them in many ways, including the use of the development contract principle, i.e. by entering into arrangements with firms, whether in their own or other industries, to carry to a production stage the results of discoveries or inventions made in their laboratories.

One of the clearest and most effective ways of getting results used is by special liaison and advisory services which ensure that member firms not merely receive documentary information, but are visited by experienced officers of the Association whose duty it is to advise on the firm's technical problems, and in particular how best the Association's scientific knowledge can be applied to solving them. Most Associations maintain such a service in one form or another and undertake special investigations to deal with particular problems arising in individual firms. Some Associations also undertake operational surveys of industrial processes for member firms. For example, the British Cast Iron Research Association maintains a team for this purpose, which is much in demand. At the request of a member firm, the team visits a works and makes a confidential report to the firm on the technical aspects of its operations, and suggests where and how, by taking advantage of recent scientific and technical knowledge, modifications might be introduced in order to increase the efficiency of production. The team will often pay a "follow-up" visit a few months later, and if necessary its advice will be supplemented by that of specialist officers who can help the firm on particular matters in greater detail.

We would here digress for a moment to emphasize that the success of a Research Association must by no means be judged only, or indeed chiefly, by the number and importance of the new "discoveries" or "inventions" which it may produce. Every Association must devote a large part of its resources to studies of details of the processes and materials used in its industry. Work of this kind may seldom produce anything spectacular, but it does produce a steady flow of small improvements whose cumulative effect on efficiency is great. The special liaison and advisory services to which we have briefly referred are probably the best, if not the only effective, way of getting these improvements quickly into use and we believe that this is at least as important to industrial prosperity as is the introduction of new materials and processes. The advisory services do, of course, also contribute to the more rapid use of new discoveries and inventions, but for that purpose they should probably be supplemented by such methods as the use of research and development contracts.

As we have said, Research Associations have long recognized that research and development contracts are one of several means of hastening development, although their activities in this respect have no doubt been limited for financial reasons. The Department has brought the Report of the Advisory Council on Scientific Policy to the attention of all the Research Associations, and consultations are in progress with them on the means which might be best suited for securing the more rapid application of scientific advances in their industries.

Before leaving this subject, however, we would refer to the steps taken by some Associations specially to organize this type of work by establishing separate but related Companies to take over their inventions and discoveries for development on a business basis. Such Companies may be regarded as having a place, within particular industries, analogous to that which the National Research Development Corporation has in relation to inventions over the whole industrial field. Companies of this sort already in existence are Shirley Developments, Ltd. (Cotton), C.U.R.A. Patents, Ltd. (Coal Utilisation), E.R.A. Patents, Ltd. (Electrical). This system has the advantage of relieving a Director of Research and his staff of responsibilities outside their normal training and experience, and transferring them to a board of directors and management experienced in the financial and economic problems which development must involve. We believe that, at any rate for the larger Research Associations, the use of this type of body, adequately capitalized, may be found to be a most satisfactory method. It is interesting to record that some Research Associations have adopted the course of arranging for the National Research Development Corporation to act as their agent for the development of inventions.

What we have said above in relation to Research Associations applies largely to the Department's Establishments. They, however, are mostly concerned with the interests of the whole community, and so only partially serve particular industries and do not have the same close relations with industrial firms as a Research Association does. On the other hand, there are Departments of State that have special executive responsibilities in the fields of some of the Establishments, and it may be that, following earlier recommendations of the Advisory Council on Scientific Policy, some aspects at any rate of development work are more appropriate to them than to the D.S.I.R. Establishments. For example, it is already understood that the development of new road materials and methods of construction at the full-scale experiment stage should be undertaken co-operatively between the Ministry of Transport and the Road Research Laboratory. Similarly the Department co-operates with Local Authorities. For example, the Building Research Station has worked directly with the Authorities of the City of Norwich in building a group of houses with the aid of a tower crane, and the results of this full-scale building experiment have aroused widespread interest in the building industry because of the marked savings achieved in man-hours employed on a site. This Station is also co-operating with the Architect to the London County Council in a study of the design of flats to be erected in one of the Council's building schemes, the study being aimed at economy combined with the application of recent developments in building science. For the development of inventions made in its own Establishments, D.S.I.R. seeks the assistance of the National Research Development Corporation just as do many other bodies, including some Research Associations. Nevertheless, there may be potentially important scientific discoveries in the fields of the Department's Establishments for which direct action by development contracts would be appropriate and desirable, and enquiry is proceeding in parallel with the enquiries addressed to the Research Associations. An already existing example is the contract with a firm for the development of a commercial model of the National Physical Laboratory's automatic computing engine.

THE FUTURE

At the beginning of this Report we referred briefly to the general anxiety we have continued to feel throughout the year about the inadequacy of the resources available for the Department's work, and to the better outlook which is now before us. We do not wish to recapitulate the unhappy past—that is on record in our Reports—but rather we would express our satisfaction at the Government's willingness to provide for a small increase of staff during the current financial year specifically for the two new Establishments for Mechanical Engineering and Hydraulics Research, at East Kilbride and Wallingford respectively, and also to increase the provision for expenditure on new buildings. Far more satisfactory are the arrangements that have been made for the five years beginning 1st April, 1954. We understand that we may now advise on the future activities of the Department on a basis which is essentially that for which we asked in our Report for 1950-51. More specifically, we understand that we may assume that staff increases at the rate of 150 non-industrial staff per annum, with about one-third that number of industrial staff, will be approvable, with funds to match; that additional funds for other purposes will be made available which will bring the net annual resources of the Department at the end of that period to rather more than £6m., assuming, as is our present expectation, that the Department will have ceased, before that date, to bear its present heavy financial responsibilities in relation to nuclear physics research in universities; and that some £6m. of building will be carried out. A specially welcome feature of the arrangements is the provision that a shortfall of expenditure in any year may, subject of course to the necessary funds being voted by Parliament, be made good in subsequent years. This will give the flexibility on which we have laid so much stress. We fully appreciate that the plan cannot be absolute, since no Government can commit its successors, or the House of Commons, to future expenditure, and that it must also be subject to reservations related to the national economy as a whole. The broad effect of the arrangements will be to bring D.S.I.R.'s post-war plans nearly to completion by 1959. We are greatly relieved to see this clear road before us, and we are most grateful to your Lordships for having moved the Government to agree to the need for these resources for the development of D.S.I.R. over the next five years.

I. M. HEILBRON,
Chairman.

B. LOCKSPEISER,
Secretary.
23*rd November*, 1953.

RESEARCH ESTABLISHMENTS OF THE DEPARTMENT

This section contains summary reviews of the work carried out by the research organizations of the Department, and includes some relevant literature references. Further details will be found in their Annual Reports and other publications listed in Appendix VII.

A note describing the work of the Intelligence and Information Division of the Department's Headquarters is also included.

BUILDING RESEARCH

Some of the more important aspects of the work of the Building Research Station are described in succeeding paragraphs: the review is far from comprehensive since the aim has been to select items of particular interest rather than to give a balanced review of the work as a whole.

MATERIALS

Early in 1949 the Station was asked by the Government of Uganda to investigate the effect of phosphates on cement burning and to suggest limits of composition for the production of reliable cement. They were also asked to suggest means of separating the phosphate minerals from the rock. The reason for this enquiry was that suitable raw materials for cement manufacture are scarce in Uganda, those conventionally acceptable being located in places remote from areas of demand for cement. The Tororo deposits are the most favourably placed and are not far from the Owen Falls hydroelectric project which is at present the largest consumer of cement in the area. The limestone however contains variable quantities of phosphate, an impurity which was known markedly to affect the quality of cement although the reasons for its action were not known.

These investigations were brought to a successful conclusion along two lines. In the first place, a system of proportioning the raw materials (clay and limestone) was discovered which permits the manufacture of good quality cement from limestone with up to 2 per cent. phosphate content. In the second place, in order to use rock of even higher phosphate content, a method of separating the phosphate was developed.

On the 21st February, 1953, the Governor of Uganda formally opened the new cement works at Tororo, designed by consultants on the basis of these conclusions. The Director of the Uganda Geological Survey has stated that with the opening "a new chapter in the development of the Protectorate has begun. The manufactory marks the beginning of what promises to be a series of large-scale industries in Uganda which may change quite radically the economy of the Protectorate".

The work mentioned last year on the use of pulverized-fuel ash for brick-making has been pursued on an increased scale, as a co-operative investigation in collaboration with the British Electricity Authority. This waste material is now produced in such large quantities that only a major industry such as brickmaking can be expected to absorb a substantial proportion of it economically.

The ash is used mixed with clay. Concurrently with laboratory and pilot scale work, full scale trials have been carried out, and a number of brickworks are already absorbing appreciable quantities of ash. In general these full scale trials have been confined to mixtures containing less than 50 per cent. of ash and the bricks have been made by the extruded wire-cut process. The addition of ash tends to reduce the strength of the brick, but this factor is seldom of primary importance and may be offset by substantial advantages in lower fuel consumption, quicker drying and increased production. Discolouration due to kiln scumming is a problem to be overcome. It is hoped eventually to be able to increase the proportion of ash used.

Dry rot in buildings continues to be a serious cause of maintenance expenditure. In treating outbreaks, the primary aims are to secure dry conditions and to eradicate the fungus. Elaborate methods are necessary for eradication because the fungus can spread through cracks or over the surface of materials, whether these provide food for it or not. Since it is virtually impossible to reach deep seated infection in massive walls by treatment with a blow lamp or with a fungicide, there is an advantage in providing a fungicidal barrier designed to prevent the spread of any infection that remains. Such a barrier may also be expected to be helpful when it is not practicable to eliminate every source of dampness. As mentioned in the last report, work carried out in collaboration with the Forest Products Research Laboratory had shown that a zinc oxychloride paint or plaster effectively prevented the spread of dry rot in laboratory tests and in small scale trials under conditions that were highly favourable to its growth, and an account of the proposed procedure was published* to encourage trials on a practical scale. The suggestion has aroused considerable interest. Two full-scale trials are being kept under observation and reports from other places will become available in due course. Practical experience has shown that the zinc oxide used to make the paint must be free from lead (Type 1, British Standard 254 is suitable), and has emphasized the need for a fair degree of accuracy in proportioning the ingredients, which are best prepared off the site. A test needs to be made to check that the paint sets in a reasonable time under the conditions prevailing on the site. Zinc oxychloride paints and plasters are intended to be used instead of the fungicidal solution normally applied as a final operation after the other preliminary measures for dealing with dry rot have been taken.

DESIGN OF STRUCTURES

During the past few years, several aspects of the behaviour of prestressed concrete have been studied. The properties of hard-drawn steel wire, which is used extensively for prestressing, have been determined from samples supplied by different British manufacturers. Because of its importance in design, particular attention has been paid to the magnitude of the loss of prestress due to creep of the steel at normal temperatures. Tests of several years' duration have shown this to be about 10 per cent. of the initial prestress. Other losses of prestress are caused by creep and shrinkage of the concrete, and these are being studied for practical conditions by measurements in a recently-constructed multi-storey building. Strain gauges have been fixed to the concrete of two of the beams in this building and a record has been obtained of the deformations during the initial prestressing operations and during subsequent construction and the measurements are being continued now that the building is occupied.

* *The Builder*, 1952, **182** (5706) 975.

Work on prestressed concrete in the laboratory has been concerned with its behaviour under static and impact loading, which has shown that a basis of correlation exists between the behaviour under these two forms of loading. Useful information has also been obtained on the fire resistance of prestressed concrete floors for dwellings, office buildings, and warehouses in an investigation being carried out in collaboration with the Joint Fire Research Organization. Larger beams than can be tested in the equipment available in this country have been prepared for testing at the National Bureau of Standards in Washington, D.C., which has kindly made facilities available. The programme is now being extended to obtain sufficient information for the formulation of general recommendations for design.

Research into the stiffening effects of walls and floors on structural frameworks has continued during the year. A theoretical study has shown that important economic advantages can arise in design from a consideration of beams and floor slabs acting together as one structural system rather than as separate units; experimental work has started to obtain confirmation of the theory before attempting to develop new design rules.

SOIL MECHANICS

Following the widespread damage to the East Coast sea defence banks in the recent floods, the Station was asked by the Chief Engineer of the Ministry of Agriculture and Fisheries to investigate the soil mechanics aspects of the failures. This has necessitated a reorientation of the research programme to deal mainly with field investigations of earthwork problems.

Site investigations, with borings and soil tests, have been carried out at selected points where serious breaching has occurred in the earth banks in Kent and Essex. The information obtained will make it possible to assess the probable mechanism by which a bank failed and so help to decide on the suitability of various designs put forward for rebuilding the banks. In a number of areas the banks will need to be built up to a substantially higher crest level; the increased size of bank introduces other stability problems which call for investigation. The Station is also collaborating with the River Boards in field measurements which will give an insight into the behaviour of banks exposed to high tide levels.

Another group of earthwork problems is concerned with the stability of earth dams for water supply reservoirs. Equipment to measure the pore water pressure in the body of the dam has been installed in two large earth dams under construction. The measurements have given a useful insight into the change of strength in the bank as construction proceeds and have had immediate practical value in giving a guide to the safe rate of building. The technique has proved of such value that engineers concerned with the construction of other earth dam projects are making provision to install similar equipment.

EFFICIENCY OF BUILDINGS

Work on the heating, lighting and acoustics of buildings is concerned with various building types—houses, flats, schools, factories, etc.—but the particular problems met with in schools are selected for discussion in the present report. The experimental work and its practical application have been facilitated by the close co-operation existing between the Station and the Architects branch of the Ministry of Education. In the realm of heating and ventilating, the most important factor is the small proportion of the day during which buildings are occupied (rather less than 25 per cent.). Detailed trials, made possible by the ready collaboration of the Hertfordshire County Council, have been carried out in a primary school and indicate that economies

in fuel expenditure can be obtained by warm air heating. The trials, in which classrooms in the school are heated by warm air, by floor heating, or by normal radiators, are being continued to determine the best control arrangements for each of the three heating systems.

The work on lighting has been carried out largely in the laboratory by means of scale models, coupled with confirmatory measurements in actual schools. Considerable progress has been made in predicting the daylighting of classrooms, making allowance for the effect of the size and position of windows and of reflection from wall surfaces.

The mobile acoustics laboratory, although mainly employed on sound insulation problems in flats, has been used on a programme of measurements of noise levels in schools, as a result of which general recommendations are being worked out for the sound insulation requirements for classrooms, corridors, etc.

The work on sound transmission in flats, conducted partly by field measurements with the mobile laboratory, partly by measurements in blocks of experimental flats on the Station's site at Abbots Langley, and partly by a survey of occupants' experience, is yielding much information of value to the designer on acceptable standards of sound transmission and of means by which they can be obtained. Special attention has also been given, in collaboration with the Ministry of Housing and Local Government, to sound transmission in flats of non-traditional construction.

USER REQUIREMENTS IN OFFICE BUILDINGS

A thermal study has been made of two large office blocks and two single-storey temporary office buildings; one of the office blocks was heated by low temperature radiant ceiling panels and the remaining buildings by hot water convector type radiators. Room temperatures and related technical data were obtained, together with information on the experience and opinions of occupants of the buildings. Analysis of the subjective data indicates that a temperature of 68° F. with a range of $\pm$ 4° F. is the most agreeable and that staff find both methods of heating equally acceptable.

A comparative economic study of fluorescent and filament lighting in an office building has been made. The results indicate that for general office purposes intensities of about 15 lumens per sq. ft. for both forms of lighting, are needed to avoid complaints and that, at these intensities, staff attach much importance to avoidance of shadow. Results also show that rooms which in normal working hours have good daylighting, do not require artificial lighting for more than about 250 hours per year; for the types of fitting at present in use fluorescent lighting is then more expensive. Capital costs and cleaning costs are the main reasons for this and modification in design seems desirable. When the lighting fittings were left uncleaned for one year the light intensities were reduced by 25 per cent.

PLUMBING AND DRAINAGE

A survey is being carried out on behalf of a Joint Committee of the Institution of Sanitary Engineers, the Sanitary Inspectors' Association, the Institute of Plumbers and the Building Research Station. The object is to correlate design and performance of drainage systems in order to make recommendations for future economical and efficient practice. The results so far obtained show that drain gradients, considerably flatter than those normally accepted, have been successfully adopted by many local authorities, and that many authorities do not now install drainage interceptors in new work. By far the greatest number of blockages occur at interceptors; others occur in order of importance at manholes, junctions and bends. Amongst the articles causing blockage the most frequent are sanitary towels,

newspapers, rags and grease. Many authorities issue instructions on the correct use of sanitary appliances and it would therefore seem that, apart from design, carelessness rather than ignorance is the main cause of the trouble.

BUILDING OPERATIONS AND DEVELOPMENT

The study of productivity described last year has continued and the analysis of data obtained from a survey of house building work completed between March, 1949, and March, 1951, showed that there was a very wide range of labour expenditure for the same work on different contracts, the highest being almost three times the lowest. Labour expenditure was lower than average in contracts having incentive schemes and where the contractor directly supervised the work or had previous experience of house building. Sub-contractors on the average expended less manhours than the main contractors for a given amount of work, and there was also some reduction with increasing size of contract. The results of this survey have now been published.*

The investigation in progress at Norwich of the potential value of a rail-mounted tower crane as an aid to productivity in house building has continued.† Although increasing use is being made of mechanical plant in the Building Industry, it is often insufficiently realized that unless the operation is well planned the fullest possible advantage will not be gained because of losses while the plant is standing idle. The whole work involved in a production run of 32 houses, built with the assistance of a tower crane, was carried out to a pre-arranged programme which included not only the part of the work which was directly assisted by the crane, namely walls, floor and roof, but also the internal finishings in which the use of the crane does not play a direct part. Since, however, the crane enabled a high rate of production of house shells, this rate needed to be maintained in the finishing processes, otherwise the advantages would in part be lost. In the event, this proved possible, and because of the planning there was a saving in manhours in the finishing trades over and above that due directly to the use of the crane in the construction of the shells.

The overall results showed that a substantial improvement in output had been made on a site where the level of production had hitherto been about average for the country as a whole. A comparison of the results with those obtained in the survey of productivity in house building referred to above showed that the total labour expenditure had been reduced from an average figure of around 2,800 manhours per house to a little over 1,800. In fact out of the total of 151 contracts studied in the survey only four achieved lower manhours. The effect of such a reduction in manhours is to produce considerable cost savings, even when allowance is made for the added cost of the crane. It is estimated that on an average level site with careful planning and organization of the work, a saving of about £100 per house could be effected.

The trials at Norwich have led to the development of a number of special pieces of equipment for handling the wide variety of building materials required, and also to the design of special equipment, such as turntables to enable the crane to negotiate corners. This equipment was tried out during the tests and proved generally satisfactory.

Based on the experiments described above, a film "House-building with a Tower Crane" has been produced and is available for loan.

* *National Building Studies. Special Report No.* 21. "Productivity in House-Building." (Second Report.)

† See Report of D.S.I.R., 1951–52, p. 30.

SCOTTISH LABORATORY

Much of the Laboratory's work, both experimental and advisory, is connected with the production and use of building materials in Scotland. Although more clay and composition bricks are being produced locally than ever before, the supply is still well below the needs of the present building programme. Consequently, every effort is being made to develop alternative materials and methods of construction.

Scottish products now being used for construction include a wide variety of concrete bricks, blocks and slabs, sand-lime, shale-lime and slag-lime bricks, and precast units made from gypsum plaster. Attempts are being made to utilize, for brick and block-making, pulverized-fuel ash, large quantities of which are available from two electricity power stations. In the construction of houses and flats, increasing use is being made of no-fines concrete and pre-stressed concrete.

The Station's experience in materials, structures and their requirements is made available to the Scottish building industry through the Laboratory. Many of the new products have been examined and reports on their quality issued to the manufacturers. Similarly, proposals for many novel forms of construction have been reviewed to assess their functional efficiency. Manufacturers, architects and builders frequently consult the Laboratory about their problems. At the same time, every opportunity is taken to study the performance of buildings, new and old, in different localities throughout Scotland so as to correlate existing information with local craft practice and conditions.

The revision of the Model Building By-laws in Scotland has presented an invaluable opportunity for applying the results of the Station's work. The Station has been represented by two assessors on the Working Party set up by the Secretary of State for Scotland to report on the revision. The Station suggested that, in order to achieve flexibility and give the fullest opportunity for the application of the results of research, by-laws should be based on functional requirements. The Station accordingly submitted to the Working Party proposals for a complete revision along these lines. These proposals were adopted so far as the existing legislative framework would allow, and the draft revisions submitted to the Secretary of State represent a considerable advance in the technique of building control in Scotland. The new Model should give designers considerable encouragement in the early application of new methods and materials.*

COLONIAL LIAISON ON BUILDING RESEARCH

Owing to his close contacts with housing developments overseas, the Colonial Liaison Officer was, in November, 1952, given the additional duty of Housing Adviser to the Colonial Office. In November, 1952, he attended, as Leader of the United Kingdom delegation, an African Regional Housing Research Conference held in Pretoria, South Africa, under the auspices of the Commission for Technical Co-operation in Africa South of the Sahara. He also visited East Africa and Mauritius. Later, he attended a UNESCO Symposium on tropical building design in New Delhi, India, and spent six weeks in Malaya and Singapore.

Colonial Building Notes have continued to be issued by H.M.S.O. during the year and their distribution by the Station is being steadily widened. Recent issues have included information on the Fiji and Jamaica hurricanes; stabilized earth construction; literature on tropical school building; types of tropical climate and their effect on building design.

* The new model by-laws for Scotland were published by H.M.S.O. in January 1954 in separate sets for burghs and for counties.

Twenty-one Colonial architects, engineers and others attended a short course at the Station during September, 1952.

INFORMATION SERVICES

During the year some 70 reports, papers and articles have been published, either by H.M. Stationery Office or in the scientific and technical Press. A special effort has been made to bring up to date publication of *Building Science Abstracts,* and it is hoped to achieve this before the end of 1953.

Over 10,000 enquiries on building problems by letter and telephone have been dealt with during the year, as well as an approximately equal number of requests for sources of information or copies of publications. About 50 special investigations have been carried out for fees paid by the sponsors, either to assess the suitability of materials for building purposes or to identify the causes of defects in structures or components.

CHEMICAL RESEARCH LABORATORY

The new microbiological laboratory was occupied in November, 1952. This is a pre-fabricated building divided into 19 rooms suitable for the isolation of microbiological operations. Special finishes for the walls and floors have been provided to avoid contamination of cultures.

It has been decided to extend the programme of the Laboratory to include work on chemical engineering problems and a committee has been set up to advise on the work to be undertaken. This extension is being made on the recommendation of a Working Party appointed by the Department to consider what immediate action should be taken in advance of any subsequent implementation of the Report of the Committee on Chemical Engineering Research.(1)

CORROSION OF METALS GROUP

Interesting and important observations have been made in the course of examination of soils from two sites, at both of which iron articles were found almost uncorroded in clay which would normally be considered aggressive owing to the activity of sulphate-reducing bacteria. In the first soil iron articles, estimated to be about 2,000 years old, were found in an excellent state of preservation during excavations by the Inspectorate of Ancient Monuments, Ministry of Works, on a site which had been the centre of an ancient leather industry. The presence of tannates in the soil led to the suggestion that they might be toxic to sulphate-reducing bacteria and thereby prevent corrosion of the iron. Subsequent laboratory investigations revealed that the activity of the bacteria was suppressed by as little as 0·01 per cent. of tannic acid, a discovery which may have practical applications.(2). In the second soil, a thermolabile substance (not yet isolated or identified) was responsible for the inactivity of the sulphate-reducing bacteria. Further possible inhibitors of the bacteria revealed by laboratory investigation include cobalt, cadmium, mercury and silver salts; among organic compounds, dichloro-*m*-xylenol is as effective as tannic acid.

Elemental sulphur, often found in the products of bacterial underground corrosion, has now been shown to play, almost certainly, an important part in the corrosion mechanism. Laboratory investigations have revealed the hitherto unpublished fact that aqueous suspensions of sulphur exert a highly specific attack upon iron and steel, the rate of which is of a similar order to that produced by dilute acids. This finding may be applied to the production of etched patterns on steel, with certain advantages over the use

of acid etching, whilst the selectivity of the attack permits its use for appraising the continuity and thickness of non-ferrous metallic coatings on steel.(3)

In studying the mechanism of the action of corrosion inhibitors, using radioactive tracer methods, the amount of inhibitive substance in a film formed on mild steel by sodium benzoate has been found to be only about 1/50th that in one formed by potassium chromate.(4)(5) This may explain why, if insufficient inhibitor is present, the corrosion is distributed evenly in benzoate solutions, whereas in chromate solutions the film usually fails only at isolated weak points, allowing severe pitting to develop at these points.

Considerable wastage of material can occur when metal parts are stored or disused. Two methods of combating this have been examined in collaboration with other Government departments. Cyclohexylamine carbonate has shown great promise as a vapour phase inhibitor when the metal is in an enclosed space such as in a disused boiler or closed package. In other cases a protective film is desirable and a thixotropic inhibitive paste, based on bentonite-sodium nitrite-magnesium oxide has been developed and is giving good results. It has also been found that if a lanolin film is applied to mild steel at less than a certain critical thickness, the metal is not protected. The precise value of this thickness will depend on the environment; in sheltered outdoor conditions at Teddington it corresponds to a mean film weight per unit surface area of 0·006 oz./sq. ft.

Assistance continues to be given to industry and public authorities on many corrosion problems arising in immersed, underground and atmospheric conditions.

INORGANIC GROUP

The examination of waste products for possible sources of selenium has been continued and of those examined so far the most promising have been some occurring during the purification of sulphur dioxide manufactured by the flash-roasting of pyrites. These may provide a source of the element if they can be produced in sufficient quantity to justify extraction. The selenium contents of most of the commercial varieties of pyrites have been determined. Difficulties have been experienced in applying established methods of analysis to some of the samples of wastes received, partly because of their variety and partly because of the wide range of their selenium contents which has varied from 5 p.p.m. up to 2 per cent. Consequently a search for improved analytical procedures has been instituted and one method, based on the co-precipitation of selenium with added arsenic, has already been developed.

Following earlier work on the extraction of germanium and gallium from flue dusts, a much improved method of purifying germanium from arsenic has been devised. This has been adopted by certain sections of industry.

As a service to industry a Collection of Pure Metals is maintained by the Group under the guidance of the Pure Metals Committee. A stock of some 26 pure metals is available and in addition the Committee has accumulated information about other pure metals obtainable from commercial sources. Samples of the pure metals are made available for metallurgical research. On the recommendation of the Committee an investigation has been initiated into the preparation of pure rare-earth metals.

RADIOCHEMICAL GROUP

A number of industrial undertakings have shown considerable interest in the development of a method for the recovery of gold and other metals from cyanide solution. In earlier work it was shown that iron and copper as

complex cyanides are removed from a strong base ion exchanger by sodium cyanide solution, whereas the complex gold cyanide is not eluted, but can be removed by the use of organic solvents containing hydrochloric acid. These observations formed the basis of two of the separation steps of the gold recovery process. It has now been found that the amount of gold held by the resin is critical. If the loading of gold exceeds a certain figure (0.5 meq. Au/g resin) gold is eluted to some extent by sodium cyanide.(6)

Molybdenum, chromium, vanadium, arsenic and tungsten as acidic oxides are adsorbed by basic ion-exchange resins. One resin has proved particularly effective in separating some of these metals under controlled conditions of acidity. All the metals are adsorbed in the pH range 1·0 to 10 with a maximum capacity between pH 3·0 and 7·0. In solutions acidified with dilute sulphuric acid molybdate and chromate are adsorbed by the resin, whereas the other metals pass through the column. Separation of vanadate from arsenate and tungstate is possible under slightly different acid conditions. In hydrochloric acid medium separation of molybdate and chromate has been achieved.

In the course of the analytical work considerable experience has been gained in application of chromatography to geochemical prospecting. Geochemical methods of prospecting call for analysis of large numbers of soil samples for a variety of metals. High accuracy is not required but speed and ease of operation in the field are essential. The paper strip technique as applied to inorganic materials appears to provide an admirable tool for geochemical work. A few metals such as nickel, cobalt, copper and zinc have been examined and promising separation has been achieved by this method. Several soil samples have been examined and, in spite of difficulties associated with large quantities of iron and aluminium usually present, the results showed that the method can be successfully employed for this purpose. The separation of other metals is now being examined.

A scintillation counter for α-particles to determine continuously the uranium content of solutions has been constructed. A zinc sulphide scintillation screen is employed and this is either protected from the solution by a very thin plastic film or else the screen is brought close to the surface of the solution to be tested. The scintillations were measured by a photomultiplier valve. It has been found that satisfactory correlation is obtained between count rate and uranium concentration. An apparatus for testing the behaviour of ion-exchange resins under repeated treatment with a series of solutions has been completed and thoroughly tested with satisfactory results. Four operations (adsorption, wash, elution, wash) are controlled automatically, the number of cycles up to failure being recorded on a counter.

ORGANIC GROUP

When work on the purification and measurement of the physical properties of organic compounds was started in 1946, the pyridine base homologues were selected for study. These bases were not available in high states of purity and they were not being examined elsewhere although they seemed to be potentially useful raw materials. Methods of separating isomers from commercial mixtures were devised and eventually samples of pyridine, α-, β-, γ-picolines, 2:4-, 2:5-, and 2:6-lutidines were obtained in purities up to 99·9 moles per cent.

Later, the discovery that *iso*nicotinic hydrazide had chemotherapeutic application in tubercular infections was made. This aroused much interest in the methods of separation of bases since γ-picoline, hitherto of no practical interest, became an intermediate for the preparation of *iso*nicotinic

acid. Analytical methods, based on infra-red spectra, were developed for estimating individual bases in mixtures(7) and a method for estimating *iso*nicotinic acid itself in mixtures of isomeric acids was published.(8)

Meanwhile precise measurements of certain thermodynamic properties of the bases, in collaboration with the Physics Division of the National Physical Laboratory, has proceeded satisfactorily and the programme is being extended to include other physico-chemical measurements.(9). The miscibility of the pyridine homologues with water has been studied.(10) This work is of special interest in connexion with the theory of solutions and has served to correct erroneous statements which had appeared in standard text books regarding the solubility of pure -picoline in water.

A synthesis of [^{14}C] benzene from Ba $^{14}CO_3$ suitable for the routine production of the labelled compound has been devised(11) and the mechanism of the isomerization of ethyl*cyclo*pentane to methyl*cyclo*hexane has been studied: the latter reaction is of interest in petrochemical industry. The existence of an exchange reaction between carbonate and formate in aqueous solutions at temperatures of about 250°C. has been confirmed using ^{14}C-labelled compounds; no other exchange reaction of this type has hitherto been described.

The total naphthalene content of coal tar oil fractions has been determined by a method which uses the radioactive carbon isotope.(12) A small amount of naphthalene labelled with ^{14}C is added to the oil fraction under examination. A sample of pure naphthalene is then extracted from the oil, and by measurement of the radioactivity of this sample the total naphthalene in the oil can be calculated, and the amount compared with that found by standard methods of estimation. This procedure can be applied to the evaluation of the accuracy of standard methods and to the study of the efficiency of naphthalene recovery in industrial processes.

Ethylene carbonate possesses unusual solvent properties. It is a good solvent for polymeric materials and certain inorganic salts, and promises to have diverse industrial applications. Methods for its preparation have been evaluated and, by chlorination followed by removal of hydrogen chloride, an unsaturated and polymerizable vinylene carbonate has been produced. This is the first example of a cyclic carbonate of an enediol. Hydrolysis of polyvinylene carbonate furnishes an interesting new type of polymer containing the repeating unit-$[CH(OH)]_n$-.

A growing need by industry and universities for a source of pure compounds as standards for calibrating measuring instruments led the Laboratory in 1950 to include in the programme of the Group the preparation of substances having certificated purity likely to be required as standards. The number of compounds now available is 42 including aliphatic and aromatic hydrocarbons, coal tar bases and carbon monoxide. During 1952, 256 were despatched making a total of 630 since the service was started.

HIGH POLYMERS GROUP

The effort in this group is approximately equally divided between studies of the ion-exchange and allied properties of cross-linked polymers, and investigations of the properties and applications of semipermeable membranes derived from synthetic high polymers.

The use of resins showing highly specific behaviour is of potential industrial importance, particularly where separations involving chromatographic procedures are impracticable for economic reasons. Resins containing chelate groups incorporated in styrene-divinylbenzene copolymers have been prepared and shown to possess high selectivity towards, for example, copper and

nickel ions in solution. Another class of resins has been prepared in which the active ion-exchange groups are at the surface of the resin particles only. The surface groups introduced may be strongly acid, weakly acid, strongly basic or weakly basic. These materials are of value in chromatographic separations involving large organic ions, and samples of the resins are under test by a number of workers in the field.

The accurate determination of the number-average molecular weights of polymers by osmometry is of considerable academic and industrial importance. Hitherto a difficulty has lain in the choice of a suitable semipermeable membrane. The work on the use of poly-(vinyl alcohol) membranes in osmometry has been extended and techniques have been developed so that membranes of varied and reproducible permeability may be prepared. Thus, using membranes of an appropriate degree of permeability it has proved possible to determine molecular weights ranging from six hundred to one million. A particular advantage of the membranes which are used in the low molecular weight range is that their permeability towards solutes may be established with simple substances of known molecular weight. In addition, there is a satisfactory overlap with ebullioscopic and cryoscopic methods of determining molecular weights. A limitation on the wider application of these membranes is that they may not be used in contact with aqueous systems. Several laboratories are now using poly-(vinyl alcohol) membranes and more than 30 representatives of industry, research associations, and Commonwealth organizations have visited the Laboratory to study techniques of preparation and utilization of the membranes. In order to assist the progress of the work on semipermeable films and related topics, a constant temperature laboratory has been provided. This is equipped with osmometers of various types, a light-scattering photometer, interferometer, and allied apparatus.

MICROBIOLOGY GROUP

In the last report reference was made to the problem of finding a cheap and abundant source of oxidizable material suitable for bacterial sulphate reduction. Since then a survey of fermentable wastes has been made by the Intelligence Division of the Department in collaboration with the Laboratory, from which it appeared that the only promising and cheap waste material at present available in this country was sewage sludge. Laboratory work is now concentrated on this material, supplemented by sulphate, to determine conditions for production of hydrogen sulphide in maximum yield either alone or in conjunction with methane.

Investigations by the unit working at the Ministry of Supply's Microbiological Research Department at Porton on the continuous method for the bacterial production of sulphide from sulphate have shown that a marked increase is obtained in the rate of sulphate reduction over that in a static process.

A discovery of considerable scientific interest is that the cells of sulphate-reducing bacteria contain cytochromes. Cytochromes are compounds consisting of protein and iron-porphyrin groups which are concerned in the respiration of all aerobic organisms. They perform a function inside the cell roughly paralleled by that of haemoglobin in the blood. Hitherto, they have only been observed in organisms capable of growing and respiring in air; they have not been observed in anaerobes; and in fact, the absence of cytochromes in anaerobes has been regarded as one of the major differences between anaerobic and aerobic organisms.

The sulphate-reducing bacteria are very exacting anaerobes. Nevertheless, the cells of sulphate-reducing bacteria contain cytochromes in amounts comparable with those in yeast. Two cytochromes have been found: one corresponds most closely to the cytochrome *c* of normal muscle, the other to the rarer cytochrome a_2, of certain bacteria. The function of the cytochromes in sulphate-reducing bacteria is not yet understood.

The National Collection of Industrial Bacteria forms part of this Group and is responsible for the maintenance of non-pathogenic industrial bacteria of which 650 strains are at present held. Several antibiotic-producing cultures, including those deposited by the World Health Organisation, are also now available. The value of this service is apparent from the fact that 708 cultures were despatched during 1952 and since its inception in January, 1950, more than 2,200 have been sent to organizations in all parts of the world.

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FIRE RESEARCH

The major part of the current work of the Joint Fire Research Organization is planned to meet the needs of the various Government departments having responsibilities in connection with fire protection, and to assist the Fire Offices' Committee and local authorities in framing their requirements.

FIRE STATISTICS

Reports on all fires attended by the Fire Brigades are collected through the close collaboration of the Home Office, the Scottish Home Department and the Fire Brigades of the local authorities; it is thus possible at the same time to obtain information for the guidance of administration, and to ensure a close relation between the research worker and the administrator.

Annual tables of fire statistics for 1952 are being prepared from a one-in-four sample of the reports received on all fires attended by Fire Brigades in the United Kingdom. Approximately 82,400 fires were attended in England and Wales and approximately 8,200 in Scotland, in each case a considerable increase on the figure for 1951. Special analyses made during the year, generally for Government departments, have included fires involving flammable liquids and other dangerous substances, liquid fuel gas, cinematograph film, and fires occurring in the process of drying grass, in schools, and in post-war houses.

The analysis of fires involving flammable liquids and other dangerous substances was concerned primarily with the materials listed in the Petroleum (Inflammable Liquids and other Dangerous Substances) Order, 1947, but was extended to cover incidents involving several substances not included in the Order but which give rise to hazards similar to those of the listed materials. The special importance of fires of this type lies in the frequency with which casualties occur. It appears that the majority of incidents were caused through carelessness or ignorance of the hazard.

There was a marked increase during the years 1942-51 in fires involving "bottled gas", such as that used in caravans. From estimates of the total sales of liquid fuel gas it has been found that the incidence of these fires has been proportional to the amount of fuel sold and the rate of incidence has remained constant at approximately two fires for each 1,000 tons of gas sold. It can be concluded that the increase in the numbers of fires is due mainly to the increase in use of the gas and not to any increase in the inherent risk. The need for careful handling and maintenance of the equipment is apparent.

The number of fires resulting from the ignition of cinematograph films decreased considerably during 1950-52. This appears to be largely due to the change-over from cellulose nitrate film to "safety film" in commercial cinemas, which began in 1951, but it may be partly due to improved fire precautions. The Fire Research Organization has assisted a Committee of the British Standards Institution in the development of a standard test to assess the hazard of different types of cinematograph film.

During each of the years 1949-51 the rate of incidence of fires connected with the process of grass drying was approximately 8·5 per year per 100 grass driers at risk. About 40 per cent. of the outbreaks were attributed to overheating of the apparatus which appears to have been due to a variety of causes. It is suggested that designers of the machines should give particular attention to the elimination of features liable to cause obstruction to the movement of material passing through, but it is important that the users

of the equipment should themselves take all possible precautions against fire and should have available an adequate supply of extinguishers for dealing promptly with small outbreaks.

In 1951 the annual tables of fire statistics were prepared from a one-in-two sample, and to make the analysis of fires in schools, all reports of fires in schools in England and Wales were extracted from the sample. The total rate of incidence in all types of schools was 148 per 10,000 schools at risk, 524 fires in all. About 24 per cent. of the fires were associated with open grates, furnaces and slow combustion stoves; 16 per cent. were associated with the use of electricity, and 10 per cent. with the use of gas.

It may not be widely realized that the collection of fire statistics on a national basis is a recent development; during the past year it has been possible for the first time to examine statistics covering a period of five years, and thus to examine trends in certain types of hazard. Particular attention has been given to a study of the hazard of post-war houses, of which some 50-60 new types have been built. There is evidence that some of the types have been rather more prone than others to outbreaks of fire and these have been, or are being, studied closely in collaboration with the responsible authorities. Steps have already been taken to remove or mitigate the worst hazards. In two types of temporary pre-fabricated bungalow an unusually high proportion of fires was associated with electric fuse boxes, distribution panels, and wiring. A large number of outbreaks in post-war houses were associated with the domestic fire arising from the "ignition of furniture, linen, etc., by sparks, embers, or radiation". It is estimated that approximately half the fires in post-war dwellings have been caused by carelessness or "bad housekeeping".

FIRE RESEARCH AND CIVIL DEFENCE

Investigations of the intensity of radiation necessary to ignite various materials have been used to assist the Home Office in estimating the range at which fires might be started by an atomic explosion. The distances from the point of explosion at which ignition could occur would depend on the materials involved, and the weather prevailing at the time, but under conditions favourable to ignition dark coloured cotton materials might be ignited at distances up to two miles. An account of the investigations is being published as a Bulletin.

SMOULDERING

Considerable progress has been made in the study of smouldering in industrial dusts and other materials such as jute sacking and fibre insulating boards. Probably the most interesting and practical outcome of this work has been that it is now possible to show how, under conditions which are commonly met with in practice, slow but persistent smouldering may be initiated by a small source of ignition and that this may develop into flaming combustion after a considerable delay period.

USE OF MODELS IN STUDYING THE GROWTH OF FIRES: SURFACE SPREAD OF FLAME TEST

The model technique described in last year's report has been used to study the growth of fire in single rooms lined with building boards protected by flame retardant treatments, with a view to linking the hazard of building materials in the Surface Spread of Flame Test with that in an actual fire. It has been shown that although a combustible wall board that has been given a flame retardant treatment is more difficult to ignite by a small source than an untreated board, once any of the contents of a room are on fire

the treatment has little effect in checking the progress of the fire. The development of fire can be substantially delayed only by covering a combustible building board with a thickness of incombustible material sufficient to prevent the transfer of heat from the fire to the combustible board.

One interesting outcome of the experiments has been the light thrown on the importance of ventilation in the development and control of fires, a point that is mentioned again below in connection with the extinction of fires. The experiments emphasize the importance of closing the door and windows in empty rooms; there is no doubt that many fires would be restricted, and might even fail to develop through lack of air, if this simple precaution were generally observed.

The 1 ft. square radiant panel mentioned in the last report continues to be one of the most useful and versatile pieces of equipment in the laboratory. Considerable interest has been shown in the apparatus, especially in connection with the Small-scale Spread of Flame Test. Particulars have been sent to Canada, Finland, France, Holland, India, New Zealand, and South Africa, and models are being acquired by several of these countries.

PRESTRESSED CONCRETE

The Advisory Council on Building Research and Development of the Ministry of Works has stressed the importance of obtaining information on the behaviour of prestressed concrete in fires, and all possible priority has been given to this subject in the Fire Research Programme. The study of the fire-resistance of scale models of prestressed concrete beams of the post-tensioned type, which has been carried out in co-operation with the Building Research Station, has been completed during the year; it has given valuable indications of the probable behaviour of the full-sized beams. It seems likely that a fire-resistance of 2 hours can be obtained with a $2\frac{1}{4}$-in. concrete cover to the cable, but for a fire resistance of 4 hours or more, an additional insulating encasement will be required. With properly designed beams sudden failure should not occur and a fireman should have sufficient warning of impending collapse. It would, however, be unwise to forecast exactly the performance of the full-sized beams before further tests have been made on beams of a size between half-scale and full-scale. The Building Research Division of the United States National Bureau of Standards has agreed to co-operate in this further work, and to carry out tests on 4/5th scale beams of the type used in tests at the Fire Research Station. This valuable and friendly co-operation, which will enable extrapolation of the results to be made with confidence, is greatly appreciated.

An interesting result of the experiments at the Fire Research Station is the demonstration of the fact that beams exposed to fire for a shorter time than that which produces failure, are likely to retain a high percentage of their original strength on cooling, although there may be a marked residual deflection and some loss of prestress in the wires. There is thus a need for an investigation of the feasibility of repairing prestressed concrete constructions that have been damaged but not destroyed by fire.

NO-FINES CONCRETE

The programme of tests to determine the fire-resistance of walls constructed of no-fines concrete has been completed, and has shown that this type of construction compares favourably in fire-resistance with concrete or brick walls of similar thickness. While a 6-in. thick no-fines concrete wall of monolithic construction using a quartzoid aggregate resisted the passage of fire for over 4 hours, a wall of no-fines concrete blocks from a basalt aggregate gave an even better performance and failed only by

temperature rise after 5 hours. A no-fines concrete-block wall from the quartzoid aggregate, by comparison, failed after 3½ hours owing to cracking of the blocks and the fall of some of the rendering from both faces. This work was carried out in the first place to obtain information at the request of the Commonwealth Experimental Building Station, Australia.

FOAM, VAPORIZING LIQUIDS

Studies on the extinction of petrol and other special types of fires, as described in last year's report, have included experimental work with foam, vaporizing liquids, and with wetting agents, but the work has not reached the stage at which a report can be made.

USE OF WATER IN FIRE EXTINCTION

There have been widely conflicting reports on the advantages to be gained from the use of high pressure sprays (sometimes called "fog") in fire-fighting. Some of the differences in opinion have undoubtedly been due to the variability of conditions under which observations have been made. Controlled experiments with fires in model buildings have yielded interesting results: they show clearly that the effectiveness of sprays in extinction depends on the stage of development of the fire and on the amount of ventilation. Sprays are most effective in dealing with fires in enclosed spaces, and the amount of water required for extinction varies according to the volume of the room multiplied by the ventilating area.

FOOD INVESTIGATION

The main objectives of the Food Investigation Organization are: (1) to add to basic knowledge of the properties and behaviour of food-stuffs; this requires continuing fundamental research. (2) To carry out experiments and surveys for the purpose of providing, improving, and testing technical solutions to specific practical problems in food preservation; in this, close contact is maintained with industry.

COMMODITIES AND PROCESSES

Meat

Factors which influence quality in fresh, frozen, and smoked meats are being studied. In fresh meat, the composition of both the fat and the lean affects quality. The firmness of the fat of beef cattle improves with increase in the amount of fat in either fatty or muscular tissue. The water content of lean meat varies slightly from joint to joint and from animal to animal, and is inversely related to the proportion of connective tissue. Toughness in meat is due mainly to a high proportion of connective tissue, which holds more water than muscle fibre tissue.

Quality in frozen beef is being investigated in co-operation with the Commonwealth Scientific and Industrial Research Organization in Australia. A survey of Australian beef carcases arriving in this country showed that, after thawing, meat of good quality "drips" less than meat of poor quality; as the quality of a muscle improves during the fattening of an animal, the frozen muscle tends to "drip" less when it is thawed. Variations in the amount of "drip" cannot, however, be accounted for entirely by variations in quality of the carcase. After the death of an animal, the muscular tissues undergo rapid changes, and the extent of these changes profoundly affects the behaviour of tissues when they are frozen and thawed or cooked.

Changes which occur before *rigor mortis* sets in may also affect the amount of "drip" formed when a frozen tissue is thawed. Work on the freezing of beef carcases at different stages of *rigor mortis* is now being carried out at the Queensland Meat Board's abattoir in Brisbane by scientists belonging to the Division of Food Preservation and Transport of the C.S.I.R.O., Australia, and the Department's Food Investigation Organization. At the same time, laboratory work on the physiology and biochemistry of *rigor mortis* in muscular tissue continues at the Low Temperature Research Station, Cambridge. It has been found that adenosinetriphosphate and a protein, which is stable at 0°C. (32°F.) for at least 10 days, play a major part in changes *post mortem*(1), (2).

In pork and bacon, quality may be affected by the diet of the pig and by the composition of the carcase, as well as by the breed of pig. The selection of breeding stock which will give high quality pork and bacon may be facilitated by X-ray examination of the live animal. With young pigs, the number of vertebrae and ribs can be seen, and with older pigs, the thickness of subcutaneous fatty tissue can be measured.

In the smoking of bacon, the performance of the traditional smoke-house depends upon the acquired skill of the operator. By using special equipment for controlling air-flow, temperature, humidity, and concentration of smoke, the smoking process can be carried out more efficiently and quickly, and the quality of the smoked product can be improved. In co-operation with industry, the methods of smoking at present employed are being examined, in order to determine the optimum conditions for a satisfactory smoke cure.

Reports on dehydrated meat(3), and on the production and preservation and the bacteriology and hygiene of whale meat(4), (5) have now been published.

Eggs

The results of laboratory work are applied in industry in co-operation with the Ministry of Agriculture and Fisheries, representing the producers, and the Ministry of Food, representing distributors and users. Standards of quality for eggs and methods of controlling quality, and standards for packaging materials, are being sought. Wastage surveys have confirmed that the washing of eggs on the farm has an adverse effect on the subsequent storage life of the egg. The method developed for dipping eggs in oil before storage, to prevent evaporation of water, has now become an established trade practice. The extent of wastage due to cracks in both home-produced and imported shell eggs is now being investigated.

During storage, certain physico-chemical changes take place in eggs. Experiments have shown that the amount of phosphate, amino nitrogen, and carboxyl groups in the white is directly related to the age of the eggs. This relation is consistent, on the basis of diffusion from yolk to white, with the large excess of these constituents in the yolk. The thick white of the egg becomes gradually thinner or more liquid during storage; the enzyme lysozyme may be concerned in this process. It has been demonstrated that thinning of the white is caused by a dissolution of the substance of the gel and a weakening of its structural components.

Poultry

There is an increasing interest in the production and storage of table poultry. A programme of work on the subject has been initiated in co-operation with the trade and executive Ministries.

Fish

If the "distant" water fishery is to be fully utilized, a method must be developed for freezing fish at sea. At the Torry Research Station, a pilot-scale, vertical plate freezer has been designed, which might be suitable for installation on existing vessels. Since the rate of catching is variable, and the space available for freezing aboard ship is severely limited, fish may have to be held in ice for a time before they can be frozen. Experiments have shown that the quality of the fish need not be affected by holding in ice for at least three days, while regulating supplies to the freezing unit. Fish which are to be frozen should be gutted and washed, according to the normal trawler procedure; if the fish is frozen ungutted, the product is inferior. Storage in ice before freezing accentuates the advantages of storing the frozen fish at very low temperatures, e.g. – 30°C. (– 22°F.), and, conversely, the use of a lower storage temperature permits greater latitude in the pre-freezing conditions.

At different rates of freezing, the effect of ice formation on cell structure in fish appears to be a complicated one. In order to investigate this a new air-blast freezer has been built, in which many of the factors which affect the rate of freezing can be controlled([6]). Research on the effect of these variable factors is expected to lead to reliable data for design purposes.

Efforts have been made to improve the quality of white fish reaching the consumer. As a method of assessing quality a numerical scoring system for the sensory assessment of the spoilage of wet white fish stored in ice has been developed([7]). Since it would be useful if results obtained by this sensory evaluation of appearance, odour, flavour, and texture could be correlated with results of chemical determination of the changes which occur during the development of spoilage, experiments are being made under strictly controlled conditions, to determine whether such correlation exists.

Experience gained in work on the preservation of fish in ice, including observations made at sea during "distant" water commercial fishing voyages, has been incorporated in a revised edition of a Food Investigation Leaflet([8]).

To meet the needs of the Humber area, which is an economic centre of the "distant" water fisheries and the white fish industry as a whole, a new laboratory, an out-station of the Torry Research Station, has been built at Hull; it was opened in December, 1952.

Fruits and Vegetables

At the Ditton Laboratory in Kent, the optimum conditions for the storage of apples, pears, plums, and other fruits and for the storage of vegetables are investigated.

To meet the demand for dessert apples during the winter and spring, late varieties of apple, which will yield heavy and reliable crops, with good keeping quality, are required. The storage qualities of 20 varieties of late dessert apple have been described in a Food Investigation Technical Paper([9]). Further trials have indicated that there is another variety, Merton Prolific, with excellent keeping quality while a number of other varieties of dessert apple which can be grown in England can be kept until the late spring without serious losses.

The quality of perishable foods such as fruits and vegetables can best be maintained at suitable low temperatures. Unfortunately cold storage facilities are not always available. A mobile refrigerated store([10]), with a capacity of about 600 cubic feet, has now been designed and built. It is being used for precooling, e.g. strawberries, raspberries or plums, immediately after harvest, in order to improve the keeping quality of the products during and

after transport, and for storing Cornish broccoli and spring cabbage. This mobile cold store can be towed to any part of the country, and has recently been used in various producing areas in England and Scotland.

Since vegetables lose moisture very quickly, and soon become wilted and unattractive, it is important that vegetable stores should be properly constructed. Suitable conditions for the commercial storage of vegetables such as broccoli, cauliflowers, and carrots are described in a Food Investigation Leaflet([11]).

The quality of many vegetables deteriorates fairly rapidly during storage and transport by methods normally used in the trade. Surveys are being carried out([12]) to determine the nature and extent of the wastage which occurs during marketing, and to develop methods of reducing and delaying deterioration. The effects of mechanical washing on subsequent wastage are being investigated([13]).

In this country potatoes are normally stored in clamps, but in Europe and in North America permanent buildings of various designs are widely used. Owing to differences in climatic conditions, the types of store developed elsewhere are not suitable for conditions in Great Britain, where, during most of the storage season, the mean daily temperature is above the optimum (40° to 42°F.) for potato storage. Results of work on the indoor storage of potatoes in wooden bins in an uninsulated shed([14]) and in bulk in farm buildings([15]) have been published.

Large losses due to sprouting in the spring occur in stored potatoes. Various methods have been suggested for preventing or reducing these losses, but before any method could be adopted on a large scale, the individual grower would have to be convinced that it would be immediately profitable to him to use it. It has been calculated that, at present prices, an expenditure of £1 per ton of ware stored until June would be justified only if it entirely prevented the sprouting of potatoes. The cost of a method of sprou- prevention would need to be much lower than that to induce a grower to adopt it. The application of certain sprout-suppressing chemical dusts will give reasonable control of sprouting at a cost of some 5s. to 6s. per ton; but these dusts must be applied to potatoes in the autumn, i.e. before it is known how long it will be profitable to store the crop. Two main methods for suppressing sprouting are being tested: the introduction, as and when required, of growth-inhibiting chemical vapours, such as amyl alcohol, into the storage atmosphere, and cool storage. Although both these methods, when tested on a large scale, were successful in suppressing sprouting, they are both still too costly. Possible means of reducing costs are being investigated.

DEHYDRATION

Practical tests, on a laboratory scale, of methods and equipment for dehydrating particular products are in progress, and studies of the chemical reactions which take place in vegetable and animal tissues during dehydration are being analysed.

Fish

A small drying tunnel has been constructed for work on the air-drying of fish. In this tunnel, conditions can be automatically controlled, and variable factors can be recorded photographically. The times required for drying have been found to be virtually independent of relative humidity in the range of 25 to 70 per cent. but they increase at higher humidities.

Fruit

As a means of utilizing surplus plums, there has been considerable interest in the possibilities of successfully drying the fruits. Methods of dehydration are described in a Food Investigation Special Report([16]). It has been found that initial drying is better at 40°C. (104°F.) than at about 70°C. (158°F.). This is because drying at a lower temperature causes a greater loss of natural colour and of acid, and hence a sweeter and darker prune.

Vegetables

A serious defect of dried vegetables is their tendency to turn brown during storage under warm conditions. The constituents of the vegetable tissue which take part in this reaction (non-enzymic browning) are being sought. The browning appears to be caused by water-soluble constituents, and is probably a reaction between a neutral fraction containing sugars and a fraction containing amino acids.

Meat

Unexpectedly, a similar reaction was found to occur in dehydrated meat. Hitherto there has been no reason to suppose that reducing sugars were present in carcase meat. Free glucose has now been shown to be present.

BASIC RESEARCH

Most of the work so far described has been concerned with practical problems of food technology; but before a solution can be found to many of these problems, much basic research may have to be carried out. The following are a few examples of work in progress.

Reference has already been made to studies of *rigor mortis* in muscular tissue, and their bearing on quality in meat. Also, since the connective tissue in meat affects its texture, the properties of the proteins of connective tissue are being examined chemically and physically, and the structure of the fibrous protein, as it exists in tissues, is being elucidated. To understand the chemical and physical changes which take place in fish during processing, the lipids ([17]), ([18]), ([19]), ([20]), proteins([21]), ([22]), and soluble extractives of fish flesh need to be isolated and identified and their properties studied. Similarly, the various polyphenols in wood smoke must be isolated and identified before the bacteriostatic and anti-oxidant properties of the smoke can be investigated; the chemistry of wood smoke is being studied.

Changes which take place in stored fruits and vegetables present different problems, since these are changes in living tissues. Studies of the respiration of Cox's Orange Pippin apples over a six-year period have shown that there are seasonal fluctuations in respiratory activity, which may prove to have a bearing on seasonal fluctuations in keeping quality([23]). During storage, certain volatile substances are evolved by fruits, and the nature and amount of these volatile substances in the atmosphere may affect the storage life of the fruits and development of the physiological disorders to which they are subject. The volatile substances produced by apples during storage are being identified and estimated. The acids present in fruits are concerned in the metabolic changes which occur during growth and storage, as well as contributing to the flavour. Various organic acids (such as quinic acid and chlorogenic acid) and amino acids present in the flesh and peel of apples are being isolated and identified([24]), ([25]), ([26]), ([27]), ([28]), ([29]).

Studies are being made of the chemical substances which are responsible for the browning, caused by the action of certain enzymes (enzymic browning), which occurs when some living plant tissues are injured. In apples, leuco-anthocyanins and catechins are the principal polyphenols concerned in

the formation of the brown pigments, and in pears, glucosides of coumarins and flavonols([30]). Chlorogenic acid occurs in both apples and pears. The action of the enzyme polyphenolase upon these constituents is being investigated. The leuco-anthocyanins have been identified as constituents of the "tannin" fraction of foods([31]). These substances contribute to the astringent taste of the fruits and vegetables in which they occur; their chemistry, and their systematic distribution in plants, are being studied.

For some years, the mechanism by which ascorbic acid (vitamin C) is produced and destroyed has been investigated. For the first time, it is now possible to specify the probable chain of reactions which occurs during the synthesis of ascorbic acid in plants, and also in animals([32]).

A survey is being made of the ascorbic acid content of the chief herbage plants, with the object of finding a material from which naturally occurring ascorbic acid could be recovered cheaply and efficiently.

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FOREST PRODUCTS RESEARCH

Under present-day conditions the basic aim of timber research in this country—the more efficient utilization of wood—still poses the difficult problem of apportioning the time and resources of the Forest Products Research Laboratory between the getting of new knowledge and its dissemination to industry as soon as possible. During the year the advisory work in all the branches of timber technology has again restricted the longer-term projects. Nevertheless, there has been a gratifying increase in research work both of the more fundamental nature and also in the wider type of technical investigation.

Many new timbers, mostly of tropical origin, are still appearing on the market, and the major routine project of the Laboratory remains the testing and assessment of the new species. At the same time, the collaborative scheme with H.M. Forestry Commission recently started to gain information on home-grown timber now maturing in the Commission's forests is now well under way and the first logs from several sites have been converted and reported upon.

On the advisory side, in addition to the large volume of written replies and reports, close contact has been maintained with timber users in industry, public bodies and Government departments both through the country-wide visits of the staff to factories and installations and the large number of technical visitors to the Laboratory.

The following notes on the various Sections refer to some interesting aspects of their work during the year:

WOOD STRUCTURE

On account of the restrictions on the imports of softwoods and some hardwoods, interest in the Colonial timbers is still keen, and their consumption in the United Kingdom as compared with pre-war has been greater than in any other Western European country. This has been reflected in the increasing demand for data and for identifications. To assist importers and users to make their own identifications the Laboratory's Lens Key to the identification has been published(1). This Key, which uses the perforated-card method, is intended to lead its operator to a comparison with an authentic specimen or a photomicrograph, and to meet the needs of those who have no such representative collection of timbers a companion Atlas of some 400 low-power photomicrographs has been prepared for publication. It is hoped that the Key will lead to some decrease in the number of specimens sent to the Laboratory for identification.

The collection of reference timber specimens has been materially increased by some five hundred during the year, particularly valuable contributions having come from the Forest Departments of North Borneo, Kenya, Northern and Southern Rhodesia, the Philippine Islands and Brazil, as well as from the United States Forest Products Laboratory. In the course of exchange and advisory work over two thousand hand specimens have been distributed.

SEASONING AND BENDING

Experiments have been put in hand to obtain information on the factors which affect the shrinkage of wood during drying. Matched samples were dried both slowly and quickly at six different temperatures in a kiln with specially designed apparatus for control. So far, the results show that shrinkage in slow drying from the green to the fully dried state is progressively greater as the temperature of drying is increased. Samples dried very

rapidly, however, tended to shrink rather less at high temperatures than at low. The curves obtained from tangentially-cut specimens dried slowly at high and low temperatures show that at high temperatures there is a tendency for the wood to expand during the initial stages of drying, and that the shrinkage, which begins at a moisture content of about 50 per cent., becomes roughly proportional to the moisture content drop from an initial moisture of about 45 per cent. At low temperatures the shrinkage becomes proportional to the moisture content drop from an initial moisture content of about 30 per cent. These results are of significance in practical kiln-drying as they confirm the general finding that green timber—e.g. beech—subjected to a high-temperature drying schedule tends to shrink, and hence to distort, more than, say, air-dried beech.

Timber used in boats, vats, etc., is exposed for long periods to contact with water on one side and air on the other. Tests have been carried out to determine the moisture gradients in wood samples exposed to these conditions, by making trays of Douglas fir and of oak and maintaining in them a small head of water on one face for periods of up to a year. The lower, freely-exposed surfaces were exposed to air at two different humidities. After exposure, moisture distribution tests showed that the moisture drop from the wetted face to a depth of about 1/5th of the thickness of the wood was very steep indeed. At this depth the moisture content was of the order of 30 per cent. On the exposed surface the moisture content tended to become slightly but not much higher than the equilibrium moisture content corresponding with the humidity of the surrounding air. Coating the dry face with bituminous paint had surprisingly little effect on the moisture content distribution. Further work on this project is in hand.

WOOD BENDING

Very considerable interest has been shown by the furniture and other woodworking industries in the process, recently developed and patented, for making plywood corners of small radius. This process, which has been described in the Press(2), makes use of a pliable insert instead of the conventional saw-kerfs or blocks. The material originally used for the insert was balsa wood, but tests have shown that others, including bombax and erimado, are suitable. For some purposes insulating board can be used.

There has been some demand from the boat-building industry for information on the most suitable techniques for making laminated bends of large and perhaps varying cross-section for boat stems, hulls, and frames. Experiments on making stems are in progress to investigate the possibilities and limitations of various bending methods, and to determine the forces induced and the influence of mechanical restraint on the glue layers when they are immersed in water.

TIMBER MECHANICS

New projects include investigations on the strength of struts of the type used in light constructional work ; on the strength of joints made with round wire nails ; on the effect of the construction of plywoods on their strength ; on the design, performance and working stresses of plywood components in structures ; and on the effect of temperature on strength.

Most of the work, however, has been on continuing projects, including the testing of timber for the comparison of new species, and tests on trusses and unconventional types of beams. To obtain data on the use of glues as jointing media in truss construction small trusses of the same design as that used previously for tooth-plate connector tests were made, but with different types of joint. Three trusses were made up with a casein glue

and two with a cold-setting urea-formaldehyde glue. One of the trusses was nearly 50 per cent. stiffer than the matched connector-jointed one, and had a recovery of deflection of over 90 per cent. at working loads. The remaining trusses have been loaded and will be left for an indefinite period to provide information under long-term loading, the bolts having been removed from one truss made with each type of glue.

COMPOSITE WOOD

Several of the series of long-term durability experiments upon adhesives for plywood manufacture and assembly work have passed their fifth year, and the resulting data have been correlated with the results of earlier projects. The plywood panels were exposed to indoor conditions, conditions of semi-outdoor exposure—i.e. those of an unheated ventilated shed, and full weathering, and the durability of the various classes of glue has been assessed and published.([3]) It is noteworthy that only the phenolic and resorcinol types of synthetic adhesive survived the rigours of full weathering over the period. New trials are being put in hand to include improved forms of existing types as well as the newer glues. With plywood the position has now been reached where the more durable types of adhesive outlast the wood itself, and means are being sought to protect the latter from weathering and fungal attack.

The glue-testing work in collaboration with H.M.S. Hornet has completed its third year. The experimental torpedo boat is itself now in need of repairs, particularly to the deck and superstructure, and these are being done as part of the general investigation. The complementary investigation of the gluing of timbers under shipyard conditions is in hand.

The tropical house is now in continuous operation, and several commercial firms have accepted the offer of space to study the storage behaviour of their packaged adhesives under export conditions.

In addition to the work on adhesives and the continuing studies on plywood plant and machinery, twelve new species of timber have been tested for their suitability for plywood manufacture. The Plywood Research Panel has evolved a simplified scheme of classification of timbers for plywood, and has classified the first twenty-six timbers tested by the Section.

WOODWORKING

A study of the action of saw-teeth has provided information from which it has been possible to formulate a tenable theory of cutting. The approach has been by observation of chip formation in cutting at different angles to the grain ; by determining the forces exerted in cutting at right angles to the grain under different conditions, the dimensions of the resulting chips and the angle of shear of the fibres, and by strength tests of the wood at different angles to the grain. An interesting result of this study was that the behaviour of the wood fibres during severance provided an explanation of the characteristic change in the shape of the edge as blunting occurs.

A report has been prepared for publication([4]) dealing with investigations carried out over a period of years on spring-set circular plate saws. It has been arranged chronologically to show how knowledge of the factors in sawing was gained and research technique improved. Information is given on saw performance in relation to feed-speed, depth of cut, hook, number of teeth and density of the timber cut. Particular attention has been given to saws with comparatively few teeth, and evidence is presented showing that the optimum number depends upon the particular application of the saw.

Other research in woodworking has included a new full-scale investigation into planing to establish the relationships of power demand, feed resistance, quality of finish and cutter wear to the cutting conditions for different classes

of timber. Further tests in boring have also been made on various types of timber to determine power requirements, the suitability of particular types of boring bit for different species and the effect of blunting on power and quality of finish. Preliminary study of the cutting action in boring has been made with the aid of ultra-high-speed photography.

WOOD PRESERVATION

A dozen additional species have been added to the tests on natural durability, which now number about 250. These tests are continuous, as new woods are continually being added, so that at any one time there are many incompleted tests. The results of over 100 completed tests have now been analysed and a relationship found between the life of individual samples and the average life of the group. This relationship has been used to forecast the durability of a species with reasonable accuracy without waiting for all the specimens to decay.

The production of preservative-treated plywood has been given high priority, and both methods of procedure—treatment of the finished plywood and of its constituent veneers—are under active investigation. Plywood made from relatively permeable species can be completely impregnated under pressure with a preservative, but that made from resistant timbers cannot be treated through and through. This has the serious disadvantage that cutting or drilling cannot be done after treatment without re-treatment of exposed untreated wood. The alternative treatment of preserving the individual veneers before gluing-up can be carried out either on green veneers directly after peeling or on the dried veneers. The best treatment of green veneers appears to be by dipping in a water-soluble preservative followed by a period in stack to permit diffusion of the salts. Dry veneers can be treated by soaking, by the open-tank hot-and-cold method, or by pressure, and all are being investigated. Promising results have been obtained even with species difficult to impregnate when made up into plywood. Some timbers, however, present difficulties in the gluing operation, and it is not yet possible to generalize on methods of bonding preservative-treated veneers.

Work has continued on the study of the combined effect of temperature and pressure on the impregnation of timber with liquids, and on the limiting values before collapse occurs. A successful technique has been developed by which collapse can be studied accurately, and knowledge gained from small-scale experiments on collapse is being applied to the difficult task of the impregnation of Douglas fir.

MYCOLOGY

It is now clear that wood-rotting fungi vary greatly as regards their ability to survive in a viable condition in air-dry wood. Active cultures can still be obtained from wood samples infected with species of *Lenzites* which have been kept for over eight years in a dry atmosphere. The Dry Rot fungus, *Merulius lacrymans*, on the other hand, has failed to survive seven months' storage in atmospheres in the relative humidity range of 90 to 44 per cent.

Stimulation of the growth of wood-rotting fungi when samples of wood are introduced into the culture vessel has often been observed. Preliminary experiments have shown that this stimulation is exerted even if the wood is not in actual contact with the fungus mycelium, indicating that it is owing to some volatile substance given off by the wood. It remains to be proved whether or not the fungus is stimulated in such a way as to direct its growth towards the source of the volatile substance and work on this aspect is proceeding.

The decomposition of wood brought about under certain conditions by cellulose-destroying Ascomycetes, such as *Chaetomium* spp., has been found to be of much more general occurrence than was previously realized. This type of decay for which the term "soft rot" is proposed and which is characterized by longitudinal penetration of the secondary cell walls of the wood elements, may assume considerable economic importance in certain conditions which are unfavourable for the growth of normal wood-rotting Basidiomycetes, e.g. in the slats of water-cooling towers. Laboratory tests have indicated that the rate of decomposition of beech by *Chaetomium* sp. may be greatly influenced by the amount of mineral nutrients available to the fungus. In this connexion it may be noted that severe "soft rot" occurs most frequently in timber in contact with the soil.

Tests with mixtures of sodium fluoride and calcium chloride on wood-rotting fungi indicate that when the fluoride is thoroughly mixed with calcium salts it loses its preservative action. In view of this, it would seem better not to rely on sodium fluoride alone as a preservative for timber—e.g. laths—which is likely to come into direct contact with materials such as fresh lime plaster.

A paper prepared in co-operation with the Building Research Station on the use of zinc oxychloride paints and plasters for eradicating *Merulius lacrymans* from infected masonry has aroused considerable interest.(5) The ingredients for the oxychloride mixtures are, at present, not readily procurable and a search is being made for available antiseptic materials which could be mixed into ordinary cement renderings. It has been found that copper aceto-arsenite will make ordinary cement toxic to fungi, but as its use might involve a risk to health, work on its use has been discontinued.

In the early part of the year a meeting of representatives of the Services, boat builders, naval architects and the fishing interests was convened to discuss the serious problem of decay in wooden craft. Arising from that meeting survey visits have been made to many kinds of boats, and a Bulletin has been prepared for publication. The problem is much more serious in pleasure craft than in fishing boats, and the vital difference appears to lie in the relative periods during which the two types of craft are in active use each year. To use a wooden boat at infrequent intervals increases the risk of decay more than has been previously realized, and for its satisfactory control in pleasure craft there must be a marked improvement upon traditional methods of construction by the use of more durable timbers or of modern methods of wood preservation. It is interesting to note that while the particular type of soft-rot found in water-cooling towers occurs commonly in wooden boats it is usually of minor importance, and in two instances it has been observed that adjacent timber had been protected by the marine anti-fouling paint.

ENTOMOLOGY

General biological work on the common furniture beetle has continued, and a report has been published on the effect of decay on the growth of the larvae.(6) New experiments are in hand to determine the effect of a range of moisture contents of decayed wood on the rate of growth. As there is little information on the conditions in sound timber, e.g. age, that determine its suitability for attack, a new approach to the problem has been made by removing the water- and ether-soluble extractives in fresh unseasoned Corsican pine sapwood before exposure to infestation. A comparison of the susceptibility of kiln- and air-dried timber is also being made.

On the applied side, a joint investigation with the Pest Infestation Laboratory has been completed on the toxicity of hydrocyanic acid gas to the eggs and larvae of the furniture beetle. The eggs are considerably more sensitive, and require a much lower time-concentration for their destruction than do the larvae.

In view of the continued importance of the house longhorn beetle (*Hylotrupes*), inspections of buildings have been made in new localities in which infestation has been reported. There is now little doubt that infestation of roofing timbers in some districts is associated with its breeding in its natural habitat in dead parts of standing trees or in softwood timbers, e.g. fence-posts out of doors. Studies have been continued on the behaviour of the beetles and their larvae, egg-laying and duration of life under different conditions, and it has been established that there is a marked difference in rate of growth of the larvae and extent of damage according to temperature and humidity, development being most rapid at 25°C. and 70 per cent humidity.

The team of three biologists appointed by the Colonial Office to study in West Africa the serious problem of damage to hardwood timbers by ambrosia beetles (pinhole borers) has completed its training. Two members have gone to the Gold Coast to begin field-work, and the third remains at the Laboratory to study the relationships between the insects and the fungi with which they are associated.

CHEMISTRY

The work on the delignification of wood with sodium chlorite solution, leading to the recognition of an acid-soluble form of lignin, has now been published in two papers([7])([8]). A third describes the preparation of a hemicellulose fraction in a fairly pure condition from beech wood([9]). The constitution of this material is now being investigated by Professor E. L. Hirst at the University of Edinburgh. The isolation and purification of the remaining hemicelluloses in beech wood will now be attempted.

Acid-soluble lignin can be isolated from the hydrolysate obtained by treating wood with 72 per cent. sulphuric acid to remove the acid-insoluble lignin. If wood that has been partially delignified with sodium chlorite is used, a product termed "modified lignin" is obtained. This contains chlorine, derived from the sodium chlorite, and is therefore believed to have been modified by the chlorite treatment so that it is no longer isolated as an insoluble residue by the sulphuric acid method. The relationship between acid-soluble lignin and the modified lignin has been examined further, particularly in regard to their ultra-violet absorption spectra. For both beech and spruce lignins there is very litte difference between the absorption spectrum of the acid soluble and of the modified lignin. This suggests that the main conjugating system is the same in the two products, and is little modified by the addition of chlorine or hydrochloric acid in the modified lignins.

Attention is now being turned to the carbohydrate portion of the wood, and the examination of the sugars formed by hydrolysis of the various polysaccharide fractions of the cell-wall will be made by partition chromatography on paper. A portion of the hemicelluloses present can be extracted by cold alkali and isolated in a fairly pure condition. The remainder can be so extracted only if the wood is first delignified, i.e. it may be combined in some way with the lignin, which prevents its extraction. It is of interest to know whether this fraction differs chemically from that which can be extracted directly.

In the work on wood starches, the starch of the Australian tree *Eucalyptus obliqua,* which has an unusually high starch content, has been successfully isolated in quantity, and has been sent to Professor Hirst for investigation of its constitution.

Further work on the production of hardboards from tropical timbers has been completed. Boards made from the British Guiana timber wallaba extracted with alcohol had a high strength, but had a considerably higher water absorption than those made from the unextracted wood. Boards having water absorption values low enough to comply with the draft revision of B.S.S. 1142 have, however, been made by adding to the pulp small amounts of rosin size or of wax emulsion. There is a slight loss of strength, but the boards so treated still retain a substantial margin over the specified minimum modulus of rupture. Considerable improvement has also been effected by prolonged heat treatment of unsized boards after pressing. Increase in the water resistance without loss in strength has been obtained, but so far the wax emulsion treatment has proved more reliable. Boards made from British Guiana morabukea have shown similar results as regards water absorption and strength. As the difficulties in the way of making fibreboards from such secondary tropical hardwoods are likely to be mainly economic, experiments are in hand to determine the practical lower limit of chemical consumption required to make boards which comply with the specification. It is also proposed to use a disc-mill to defibre the cooked chips instead of the beater at present in use, as it is thought that it will be more efficient and may further reduce the consumption of chemicals.

Advisory work in chemistry has, as usual, covered a wide range of industrial subjects, among which have been the bleaching of wood-flour for the plastics industry and the determination of arsenic in wood and foliage to see whether, with trees killed with arsenic to facilitate bark removal, the arsenic transported with the sap into the foliage and twigs might eventually, in the litter, have a toxic effect on the young roots of surrounding trees. The amount of arsenic found was, in fact, very small.

PHYSICS

The effect of temperature on the three principal Young's moduli of beech, oak and Corsican pine has been measured over a wide range of relative humidities. The results show that at a given humidity the Young's moduli decrease linearly with increase of temperature, although at 90 per cent. relative humidity there is evidence of a curvilinear relationship. The temperature coefficients do not vary greatly from one species to another, nor from the radial to the tangential specimens, but the longitudinal modulus is only about half as sensitive to temperature change as the transverse moduli. The reduction in subsequent equilibrium moisture content after heating wood in a dry atmosphere is well known, but these experiments show that the reduction also occurs on heating in a moist atmosphere. Evidently the heating introduces irreversible changes, which seem, however, to be complete in one or two days.

Measurements of the effect of temperature on the vapour pressure isothermal of wood have been continued, and isothermals at 25° and 30°C. completed. The work has been carried out by the standard method of measuring simultaneously the vapour pressure and the moisture content at equilibrium. This method, however, becomes very difficult and inaccurate at high relative humidities, and other possible methods of exploring the region above about 30 per cent. moisture content are being explored.

The experiments on the flow of water vapour through discs of wood at various temperatures under a relative humidity gradient of 100 per cent. have been completed. The flow through 12 species in the three principal directions was investigated and the results show that with the exception of Sitka spruce the magnitude of flow through all species and at all temperatures is greatest in the longitudinal direction and least in the tangential. In Sitka spruce the radial flow is slightly less than the tangential flow, but in the other species it is 2-4 times the tangential flow. In all species the longitudinal flow is about 10-25 times the tangential flow. Temperature, mainly because of the rise in vapour pressure, has a marked effect on the absolute magnitude of flow, which is approximately doubled in all the directions on raising the temperature from 20° to 40° C.

Advisory work on the application of physics to wood problems has included enquiries on thermal conductivity, calorific value, electrical properties, the sinking of logs, and the detection of metal.

EXTERNAL RELATIONS

Excellent progress has been made in the procurement of new timbers for test and the publication of data on timbers tested. Thirteen reports were printed and distributed. Twelve Colonial tropical woods were brought in, as well as parcels of eight home-grown timbers.

The long-term co-operative project with the Forestry Commission on timber quality in relation to silviculture is now in operation, and tests have been carried out on consignments from their plantations in various parts of the country. The quality of the timber so far tested has shown considerable variation, but it is too early to make any generalizations.

Industrial surveys have been limited by work within the Laboratory and the handling of the many technical visitors, but visits have been made to furniture makers, brush makers, import timber merchants, joinery manufacturers and bus and coach builders. During 1952 technical visitors from 27 nations or colonies came to the Laboratory.

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FUEL RESEARCH

The previous report referred to the increased calls being made on the Fuel Research Station for advisory work. This has continued and in the sections dealing with domestic heating and atmospheric pollution, there are increasing demands for assistance and advice. Every effort is being made to meet these demands, but they are throwing a heavy burden on the Station's limited resources.

CONSTITUTION OF COAL

Evidence of many kinds has been obtained in the past which has led to the suspicion that as coal matures the transformations it undergoes change markedly in character when the carbon content reaches 85 to 89 per cent. These transformations can be studied in a variety of ways, among which chemical methods rank high in importance. Accordingly, efforts are now concentrated on an investigation of the oxidation products of coals of progressively increasing rank as a means of assessing the extent to which a carbocyclic structure has been developed. Results obtained up to the present indicate that the rate of development of this type of structure with increase in rank increases significantly at a carbon content between 85 and 89 per cent. Work is also in progress at Birmingham University, under an extra-departmental contract, on a study of controlled oxidation by which it is hoped to isolate and identify products more complex than the simple aromatic acids normally produced.

The occurrence of germanium in coal has become of considerable practical importance in view of the utilization of flue dusts as raw material for the recovery of the element. Its properties as a rectifier are being used increasingly in the electronic industry and, in this country, flue dusts provide virtually the only means of satisfying these demands. As part of a survey of the occurrence of germanium the possibility of a relationship between the rank of a coal and the germanium content is now being explored. Eight coals from the Nine Feet Seam, South Wales, covering a range of carbon contents from 84·5 to 93·8 per cent., were examined and the germanium contents were found to be low and to show no signs of any correlation with rank. Analysis of various vitrains and bright coals has revealed that wide variations can occur in the germanium content of the pure coal substance, values as low as 0·05 part per million (South Wales) and as high as 50 parts per million (Durham) being obtained.

CARBONIZATION

Work on the production of metallurgical coke by carbonizing blends of good quality coking coals with coals of less strongly caking properties has been continued in the setting of intermittent vertical chambers in order to determine to what extent it may be possible to eke out our limited reserves of best quality coking coals. Blends of a first-grade Durham coking coal, and of a Durham gas-coking coal, with a Durham gas coal have been carbonized under standard conditions and it has been found that, although the additions of gas coal decrease the shatter strength of the coke, up to 60 per cent. can be incorporated in the blend without making the coke unsuitable for metallurgical purposes.

Some coals from the southern part of the Northumberland coalfield have appreciable caking properties and at the suggestion of the National Coal Board four of these coals have been carbonized to see whether they would be suitable for the production of metallurgical coke. All four cokes had

shatter strengths lower than that of high quality metallurgical coke; three of them had 1½ in. shatter indices of about 80 and so could be used in blast furnaces, but the fourth was not sufficiently strong.

Assistance has been given to the Government of Western Australia in an investigation of the possibility of using a non-caking coal for the production of carbonized briquettes for use in metallurgical cupolas. A consignment of the pre-carbonized coal was briquetted by an industrial firm, using pitch as a binder, after preliminary experiments at the Fuel Research Station had indicated the best conditions; the briquettes were then carbonized at the Station and sent to Australia for trials.

GASIFICATION OF SMALL-SIZED SOLID FUELS

Work on the complete gasification of solid fuels is directed to the use of cheaper and more plentiful types of coal and coke for the production of fuel gases and synthesis gas. In particular, methods of making water-gas from non-caking coals and producer gas from coke breeze are being developed. In addition to their direct use as gaseous fuels in industry, these gases can be converted catalytically into town's gas of high calorific value or into synthetic liquid fuels. The economic possibilities of large-scale production of gas in this way are under review by a Working Party which includes representatives of the Fuel Research Station, the Ministry of Fuel and Power, and the Gas Council.

The economic use of non-caking coals for generating water gas requires a process in which fines and dust can be gasified with steam. For this purpose the "fluidized-solids" method is being used in a small pilot plant, in which steam is blown through a bed of finely-divided coal at about 900°C. Water-gas of satisfactory quality has been made, but the efficiency is limited by the amount of carbonaceous dust which is carried out of the bed by the gas. In early experiments this entrained dust contained 30 to 40 per cent. of the carbon in the fuel, but improvements in design have enabled this proportion to be reduced to about 20 per cent. Further reduction will be necessary before the process can be considered satisfactory.

For making producer gas from coke breeze, which is available at a substantially lower cost than large coke, experiments are being continued with a cyclone generator, fed with 500 lb. of solid fuel per hour. Air is blown into a cylindrical chamber with a whirling motion, and the finely-divided fuel is gasified partly in suspension and partly in contact with a viscous film of fused ash on the walls. The temperature in the chamber is above 1400°C., and the ash is removed mainly as liquid slag. The cyclone chamber has so far been used with an oxygen-enriched air blast and coal crushed to pass a $\frac{1}{16}$ in. screen, and 50 lb. of coal per cu. ft. of reaction space has been gasified per hour. The quality of the gas is not yet satisfactory, and attention is being directed to accelerating the ignition of the fuel particles by preheating the air blast.

FISCHER-TROPSCH SYNTHESIS

Work on the Fischer-Tropsch synthesis for the production of liquid fuels and chemical products from coal includes the study not only of purely chemical problems concerned with the development of suitable catalysts and with conditions required for the synthesis, but also of the chemical engineering problems associated with the operation of the process on an industrial scale. These chemical engineering problems include the design of reaction vessels for the different methods of working, using, for example, a fixed bed of catalyst granules, a fluidized bed of powdered catalyst, or a suspension of powdered catalyst in a liquid medium, and taking into account

the highly exothermic nature of the reaction. During the year a pilot plant to treat 2,000 to 2,500 cu. ft. of a mixture of hydrogen and carbon monoxide per hour has been completed and two runs have been carried out using a reaction vessel of length 12 ft. and diameter 8 in., containing a water-cooled bed of fluidized iron catalyst. In the second run, which lasted 15 days, smooth operation was achieved with a gas conversion of 92 per cent. and a daily production of 60 gallons of products—condensible gas, liquid hydrocarbons, wax, and water-soluble compounds containing oxygen. A comparison of the results with those obtained under similar conditions in a small 1 in. diameter reactor shows that the gas conversion and catalyst life were less in the large reactor than in the small one; the significant factor may be the ratio of height of catalyst bed to its diameter, which is smaller in the large plant. Work on these problems is continuing.

The radioactive tracer technique is being employed in studies of reaction mechanism. Under the conditions used for the Fischer-Tropsch synthesis mixtures of ethylene and hydrogen react to give ethane as the sole product. but in the presence of a small proportion of carbon monoxide a range of higher hydrocarbons is obtained. Experiments are in progress with mixtures of ethylene, hydrogen, and carbon monoxide labelled with ^{14}C in an attempt to elucidate the mechanism of the reactions.

FLOW PROPERTIES OF RESIDUAL FUEL OILS

The study of the factors responsible for changes in the flow properties of residual fuel oils during storage has been continued. This work, undertaken in collaboration with the Flow Panel of the Fuel Sub-committee of the Admiralty Fuel and Lubricants Advisory Committee and with the Flow Panel of the Institute of Petroleum, has resulted in the development of a laboratory procedure for the artificial ageing of residual oils. By subjecting a sample of a freshly prepared oil, or of one that has been stored for a moderate time, to a cycle of heating, rapid cooling, and re-heating, its flow properties can be made to simulate those that the bulk of the oil acquires after storage for long periods. A more fundamental approach to the problem has shown that the flow properties depend to a large extent on the manner in which the wax in the oil crystallizes ; this in turn depends on the resin and asphaltene content of the oil and on its thermal history, but the mechanism by which the size and shape of the wax crystals are modified has not yet been elucidated. Normally asphaltenes increase the fluidity of an oil but recent evidence indicates that under certain conditions they may diminish it, even to a greater extent than would correspond to a simple dilution effect.

SURFACE CHEMISTRY

Work has been started on the adsorption of argon at low temperatures on the iron catalysts used for the Fischer-Tropsch synthesis to see whether there is any relationship between pore structure and catalytic activity. The more general problem of adsorption on heterogeneous surfaces is also being investigated with the ultimate object of being able to use adsorption data to give a measure of the heterogeneity. Artificial composite surfaces of known surface composition have been prepared, for example, by the adsorption of methanol on kieselguhr, and good agreement has been found between the observed and calculated low-temperature adsorption of nitrogen on them.

In the course of an attempt to discover the source of the discrepancy between the surface area of coal as determined by the heat of wetting with methanol and by the low-temperature adsorption of nitrogen it was found that coals of low rank can absorb appreciable quantities of methanol at room temperature without affecting the amount of nitrogen that can be adsorbed at $-195°C$. These observations are being followed up.

An improved form of robust all-metal apparatus for the determination of the surface areas of powders by the low-temperature adsorption method has been designed for use in works laboratories. It was shown at the British Instrument Industries Exhibition at Olympia in July, 1953.

BOILER AVAILABILITY

The increased use of pulverized fuel firing in modern generating stations has resulted in work for the Boiler Availability Committee being re-oriented to give more attention to problems peculiar to this method of firing. Already a new type of deposit, apparently bonded by calcium salts, has been discovered which may cause trouble when coals of high chlorine content are being used. Laboratory investigations have suggested that calcium chloride is an essential intermediate step in the formation of the deposit although it does not occur in it.

The formation of sulphuric acid in flue gas, which leads to corrosion of the air heaters, has often been attributed to catalytic oxidation of sulphur dioxide on the steel superheater tubes. The Station has collaborated in an investigation at Kingston generating station in which a bank of dummy tubes was installed above the superheater to provide an increased area of steel maintained at a high temperature. No corresponding increase in the formation of sulphuric acid was observed.

REMOVAL OF SULPHUR COMPOUNDS FROM FLUE GAS

The study of Fulham-Simon-Carves ammonia process for the recovery of sulphur from flue gas as ammonium sulphate and elemental sulphur has included work with a scrubber lent by an industrial firm containing a carbon packing designed so that the grid surfaces are thoroughly wetted at low rates of liquor circulation. It was found at first that only about 85 per cent. of the sulphur dioxide in the flue gas was removed and the loss of ammonia was high, but earlier work with the Station's scrubber suggested that these results might be due to ammonium sulphites building up in the liquor owing to a relatively low rate of oxidation. This difficulty was partially surmounted by using manganese as a catalyst, but a satisfactory rate of oxidation was only obtained by aerating the liquor through a ceramic filter-candle. Efficiencies of removal of sulphur dioxide of the order of 90 per cent. were then obtained.

COMBUSTION CHAMBERS FOR COAL-FIRED GAS TURBINES

Further experimental work has been carried out with the three types of combustion chamber intended to enable solid fuel to be used in industrial gas turbines: viz., a "Straight-through" combustion chamber using the F.R.S. "Grid" or "Multijet" burners originally designed for Lancashire boilers, a F.R.S. "Vortex" combustion chamber in which centrifugal force is employed to obtain the relative motion necessary for a very high rate of heat release, and a "Cyclone" combustion chamber in which the fuel particles are held in contact with the wall of a cylindrical chamber and "scrubbed" by air moving at a high velocity. The first two types are being developed at the Station and are operated with powdered fuel under non-slagging conditions, while the third, which is being developed by the British Coal Utilisation Research Association under a contract with the Department, uses granular fuel and is operated so that most of the ash in the fuel is removed as molten slag.

For convenience, development of each of the three types has hitherto been carried out working at atmospheric pressure, but straight-through combustion chambers based on Fuel Research Station data have already been

used for short periods in experimental gas turbines using coal and peat in both open and closed cycle plant by firms developing solid-fuel-fired gas turbines under contracts with the Ministry of Fuel and Power. Further data are desired on the effect upon performance of operating at the combustion chamber pressures (about 4 atmospheres) required in the open cycle gas turbine and it has been decided that the development of the straight-through chamber is sufficiently advanced for it to be used for that purpose. Attention at the Station has therefore been concentrated during the last year upon experimental design work leading to the construction of a pressurized chamber of this type. When construction has been completed the chamber will be erected at the National Gas Turbine Establishment of the Ministry of Supply where a new laboratory has recently been built with special facilities for this type of investigation.

The experiments on the cyclone combustion chamber are also making satisfactory progress and a chamber of this type has been built for an open cycle experimental gas turbine developed by one of the firms under contract to the Ministry of Fuel and Power.

GRINDABILITY OF COAL

In view of the rapidly increasing use of pulverized coal in power stations, great interest has been focussed on the performance of pulverizing plant. The subject is being investigated jointly on full scale plant and independently in the laboratory by the Station and the British Coal Utilisation Research Association.

The work is not complete, but data of both practical and fundamental interest have been obtained relating to the commercial performance of one type of mill which is widely used in power stations.

PREVENTION OF SMOKE

The emission of smoke from factory boiler chimneys is not only an obvious source of atmospheric pollution, but it is also an indication of waste of fuel—in bad cases well over 10 per cent. of the fuel fired. Work at the Station has shown that the emission of smoke from either the forced-draught or the natural-draught hand-fired steam boilers commonly used in industry and frequently guilty of excessive smoke production can be prevented by the correct use of secondary air, and in the case of the natural-draught types a special fire door known as the F.R.S. Smoke Eliminator has been developed for the purpose. The door is being manufactured by several firms and one maker reports having sold more than 1,000; but it is considered that the device is not yet sufficiently widely known. A film "Fire without Smoke" was prepared, describing the door and the advantage of using it to prevent smoke and save fuel; this film can be obtained on hire from the Central Film Library.

ATMOSPHERIC POLLUTION

As organizers of the nation-wide co-operative scheme for the investigation of atmospheric pollution, the Station has continued to collate and publish the results of the measurements made by local authorities and other bodies who collaborate in this survey. Technical advice on the operation of the measuring instruments and on the selection of sites for them is also provided and steady progress has been made in experimental work aimed at improving existing methods of measurement and the development of new ones. During the last three years the number of local authorities and other bodies taking part in this co-operative investigation has doubled, approximately, as has also the number of instruments in regular use. There are now about 160 co-operating bodies, and more than 1,250 instruments in operation in various parts of the country.

Special surveys of pollution have been undertaken from time to time to obtain answers to specific problems, and work has continued on several surveys which were started a few years ago, with the object of obtaining data on the distribution of sulphur dioxide in the neighbourhood of certain electricity generating stations. Another special study was concerned with the incidence of pollution during the dense fog which covered London and some other parts of the country for several days in December, 1952, and had serious effects on health and transport. Measurements made during this period showed that in parts of the London area the concentration of smoke and sulphur dioxide in the air rose to levels appreciably higher than any previously recorded. Full co-operation has been maintained with the medical and other investigators who are studying not only the effects of this fog but also the wider aspects of the effects of atmospheric pollution in general on health.

DOMESTIC HEATING

During the post-war years it has been a requirement that, before any design of domestic-heating appliance burning solid fuel could be recommended to local authorities for installation on their housing estates, it should have passed a series of tests. The test procedures and the minimum standards of performance required, have now been revised in the light of experience and as the result of extensive investigations at the Station during the last few years. The new testing schedule came into operation on 1st July, 1953, and all appliances now on the recommended list will in due course be tested again in accordance with its provisions.

The deliberations of the Ridley Committee focussed attention once again on the difficult problem of defining and measuring an "efficiency" by which the relative values of different systems of heating appliance may be compared. The Committee adopted the recommendations of the Fuel and Building Research Stations that a form of "room-heating efficiency" was the best criterion which could be used in the light of existing knowledge. Researches establishing this efficiency on a consistent basis are now actively in progress in the Calorimeter Building at the Fuel Research Station, which is uniquely suitable for such work. Ultimately it is hoped to establish typical figures of room-heating efficiency for each of the main classes of appliance used in this country for domestic heating.

The Report of the Ridley Committee advocated the development both of "utility" types of open fire, and of devices to restrict the throat apertures of open fire chimneys. Designs for both these purposes are now being submitted by the trade and their performance is being studied in the Calorimeter Building.

GEOLOGICAL SURVEY AND MUSEUM OF PRACTICAL GEOLOGY

The geological survey of the United Kingdom involves the provision of geological maps with explanatory memoirs, up-to-date in that all information available from the surface and from underground sources is utilized in their preparation. Legislation enables the service to study all mine-workings, boreholes for minerals and water and their pertinent records.

The current necessity for concentrated work on problems connected with future coalfield development, mineral and water resources and hydro-electric schemes inevitably slows down the publication of maps and memoirs;

nevertheless, the programme has been adjusted to allow some progress to be made with the duty of acquiring new basic geological data and with the application of new methods of research.

FIELD WORK

Revision six-inch mapping and borehole inspection in all the working coalfields have occupied the attention of two-thirds of the field staff. The area of revision survey covered in the year was 311 square miles, 40 of which were in Northern Ireland, and the area of primary six-inch mapping was 202 square miles.

Following the disastrous floods in North Devon in August, 1952, a special survey was made of the causes and results of erosion in the valleys converging on Lynmouth.

Help was given to the Yeovil authorities in interpreting the local geology and in the siting of a dam for a reservoir at Sutton Bingham.

The suspension of primary six-inch survey work in the Canterbury area (Sheet 289) due to the incidence of foot and mouth disease provided an occasion for revision mapping in the Dorchester Sheet (328) due for reprinting. In this ground the outcrop of the Gault was found to have been included with that of the Kimmeridge Clay and this will be remedied in the new issue.

In the neighbourhood of the Geological Survey Boring at Upton, near Burford, some primary mapping was carried out and the survey of the Cambridge Sheet (188) proceeded.

Revision survey was continued in the South Wales Coalfield both in the anthracite area in Carmarthenshire (Sheet 239) and in the steam coal area of Glamorganshire (Sheets 247, 248).

One of a series of deep exploratory boreholes drilled by the National Coal Board in the Dulais Valley, near Crynant, revealed seven marine bands in the Coal Measures. Knowledge of these and other such marine horizons has increased considerably during the resurvey and they are proving invaluable in interpreting structure and in effecting correlation across the coalfield.

A start was made with the resurvey of the Newport Sheet (249). This, the last of the series to be revised, was the first to be surveyed on the six-inch scale when the detailed investigation of the South Wales field was begun in 1891. The survey of the Special Bristol and Somerset Coalfield One-inch Sheet was competed and the map is in preparation.

In the West Midlands the primary six-inch survey of the Church Stretton Sheet (166) was commenced. In the East Midlands, the revision of the Chesterfield Sheet (112) made satisfactory progress and the primary mapping of the Chapel en le Frith Sheet (99) was resumed. These two adjoining sheets cover the greater part of the Derbyshire lead, flourspar and barytes mineral field.

As a development from the mapping of the Jurassic ironstone field, primary survey is now in progress in the Bourne Sheet (143). This ground includes an active part of the ironstone field in Rutland and Lincolnshire and also a tract further east in which it is anticipated that the Northampton Ironstone will be mined.

In Lancashire, most of the Clitheroe Sheet (68) has now been revised on the six-inch scale. The National Coal Board boring programme, organized in consultation with the Survey, in the Prestwich area, Manchester, has proved a number of coals of workable thickness and workable depth;

faunal marker horizons have played an important part in enabling the strata in these six boreholes to be correlated. In Durham revision of the Wolsingham Sheet (26) has been completed and that of the Coal Measures and Permian in the Sunderland Sheet (21) begun. Revision of the Bewcastle Sheet (12) in Northumberland has started and the drift deposits and glacial features throughout the Hexham Sheet (19) have been reviewed.

The necessity for an expensive scheme of piped water-supply to Holy Island has been averted by advice given by the Survey to drill a borehole on the island. Tests reveal an adequate supply of potable water.

Revision work in Scotland has continued in the Canonbie Coalfield (Langholm Sheet 11) and some correlation of limestones has been accomplished in this area which is greatly concealed by drift. In all Scottish coalfields, close collaboration is maintained with the National Coal Board in its borehole work and correlation; in Fife, advice was given on driving haulage roads in relation to irregular igneous intrusions. Revision mapping in the Lowlands has included Old Red Sandstone and Carboniferous areas. Primary survey has continued in the Loch Eil Sheet (62); one-third of its area has now been completed and the evidence for a great crush belt along and south-east of the Great Glen Fault has been amplified.

Advisory work and recording of tunnel sections for the North of Scotland Hydro-Electric Board and for their consulting engineers and contractors has continued in connexion with the following five projects: Mullardoch-Fasnakyle-Affric; Fannich-Orrin; Tummel-Garry; Lyon-Lochay; Garry-Moriston.

In Northern Ireland revision of the Dungannon Sheet (35) has been completed and important fossil evidence has been obtained towards the correlation of the strata in the Coalisland Coalfield. Revision mapping in the Ballycastle Sheet (8) has continued and valuable results are being obtained from the examination of shallow borings for coal in that district.

PALAEONTOLOGY

Work continues on fossils collected from strata in the several districts in which mapping is being undertaken as well as on fossiliferous cores from boreholes. These include material from eleven coalfields in England and Wales and five in Scotland in which the National Coal Board is conducting exploratory boring; material has also been examined from the two coalfields in Northern Ireland (Dungannon and Ballycastle) which are being mapped by the Survey. The study has continued of the Mesozoic fossils collected from the Stowell Park Borehole and on the Palaeozoic fossils from the current Survey boreholes with stratigraphically interesting results. Fossils examined from a water boring at Castleton, Derbyshire, enabled the junction between Millstone Grit and the Carboniferous Limestone series to be located accurately within a shale sequence.

Over 17,000 fossils were received during 1952, of which number nearly 3,000 were presented from 56 donors. Nearly 10,000 specimens were lent to palaeontologists in connexion with special researches.

PETROGRAPHY

In England petrographical investigations have concerned rocks collected during systematic field survey and from various boreholes drilled for economic minerals including potash. In Scotland petrographical work has arisen mainly from the survey of the Midlothian and Loch Eil Sheets (52 and 62). One thousand and forty-four thin sections were prepared for microscopical examination, bringing the total number of sections in the collection to 76,580.

X-RAY ANALYSIS

X-ray determinations using powder methods have been made in connexion with a large number of individual mineralogical problems. The library of registered photographs has been augmented by 249 powder diagrams.

CHEMISTRY

Eighteen quantitative chemical analyses of rocks involving about 450 separate chemical determinations were performed during the year. The total number of quantitative analyses registered by the end of 1952 was 1,712.

Progress has been made in the use of the spectograph for the detection and approximate determination of about thirty of the rarer elements in rocks and minerals, and analyses of lithium and rubidium content are now being made spectrographically on all specimens submitted for chemical analysis.

GEOPHYSICS

Gravimeter survey continued over 1,000 square miles in the English Midlands. Low gravity values were found to be particularly developed in the Cheshire Basin parallel to, and two or three miles to the north-west of, the course of the Red Rock Fault. A magnetometer survey in the Burton upon Trent region supplemented gravimetric results.

Gravity surveys were also undertaken in Northern Ireland in an area where geological field mapping is almost complete. To compare these gravity observations with those made in the English Midlands, gravity connexions were observed between the main bases in Northern Ireland, a gravity station at Ringway Airport (Manchester) and a pendulum station near Dublin. The triangulation network was obtained by a road link between Belfast and Dublin and by air-links between Ringway Airport and Belfast and Dublin respectively. The Ringway to Belfast air link was surveyed via an intermediate station at Ronaldsway Airport in the Isle of Man, the first gravity station to be recorded in that island. The kind co-operation of British European Airways and Aer Lingus officials is gladly acknowledged.

Six-channel seismic equipment for refraction and reflexion surveys was obtained during the year and tested in the laboratory prior to field trials.

GEOLOGICAL SURVEY PROGRAMME OF BORING

Four boreholes were in progress during the year. The Ashton Park (Bristol) Borehole, begun in July, 1952, was sited to prove the sequence and thickness of strata lying between the Coal Measures and Carboniferous Limestone Series and thus to assist the mapping of the Bristol Coalfield. The hole reached a depth of 2,195 ft. A second borehole started in August, 1952, at Upton, near Burford in Oxfordshire, to test the strata below the Mesozoic rocks; the records of a previous borehole drilled at Burford Signet in 1875-7 were confirmed and amplified in that here, Upper Coal Measures were entered at 1,105 ft. and were proved to a depth of 3,769 ft. but the coals found were only thin. In January, 1953, a bore was begun on Canvey Island to seek the reason for a gravity "low" found by gravity surveyors employed by an industrial firm. Coring was started in the Upper Greensand at a depth of 1,200 ft. and below the underlying Gault at 1,320 ft. the bore passed into a sandstone-mudstone sequence yielding fossils of Downtonian or Devonian age. A fourth boring, at Cambridge, was jointly undertaken with the Woodwardian Professor of Geology who was financially assisted by the Royal Society and various industrial firms. This

borehole was also planned to supplement geophysical observations. Here seismic reflexion work by Sir Edward Bullard, Director of the National Physical Laboratory, had suggested the presence of Palaeozoic rocks beneath the Mesozoic cover at 360 ft. below Ordnance Datum. Such rocks were met closely in accord with this prediction but they were not expected to be the Carboniferous Limestone encountered at 434 ft. below surface (356 ft. B.O.D.). This borehole is still in progress at 590 ft. depth. Work continues on the study of the rocks, fossils and geophysical data obtained from these boreholes.

UNDERGROUND WATER

The Water Department's work of collecting and correlating information from wells continued. The number of new wells notified during 1952 was 437, the lowest number since the passing of the 1945 and 1946 (Scotland) Acts ; records of 834 wells sunk before 1945 were acquired.

A survey of water resources in areas of Bunter Sandstone in Nottinghamshire showed that in the northern part of the county reserves will permit a further daily abstraction of about 19 million gallons. Similar work in Chalk areas of Yorkshire and East Lincolnshire enabled the areas of saline water infiltration to be defined.

Measurements of electrical resistivity taken at various depths in wells within the Chalk, disclosed belts of high and low resistivity, as yet unexplained ; these are unrelated to the well-defined Chalk Rock and Melbourn Rock horizons.

RADIOACTIVE ORES

Throughout the world the search for uranium is now occupying the attention of more geologists than explorations for all other minerals put together, excluding oil. During the past year field investigations of ore deposits have been undertaken by officers of the Atomic Energy Division of the Survey in most of the British Colonies, some Commonwealth countries, and various other territories overseas.

The time-lag between the discovery of an ore-field and the commercial production of mineral or concentrate is seldom less than five years, this period being necessary for treatment research and mine development ; and the fruits of some early unpublicized work of the Division are only now beginning to ripen. The most notable advance during 1952 was the inauguration by the Prime Minister of South Africa of the first plant to extract uranium from the South African gold ores. This new South African industry, which will ultimately raise a gross annual revenue of £30m. and so become an extremely valuable item in the Union's economy, stems from field work undertaken in 1945 in which the Division took a prominent part. Similarly, in South Australia the Department of Mines is vigorously promoting the development and exploitation of the refractory uranium ores at Radium Hill, following assessments carried out by British geologists in 1947. In Portugal a production plant now yielding high-grade concentrate derives its feed from ore deposits discovered some years ago during an intensive exploration programme undertaken by the Division.

The discovery during 1952 of a limited tonnage of good grade uranium ore in association with the copper deposits of Northern Rhodesia encourages hope that greater finds will be made throughout the Copperbelt. In various other territories of Central Africa the Division's geologists have located new occurrences of uranium mineralization which merit further exploration. A laboratory examination of about 10,000 placer concentrates from the Gold

Coast has given much new information on the distribution of radioactive minerals in West Africa. Field radiometric surveys are currently being conducted throughout Bechuanaland and Swaziland.

In England, a programme of diamond-drilling for uranium has been undertaken at the derelict South Terras uranium mine near St. Austell in Cornwall; the present ore reserves here have unfortunately proved to be insufficient to support any significant mining operations. Also in Cornwall attention has been given to new techniques of geochemical prospecting for radioactive metals, the procedures developed being designed for use by prospectors in the more impenetrable Colonial territories like the forests of Ruwenzori or British Guiana.

Routine mineralogical identification work for prospectors and mining companies leaves little time for fundamental research, but a study has been published on a new mineral "cheralite", akin to monazite but rich in calcium, thorium and uranium. In co-operation with mass-spectographic laboratories in Britain, Canada and U.S.A., work has also been carried out to determine the absolute age of various uranium deposits, using lead isotope techniques.

Approximately 12,000 radiometric assays were carried out during 1952, and about 1,300 enquiries relating to radioactive ores were submitted by prospectors, mining houses, and Government departments.

MUSEUM OF PRACTICAL GEOLOGY (GEOLOGICAL MUSEUM)

The public recognition of the Museum as a centre for instruction and geological information is shown by the record attendance of 349,705 visitors during 1952, nearly 11,000 more than in 1951. Attendance at lectures and demonstrations was 5,433, nearly a thousand more than in the previous year

New temporary exhibits were arranged in succession in the Main Hall—Conté drawings of the Penmaenmawr and Trevor Quarries lent by the artist, Miss M. E. Thompson; coloured cut gemstones from the Museum collections, which had been reproduced as coloured plates by the Illustrated London News; Geological Survey and Museum photographs showing effects of the Exmoor floods in August, 1952; illustrations for an educational film strip *The Crust of the Earth* shown by courtesy of the Hulton Press, Ltd.; and a display of carved decorative stones. The Museum also arranged or lent material for a number of external exhibits.

LIBRARY AND INFORMATION

The Library was used by over 5,600 visitors, many of whom brought enquiries; more than 2,500 books and 88 maps were added during 1952.

During the same period the Geological Survey and Museum answered 3,751 enquiries from Government departments, public authorities, industry and agriculture, research and educational workers and from private individuals. Of these enquiries 1,316 were problems referred to the field staff and the others were classified as follows:—water supply 924, palaeontological 676, petrographical 214, mineralogical and general 621, geophysical 43.

HYDRAULICS RESEARCH

The construction of the main hall of the new Hydraulics Research Station at Wallingford has not progressed as rapidly as had been hoped, and it is now expected that the first stage of the building will be ready for occupation early in 1955. Work has proceeded with the facilities and apparatus available, both at Wallingford and at the National Physical Laboratory. The transfer of staff from the latter to Wallingford was completed in September, 1953. As in previous years, work is also being carried out at the Royal Victoria Docks, London, and at the Imperial College of Science and Technology.

TIDAL STUDIES

Work on the large model of the Thames Estuary, which is being carried out by the Port of London Authority in consultation with the Station, continues to be concentrated on the problem of siltation in the Tidal Basin at Tilbury. After a period of trial and error, it was found practicable to reproduce the three-dimensional flow pattern in and around the Basin as it had been shown to exist in nature. Experiments are now proceeding with various means of improving conditions in the Basin using various types of flow-deflecting and excluding structures. The scales of this model are 1/600:1/120.

In the pilot model of the Thames, the scales of which are 1/3000:1/120, a study is being made of the behaviour of storm surges in the estuary. This work is being done at the request of the Waverley Committee, which is considering the effects of the storm and floods of January 31st, 1953. Immediately after the storm two survey teams were sent out from the Station to inspect the storm and flood damage on the East coast. These two teams visited some 22 places on the coast between Margate in Kent and Scarborough in Yorkshire in three days, taking photographs and making notes of the type of damage which had occurred. The model experiments have been designed to determine the effects on tidal levels in the river where it flows through London of (*a*) a tidal surge occurring during a fresh water flood, (*b*) a tidal surge coinciding with high water of spring tides ; also to devise methods of preventing flooding at Canvey Island, Cliffe, Tilbury and Purfleet.

In a model of the estuary of the River Wyre, experiments have been made to determine the effect of stabilizing the low water channel in a westerly position at the Jetty at Burn Naze by means of deflecting spurs of various shapes and lengths. This work has met with some success but is not yet complete.

As the forerunner of a large model for the investigation of the proposed Severn Barrage and its effects on the Severn Estuary, a pilot model of the Severn from Barry to Gloucester has been constructed to scales of 1/8500:1/200. The primary object of this model is to determine a suitable location for the seaward limit of the large model which it is intended to construct in the Main Hall. The model is a replica of that built for an earlier investigation of the Severn Barrage by Professor Gibson, and it is proposed to run the model to see how far it can reproduce the changes which are known to have occurred in the estuary since the completion of Professor Gibson's investigation in 1932.

Research into certain aspects of the reclamation of tidal lands, particularly of those around the Wash, has been started at the suggestion of the Ministry of Agriculture and Fisheries. In considering methods of hastening accretion in the Wash, it is obvious that the drainage of the Fenland must be taken

into account. Investigation shows that the various training works for improving the tidal outfalls of the four principal rivers have not only had the expected subsidiary effect of causing rapid accretion on either side of the trained portions of the outfalls, leading to a rapid advance of the salt-marsh edge, but have also eventually caused deterioration in the channels themselves downstream of the trained stretches. By treating the Wash as a whole, the four outfalls might be improved by suitably-designed extensions to the existing training works and at the same time an additional 50,000 acres or so of saltings would gradually become available for reclamation.

WAVE STUDIES

Research into the effect of sea walls on beaches is still in progress in a wave tank 54 ft. × 10 ft. × 3 ft. A sand bed 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. In the experiments so far carried out, severe erosion has taken place near the wall soon after the insertion of the wall, the profile stabilizing at a lower level after 50 or so tides. Further experiments, to determine the effect of changing the ratio (wave height)/(tidal range), are in progress.

A mobile bed model of Southwold Harbour, Suffolk, to scales of 1/50:1/33⅓, is being 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. Tidal currents will be reproduced in addition to waves and the tidal rise and fall. Data on bed contours, waves and currents are being collected by the Coast Survey Team for this study.

Apart from studies relating to conditions in Great Britain, several investigations are being undertaken for other Commonwealth countries. Two of these are described below.

An investigation, mentioned last year, on behalf of Lyttelton Harbour Board, New Zealand, is being carried out in two models which have been built in Wave Basin 1. Designs for new extensions to the existing harbour are being studied for their effects on siltation and from the point of view of obtaining adequate protection from wave action. One of the models, with scales of 1/600:1/100, is being used to study the deposition and movement of silt under the influence of waves and tides, and has indicated that the mechanism of silting in the harbour has two components. One is the deposition of clay, that is suspended in the water entering the harbour on the flood tide, producing a thin and uniform layer over the whole harbour; the other is the flow of a thick slurry along the bed of the dredged channel which forms a fan-shaped deposit in the harbour entrance. The latter movement accounts for the greater part of the deposition in the harbour. The model has reproduced the normal cycle of siltation in the harbour and inlet satisfactorily. The second model, of part of the inlet to scales of 1/180:1/90, is being used to examine the protection from wave action afforded by various designs, with particular reference to the susceptibility of the harbour to ranging.

In Cyprus, a new power station has been built near the sea at Dekhalia. Sea water is used for cooling, and is discharged through a rectangular concrete channel which runs directly on to the beach. During storms, waves travel up this channel and, in breaking at its upper end, they splash and cover with spray the steel-work of the power station, which in consequence has suffered corrosion. Experiments are being carried out in the 2-ft. flume to find a means of preventing the passage of these waves up the channel. This

has been done by inserting a low broad-crested weir in the channel, the critical flow over which effectively damps out all but solitary waves, and even these are reduced very greatly in amplitude. The weir will be inexpensive to construct and will cause an afflux of not more than 12 in.

RIVER STUDIES

A rigid-bed model to scales of 1/200:1/50 is being constructed to investigate the head losses at certain bridges in the vicinity of Shrewsbury as a preliminary to a general study of a flood relief scheme for this portion of the River Severn.

WEIRS AND SPILLWAYS

The discharge characteristics of a V-flume for the measurement of flow in sewer pipes have been investigated for the Road Research Laboratory. In this study, the V-flume was set with the bed tilted at 1 in 60, the slope of the sewer. In continuation of this work, the behaviour of the flume with its bed-line truly horizontal was examined and found to be more satisfactory.

A new type of air-regulated, vortex spillway has been designed and constructed and is now under test for the maintenance of a constant water level in tanks supplying models.

Three models of a composite weir of standard triangular section, having a central gap for the measurement of low flows, are under construction in the 5-foot flume. This weir has been designed for use at Cefn Brwyn. Scale ratios of Models Nos. 1 and 2 will be 1/8; that of Model No. 3 will be 1/16. Model No. 1 will be placed in a channel moulded to conform with the natural features at the site of the prototype, and its behaviour will be compared with that of No. 2 set in the normal rectangular flume cross-section. Model No. 3 will be set in the narrow rectangular return channel and scale effects will be determined by comparing its behaviour with that of No. 2.

INSTRUMENTS

A new type of propeller current meter has been developed for measuring a wide range of water velocities. The smallest of the propellers is $\frac{3}{8}$ in. in diameter, with helical blades, cut from a solid block of polystyrene. The speed of rotation of the propeller is measured by counting the pulses produced as each blade passes in turn between two fixed electrodes. The instrument is awaiting calibration, but preliminary tests indicate that it will operate at velocities of 0·2 in./sec. upwards to 10 ft./sec.

INTELLIGENCE AND INFORMATION DIVISION

D.S.I.R. HEADQUARTERS

The fields of activity of the Division, its current duties and the principles governing its activities have been described on pp. 21-23 of the report of the Advisory Council. Its service functions include maintaining the H.Q. Library; Records, Press, Publications and Exhibitions Sections; Technical Information and Documents Unit; and Overseas Liaison. In addition, the Division is concerned with providing adequate links between science and Government policy, science and its users, and between research organizations in government, university and industry. Efforts are also made to develop activities in a number of fields relatively new to the Department, such as economics, human factors in industry and industrial engineering.

The Division's prime interest is to ensure as far as possible that research results and research facilities are made known as widely and as effectively as possible; that they are used and the results applied by industry and government more quickly; and that research and development is undertaken on items of real national importance so that major benefits may accrue with increasing speed and efficiency. The work is complementary to that of the Department's Establishments and the Research Associations and though much of it does not lead to published reports, the information accumulated is made freely available to all who are directly interested.

The past year has been notable mainly for work on raw materials conservation and for the development of research programmes on human factors in industry, production economics and industrial engineering.

RAW MATERIALS SURVEYS

Sulphur

Much attention has been given in recent years to the supply of sulphur and sulphuric acid. Following the general survey published last year, assistance has been given to the Chemical Research Laboratory in the preparation of an economic survey of nutrient materials suitable for the microbiological production of sulphur from sulphate. The materials considered included beet sugar residues, whey and several effluents. The only biologically and economically suitable material available in large quantities is sewage sludge.

Pyrites Cinders

Arising also from the general survey of the sulphur position an economic and technical examination was made of the possibility of recovering non-ferrous metals from the pyrites cinders of sulphuric acid plants and at the same time converting the cinders into a suitable source of iron for blast furnaces.

This showed where further research was necessary and the Fuel Research Station, the Chemical Research Laboratory and the British Iron and Steel Research Association are now carrying out additional work on this subject.

Selenium

Selenium is a vital industrial material with many uses. In the electrical industry, for example, it is of necessity used almost exclusively in the manufacture of rectifiers—components which find wide application in all manner of industrial and domestic equipment. The glass industry uses selenium to decolourize glass and also to make various coloured glasses, particularly red glass, and no satisfactory alternative exists. Demand continues to increase and in recent years the shortage of selenium has become increasingly severe. By 1951, the electrical industry was gravely concerned about the scarcity of selenium and this resulted in a request from the British Electrical and Allied Industries Research Association for an investigation. The Division carried out a comprehensive examination of the supply, demand and utilization of selenium, devoted mainly to the possibility of recovering selenium from wastes and residues, particularly from pyrites or pyrites cinders. The Electrical Research Association has agreed to co-ordinate the recovery of selenium from used equipment.

Germanium

Germanium is a possible alternative to selenium in certain of its major electrical applications and it is estimated that the coal mined each year in the United Kingdom contains 1,500 to 2,000 tons of germanium. The germanium is probably mainly associated with the coal substance and no

physical method of concentration is possible. In 1937 the Chemical Research Laboratory showed that germanium is concentrated in the dusts accumulating in certain of the flues in gasworks, and that the germanium could be extracted.

Since the war, large numbers of germanium diodes and transistors have been used in a wide variety of electronic devices. However, despite special efforts by producing firms to collect germanium-rich flue dusts, the present production, which is expressed in pounds, is barely sufficient for research and development purposes, let alone manufacture.

In collaboration with the British Electrical and Allied Industries Research Association the potential demand for germanium has been estimated, and with the Ministry of Materials and others, the potential sources of supply reviewed. In three years time it is estimated that the U.K. electrical industry alone may need 5 tons of germanium a year. In addition, other developments only await adequate supplies; such developments may include its use in the manufacture of fluorescent tubes and various metallurgical applications. It seems unlikely with the present extraction processes that a demand on this scale can be met and alternative methods of improving the supply have been suggested. Discussions are being held with various research organizations with a view to initiating research.

HUMAN FACTORS IN INDUSTRY

The two new joint D.S.I.R.-M.R.C. committees on human factors in industry (*see* D.S.I.R. report 1951-1952, p. 8 and p. 19), have been enabled by an allocation of £190,000 of Conditional Aid funds to initiate research work sooner and on a greater scale than would otherwise have been possible.

A considerable number of research projects have already been placed with universities and research organizations.

The Committee on Human Relations in Industry is concentrating its present programme of research in the following broad fields:

(*a*) factors influencing the effectiveness of incentive payment schemes;

(*b*) factors restricting and facilitating the introduction of new production techniques and methods;

(*c*) characteristics of management organization influencing productivity;

(*d*) factors facilitating the efficient utilization of special groups in industry (e.g. university graduates and married women);

(*e*) promotion and training in industry.

The Committee on Individual Efficiency in Industry has selected the following fields for its initial research programme:

(*a*) the effect of equipment design and working conditions on operator efficiency;

(*b*) factors affecting the efficient utilization of industrial engineering techniques (e.g. time and motion study);

(*c*) industrial training methods.

PRODUCTION ECONOMICS

It has been realized for some years that the Department has an essential interest in the economic factors affecting the support of research, the manner in which research results and scientific knowledge generally are taken up by industry, and the causes, technological, economic and social, that affect industrial efficiency. Some work has been done in this field in the past by the Division, and rather more at certain Establishments and Research Associa-

tions, but on the whole the effort put in has been small. A sum of £75,000 has been made available to the Department over the next three years from Conditional Aid funds to set up a programme of research covering:

(*a*) innovation and the development of new ideas—factors other than sociological that have helped or hindered innovation ;

(*b*) industrial communication systems ;

(*c*) the economics of re-equipment ;

(*d*) the measurement of productivity and causes of variation of industrial efficiency.

An *ad hoc* committee of the Advisory Council has been appointed to advise on the selection of suitable projects and a number have already been placed with research organizations.

In this general context, it can be reported that the Manchester Joint Research Council's survey of technological resources and the requirements of industrial firms in N.W. England has been completed. The report will be published shortly.

INDUSTRIAL ENGINEERING

For the past few years there has been considerable interest within the Division in the techniques (mainly motion and time study) of industrial engineering and in 1952 activities were extended. A member of the Division has concentrated on stimulating interest over a wide national field, by advisory services and numerous lectures to the Trades Union Congress, the National Coal Board, the Naval Motion Study Unit, technical colleges and industrial organizations such as the British Association for Commercial and Industrial Education and the Industrial Welfare Society. In addition, advice and information has been given to a number of Research Associations on industrial engineering matters.

The past year has been devoted to assessing what demands exist for expert advice and information. It emerges clearly that there is a rapidly developing demand, stemming from growing industrial interest in methods study, time study, materials handling, etc., for advice and information on these matters. With the help of Conditional Aid funds it will be possible to provide a small advisory service in this field.

REGIONAL ACTIVITIES

A Liaison Officer was stationed in Wales during 1952 by arrangement with the Industrial Association for Wales and Monmouthshire. His activities were so successful that, at the request of the Office for Welsh Affairs, it has been decided to set up a Welsh Office of D.S.I.R. for an experimental period of five years. The Welsh Liaison Officer took up his duties in Cardiff on 1st November, 1953. His duties will be similar to those of the officer who has been in Edinburgh for some years.

OVERSEAS SCIENTIFIC ACTIVITIES

The volume of scientific research work continues to increase in many countries. To supplement the information which is available in published reports, the Department has representatives in several foreign countries (see Appendix VIII). These representatives are maintained for the benefit of all Government departments and of industrial organizations. Besides submitting reports on the important developments in scientific organizations and research in their areas, the representatives abroad have a variety of other duties. They advise H.M. Ambassadors on scientific questions ; they receive important

scientific visitors from the United Kingdom; they represent the United Kingdom at important scientific conferences and they establish friendly relations with those responsible for scientific work in their areas.

Frequent proposals for international co-operation in scientific research are reaching the Headquarters of the Department. These come from such organizations as U.N.E.S.C.O. and O.E.E.C. with its constituent European Productivity Agency. Some proposals arise because the cost of the research equipment is very high. This consideration has assisted in the formation of the European Organization for Nuclear Research.

Others of a more specific nature arise, through O.E.E.C., because the same practical problem confronts several countries. Several technical working parties have been set up by O.E.E.C. to study such problems as the uses of tonnage oxygen, new coking processes, desalting of brackish water etc. These working parties study the problems and identify present research needs, which may vary from the provision of specialist bibliographies or abstracts to practical development work financed and operated jointly by interested countries. The latter course is being considered in respect of several selected processes for desalting brackish water. The Division undertakes technical and administrative liaison work between the O.E.E.C. secretariat and the appropriate U.K. interests, with a view to ensuring that proposals for international co-operation in research work are adequately considered.

MECHANICAL ENGINEERING RESEARCH

Following last year's transfer of much of the work of the Laboratory to East Kilbride, the current year has been one of consolidation rather than of any marked expansion. The Hydraulic Machinery building was, however, rather more than half completed at the end of the year and it is hoped to start the Heat Transfer building in the spring of 1954.

The greater part of the research programme is of direct interest to other Government departments, notably the Defence Departments, and increasing calls are being made upon the Laboratory by industry for advisory and test work.

Only selected items are described below since it is not possible to cover the whole programme in the space available.

DIVISIONS A AND B—MECHANICS AND MATERIALS

Properties of Engineering Materials under Static and Fatigue Loading

Work on the effect of size of specimen on the fatigue strength of notched and unnotched high-strength aluminium alloy DTD 683 is nearing completion and a similar investigation has begun on aluminium alloy DTD 364. Tests are being carried out under conditions of fluctuating tension. In addition, the alloy DTD 364 is being used in tests to obtain design data for simple pin joints under static and fatigue loading; this is one of the basic design problems in the aircraft industry. It is already apparent that fretting plays a large part in reducing the fatigue strength of a joint, compared with that of the material.

A knowledge of fatigue strength of aluminium alloys and alloy steels at stresses well above those usually investigated is required for the economical design of parts intended only for a known limited life, and a programme of fatigue tests is being undertaken to provide this information. Fatigue tests under conditions of plane bending on an aluminium alloy sheet material

are nearing completion for endurances between 500 cycles and 20 million cycles. Apparatus is being constructed to obtain information at even shorter endurances.

Fatigue Strength of Screw Threads

Fatigue tests have been carried out on larger screw threads of 64 mm (2½ in.) diameter, the material being a mild steel of 34 tons/sq. in. tensile strength. The threads were ground and were of 4 mm and 6 mm pitch respectively. Some size effect was found, the fatigue strength of these large threads being roughly 20 per cent. less than would have been estimated from ⅜-in. diameter threads. Experiments are in hand to determine the effect of cold-rolling the roots of pre-cut threads. Preliminary tests on ¾-in. studs indicate that with material of 63 tons/sq. in. tensile strength, the fatigue strength obtainable is as great as from threads completely rolled.

Investigation of Crack Propagation

Further tests under combined fatigue stress (bending and torsion) have been carried out on square section specimens of aluminium alloy DTD 364. As in the case of aluminium alloys RR 59 and DTD 683, the fatigue cracks seem to originate and propagate under the action of principal tensile stress for all combinations of bending and torsion.

Creep, Relaxation and Plastic Strain under Combined-Stress Systems

During the year, laboratory equipment for work on materials subjected to high temperature and complex stresses has been installed and put into operation. Tests to determine the stress/plastic strain relations of aluminium alloy RR 59 at 20, 50 and 200°C and of 0·17 per cent. carbon steel at 350 and 450°C and up to plastic strains of 2 per cent. are nearly complete. A theoretical analysis of the first group of tests indicates that, for RR 59, general and simple loading stress-strain relations are similar in form.

Examination of the general loading criterion for creep of a magnesium alloy at 20°C has been carried out by means of tests in which, to an initial tensile load, successive increments of torsional load have been added at intervals of 200 hours. Creep curves for successive periods of 200 hours have the same composite curved form, and anisotropy, where it occurs, is precisely as in the virgin material. The whole of the data is well represented by an expression in which the strain-energy term of the relation between creep rate and stress is modified by subtracting a term proportional to the previous creep strain.

Creep and recovery tests at low strains corresponding to creep rates of the order of 10^{-9} to 10^{-5} per hour have been completed on aluminium alloy RR 59 and similar tests are in progress on magnesium alloy. The work will be completed by carrying out relaxation tests in the same range of creep rates. Time- and temperature-dependence of the creep of a magnesium alloy is under examination, together with the criterion of fracture under combined-stress creep conditions of a fully-annealed pure copper.

During the year, the work of compiling the Third Report of the Pipe Flanges Committee of the Institution of Mechanical Engineers has been undertaken and completed.

Gas Cylinders

Technical advice to the Home Office about proposals for gas cylinders and containers which do not comply with present regulations has continued. Mechanical tests have been made on various types of seamless cylinders and welded containers. A test on a cylinder made from a high tensile carbon

steel (approx. 60 tons/sq. in. tensile strength) showed that the cylinder had very little capacity for permanent expansion before bursting under internal pressure. Investigations of accidental cylinder failures have been made in conjunction with the Metallurgy Division, National Physical Laboratory.

Some study has been made of the general design features of gas cylinders with special reference to international standardization and proposals have been prepared for the International Standards Organization for filling ratios to be used for mixtures of liquefied hydrocarbon gases.

Failures in Service

Parts and assemblies which have failed in service continue to be sent to the Laboratory for comment and advice. Items examined during the period include a fractured bucket from a Pelton wheel, a ship's rudder post, valve springs from a car engine, hardened gear spindles from textile machinery, the stub axle from a racing car, a deep well boring bit, and large diameter water mains; assistance has been rendered in each case.

DIVISION C—FLUID MECHANICS

Research is proceeding in temporary quarters at East Kilbride using comparatively small-scale apparatus specially developed for the work. Problems connected with the special plant and equipment required for the new Hydraulic Machinery laboratory continued to absorb a large proportion of the total effort.

Flow Measurement

Experiments on pitot-tubes in water have established that flutter at higher speeds affects the tube coefficient, but that the phenomenon can be virtually eliminated by the use of a supporting strut having an aerofoil instead of a circular section. Reynolds-number experiments on pitot-tubes in air have shown the existence of three regimes of instrument behaviour corresponding to a laminar range, a transitional zone and a turbulent zone respectively. The lower limit of useful application of present designs of pitot-tube was found to be of the order of $R_n = 500$ (based on tube diameter).

Cavitation

Cavitation phenomena are being investigated in a venturi throat forming part of a small variable-pressure closed circuit, the present objective being to determine quantitatively the effects of air content and absolute pressure on incipient cavitation. As part of this research, apparatus specially designed to measure air content has been found to be quicker in action and more accurate than conventional methods.

Experiments under extra-departmental contract, using apparatus of the magneto-striction type, are concerned more particularly with the physico-chemical effects of cavitation on engineering materials.

Improvement in the Performance of Pumps and Fans

Two closed circuit research rigs have been designed for investigating flow conditions in centrifugal and axial flow pumps up to 25 h.p. The pumps are electrically driven by specially developed "swinging field" type dynamometers which maintain any set speed over a 10 : 1 range with less than $\pm$ 0·1 per cent. error. Frictional errors in conventional forms of trunnion support have been made negligible by using contra rotating bearings, and also air lubricated bearings. The torque is taken off the motor casing through a hydraulic piston and rotating cylinder mechanism which almost entirely eliminates friction.

Flow in Nozzles and Diffusers

Aerodynamic studies have begun on the first of a series of straight conical diffusers. Changes in laboratory temperature distribution were found to cause inconsistencies in performance. These effects were eliminated by modifying the design of diffuser inlet.

Experiments on the swirling flow of water through a nozzle have confirmed mathematical ideas that a thin boundary in the vicinity of the air core rotated as a solid body. The work is proceeding under extra-departmental contract at the University of Cambridge.

Scale and Roughness Effects

A critical analysis of existing formulae used for scaling-up the performance of model water-turbines has led to the conclusion that Reynolds-number corrections should be applied to only part of the losses. A new formula is suggested for variable-pitch blade turbines which provides a means for scaling-up not only optimum efficiency but also the efficiencies at other than optimum conditions.

As part of the work on scale effect, an analysis has been made of the influence of surface roughness on the performance of a venturimeter. It is established theoretically that although roughness effects in the upstream piping can be made negligible, the surface roughness in the meter itself is important and can account for appreciable changes in the performance of a flow-meter in service.

Scavenging of Two-stroke Engines

Investigations at the University of Cambridge on loop-scavenging in two-stroke engines have continued using a water model to show the vortex formation in the flow. The axis of the vortex is found to be unstable about its commonly-assumed position. Experimental study of the mixing characteristics of an impulsive jet using colour-reacting fluids has continued, and fresh data have been obtained for multiple parallel jets injected simultaneously.

DIVISION D—LUBRICATION AND WEAR

A comprehensive programme of research has been followed during the year with particular emphasis on the operation of bearings at higher speeds and on the elucidation of some fundamental aspects of the wear process.

Plain Bearings

Pending the construction of two machines of 100 h.p. output designed to operate at speeds up to 60,000 r.p.m., experiments have been carried out on small-scale apparatus running at moderate speeds. This has demonstrated the effectiveness of the air-gauging method for measuring attitude and eccentricity of journal bearings, but has revealed that bearings may tilt as loading conditions are changed. Friction torque at a given speed has been shown to be virtually independent of load, whilst the amount of oil demanded by a bearing increases both with speed and load. As speed is increased the amount of heat dissipated in the lubricant also increases. Its viscosity consequently falls and this causes eccentricity to increase, thereby increasing the pumping action of the bearing so that equilibrium conditions are restored. The implications of these effects are being explored for the benefit of designers.

Rolling Bearings

The study of the behaviour of bearings at relatively high temperatures has been continued ; bearings have been run at speeds of 20,000 r.p.m. for

about thirty hours at a temperature, measured at the inner race of the bearing, of 300°C. Conventional mineral-base lubricating oils failed to withstand these conditions and synthetic lubricants specially developed for use in gas turbines were shown to be necessary.

Lubricating Greases

Whilst a considerable amount is known about the constitution of lubricating greases and its effect on their rheological properties, the actual mode of action of a grease in lubricating a bearing has hitherto received little attention.

By a theoretical consideration of the rheological aspects of lubrication, with lubricating grease regarded as a Bingham fluid, it has been possible to write down equations governing its action in a bearing which are analogous to Reynolds' hydrodynamic equations.(1) An important conclusion of this work is that the plastic viscosity rather than the apparent viscosity becomes the important criterion of grease as a lubricant.

In a second investigation, new and used greases have been examined in the electron microscope. This has shown that in grease taken from different parts of a roller bearing after varying times of operation the fibre structure characteristic of a lubricating grease is rapidly broken down in those parts of a bearing where the grease is subject to severe working.

Wear

It has been suggested by Kramer in Germany that metal surfaces which have been abraded or otherwise worked emit electrons over a period of time. The emission can be detected by a special Geiger counter open at one end. Investigations in the Laboratory have demonstrated that the particles which actuate the counter are not electrons but charged oxygen molecules. Their rate of emission from an abraded surface is very much increased if energy in the form of light of a particular wave length is supplied to the surface. Experiments on the true nature of these emissions have led to the tentative conclusion that they arise from the oxide structure formed at the surface during the process of abrasion.

A parallel investigation has shown that the blackening of a photographic plate when placed close to an abraded surface is due to the formation of hydrogen peroxide near the freshly abraded area. It has also been shown that metals when cut under water give rise to the formation of hydrogen peroxide.(2) It is thought that the emissions referred to previously are the cause of the formation of this peroxide.(3)

Practical implications of the work in the realm of lubricant technology are twofold. In the first place, it is possible that the action of abrasion may produce chemically-modified surface layers on bearing metals which account for their wear resistance; furthermore, the formation of peroxides on freshly-worked surfaces may be a contributory factor in the deterioration of lubricating oils in service.

Scuffing

Work on the nature of failure by scuffing has shown that the degree and nature of surface roughness have important effects.(4) It appears that slight irregularities at right angles to the direction of relative motion are beneficial in preventing scuffing. Whether this is because they provide oil reservoirs or because they shorten momentary contacts is as yet unknown.

Pitting

An account has been published(5) of experiments made on simplified angular-contact bearings consisting of three balls free to rotate in an outer

race, a fourth ball forming the inner race. The fourth ball was sectioned for metallurgical examination after experiments of varying duration, and incipient cracks were detected below the surface.

Mechanical Engineering Aspects of Corrosion

Fretting-corrosion is a term used to describe the surface damage occurring between two closely fitting surfaces subject to slight vibrational movement. Research aimed at obtaining quantitative measurements of the degree of fretting damage has shown that considerable reproducibility can be obtained. It is thus possible to correlate the degree of damage with such variables as total number of oscillations, load, or atmospheric humidity.(6) Humidity variations have been shown to have a pronounced effect on both the form and total amount of damage, and this probably accounts for the large discrepancies between the observations of different workers.

Although most of the measurements have been made using lapped carbon-steel specimens, some results were obtained with other materials such as chromium, nickel, and gold. Nickel plating has been advocated as an anti-fretting surface, but the experiments clearly show this to be ineffective, unless it can be assumed that it has the additional effect of reducing the slip between the two surfaces. From the results obtained with lubricated phosphated surfaces rubbing against a steel flat, this form of surface preparation can however be strongly recommended for inhibiting fretting-corrosion.

DIVISION E—MECHANISMS AND METROLOGY

Metrology

During the course of the year, the recalibration of precision measuring equipment, transferred from the National Physical Laboratory, has been completed. Much work, particularly on the measurement of gears, has been carried out for industry and the Service Departments, as well as for other divisions of the Laboratory. It is hoped to reduce the amount of test work handled by the Division by delegating the responsibility for final examination to manufacturers. This has already been done in the case of one firm making gear-cutting hobs for the Admiralty, after the firm's inspection equipment had been examined and approved by the Division.

A new portable instrument for measuring profile errors on large marine gears has been completed and used on several sets of gears for the Admiralty.

Servo-mechanisms and Instrumentation

Work on the design and development of the prototype apparatus for both torque and vibration measurements on small high-speed precision ball-bearings for the Admiralty is nearing completion. Tests have been successfully carried out at speeds up to 45,000 r.p.m. at varying axial and radial loads, and further work is now being carried out to provide data for the final design of the high-speed ball-bearing test rig. The drive for this rig will consist of a motor mounted on air-lubricated bearings, which has been designed and is at present under construction in the central workshop of the Laboratory.

The application of electronic and pneumatic techniques to the accurate measurement of moving parts is being investigated, and two instruments are now in the final stages of development. In one of these an electronic capacitative gauge is used to check continuously the vertical alignment of the hob saddle traverse of a gear-hobbing machine relative to the axis of rotation of the main table. In the second machine, pneumatic techniques are used for the automatic measurement of pitch errors in gear teeth, and gears of up to 200 teeth can be measured without manual aid or supervision, the pitch errors being presented graphically on chart paper with an accuracy of 0·00005 inch.

Heavy Mechanisms

As part of the work on deflection of gear teeth under load a series of curves has been derived for the static deflection of a gear loaded through a basic rack, the loads being applied at various points over the working face. On the theoretical side comparisons are being made between results obtained by simple bending and a combination of bending, shear and Hertzian deflection. The deflection of gear teeth under dynamic conditions is also being studied by loading the gears in a specially-constructed power circulator. The deflection of the teeth during the load cycle is measured by phase-displacement of signals obtained from transducers placed in loaded and unloaded positions on the gear. The work has shown the stability and sensitivity of the instrumentation to be satisfactory. However, the measurement of transients has proved to be difficult and steps are being taken to improve the response of the equipment.

Two power circulators are being used to investigate the relative load-carrying capacities of gears manufactured by different machining processes, particular reference at present being made to hobbing and shaving. The specimens are manufactured, under close inspection, in the Laboratory workshop, and then put through a rigorous metrological inspection. During running tests a close inspection is made every million cycles, any phenomenon appearing being photographed. Other data, such as change in hardness, surface finish and physical wear, are noted.

Fundamental work has been carried out to provide a further understanding of the mechanism of pitting in curved elastic surfaces subjected to cyclic loading. Spherical surfaces have been used up to the present and have been examined by micro-inspection and non-destructive flaw detection. The results indicate the tendency of the surfaces to fail by cracking. The cracks appear to start on the outside and work into the material, the depth of penetration being dependent, to a certain extent, on the load applied.

A critical approach to the understanding of losses arising in power transmission units has been made. As a first step a precision dynamometer, which can accommodate units up to 75 h.p., has been designed and is in the process of being erected, the speed range being limited to 6,000 r.p.m. It is hoped to be able to approach an accuracy of torque measurement of 0·1 per cent. The design of a larger machine, having a capacity of 300 h.p., is being considered.

DIVISION F—PLASTICITY

Theoretical and Crystal Plasticity

A method(7) has been evolved to compute the combined stresses under which an isotropic aggregate of face centred cubic crystals (among metals with face centred cubic structures are aluminium, copper and nickel) will yield plastically. The way in which the individual grains rotate when various stress systems are applied to the specimen is being studied. This will make it possible to predict the preferred orientation developed when the material is subjected to such stress systems.

The majority of current solutions to problems in plasticity consist of a deformation mode compatible with the displacement boundary conditions and a stress solution in the plastically-deforming region only. An investigation has been made to determine under what circumstances the partial stress-field can be extended to the remainder of the body, thus enabling the actual yield-point load to be determined.(8)

Plastic Properties of Materials

A general programme of investigation into the properties and behaviour of materials under hydrostatic pressure is in progress. In the theory of plasticity it is commonly assumed that moderate hydrostatic pressure has no significant effect on the yield characteristics of metals. The current investigation will provide fundamental data on the behaviour of metals under pressure and will indicate the range of pressures in which the yield stress is unaffected. The work will assist in clarifying the conflicting results reported to date and is specially relevant to such processes as forging and extrusion, in which plastic deformation occurs under high hydrostatic pressures.

Mechanics of Formation of Materials

The study of the basic principles governing the plastic deformation of metals in press- and drop-forging processes is being continued on the lines described last year. This study should assist in arriving at a better understanding of the properties of forgings and in placing industrial forging techniques on a scientific foundation. The work of determining the factors governing the resistance of a material to deformation and the force required to produce a given shape by compression is being continued. Particular attention is being given to the modifying influences of the type of deforming process, the effect of lubrication, and the surface condition of the metals and dies. From the data obtained, it should be possible to evaluate the force or energy required to produce a given deformation in a simple geometrical body from empirical consideration.

A theoretical examination of sheet drawing under back-pull through a rough wedge shaped die has been concluded.(9) The calculations are based on a plane-strain slip-line-field theory which takes into account the redundant work performed in the deformation. This is in contrast to the earlier theories of drawing in which the deformation is assumed to be homogeneous. The results are summarized in terms of a single empirical formula which expresses the drawing stress as a function of die angle, coefficient of friction, back-pull and reduction. This investigation extends the work of previous authors, in which reductions were determined for uniform die pressures, to reductions in which the die pressure varies along the die.

Mechanics of Shaping of Materials

The micro-technique, originally developed for measuring tool wear with the minimum expenditure of work materials, has been used to study the machining characteristics of a number of steel bars of varying composition. In general, considerable variation in tool wear has been observed as the diameter of the bar material being machined is reduced. In some steels, tool wear has increased, whilst in others it has decreased. In most cases, however, it has been possible to ascribe these inconsistencies to some variation in the metallurgical condition of the bars. Investigations of the effect of cutting temperature and friction on tool wear are being made in order to ascertain the factors governing tool life and to establish some fundamental mechanism of tool wear. It is hoped that the data obtained will be both of direct benefit to the machining industry and of fundamental significance.

A theoretical investigation has been made of the distribution of temperature in the work material, the chip and the tool during the cutting operation. In the cutting process energy is dissipated during the plastic distortion of the material and this appears in the form of heat. The present method employs distributions of heat sources to simulate the conditions occurring in the actual process. A mathematical technique has been evolved for solving the problem whatever the boundary conditions. It cannot be applied without further data on the boundary conditions occurring in practice.

DIVISION G—HEAT TRANSFER AND THERMODYNAMIC TABLES

Heat Transfer

A survey of a part of the literature on heat transfer covering the period 1948–50 has been accepted by the Institute of Fuel for publication and further surveys on a permanent and more comprehensive basis are planned. In addition, a detailed survey is being made of all the data relating to natural convection from vertical surfaces.

Preliminary runs have been made in the investigation of the effect of bends and elbows on the heat transfer from a pipe wall to water flowing through it, using a right-angle bend having a pipe-radius/bend-radius ratio of 0·125. It is intended to investigate a range of bend-angles and radii ratios at Reynolds numbers up to about 100,000.

The investigation of the effect of an abrupt change in cross-sectional area of a pipe on the coefficient of heat transfer from the pipe wall to water flowing through it has been extended to cover the case of abrupt convergence. It has been found that for Reynolds numbers in the range 4,000 to 100,000 the local coefficients are less affected by the change of section than in the case of abrupt divergence. Work is now in hand to extend the range of Reynolds numbers and later to vary the ratio between the diameters.

In connection with the Home Office interest in estimating the safe filling limits for gas cylinders, a theoretical investigation has been made into the maximum temperature to which the contents of such a vessel will rise when, starting from an arbitrary temperature, it is exposed to surroundings where the temperature varies in a manner similar to the natural variation of air temperature during a period of 24 hours.

Work carried out under contract has included that at Queen Mary College, University of London, on measurements of heat transfer in dropwise condensation.[10][11] A substantial difference has been found between the performance of tubes and plates under these conditions. New work has commenced on the fundamental chemistry of substances which promote dropwise condensation with a view to understanding their mechanism and to developing a promoter which either produces prolonged dropwise condensation or, alternatively, if required to be used continuously, does not cause trouble in other parts of the system. A number of organic materials theoretically possessing the requisite properties have been synthesized and an apparatus to investigate their "life" as promoters is under construction. Subsidiary experiments have also been made in which steam has been allowed to condense as a film on the outside of threaded tubes to compare their performance with plain tubes.

In addition an investigation has been made into the effects on heat transfer of the presence in steam of substantial amounts of carbon dioxide. The results are only applicable quantitatively to the geometrical arrangements existing in the experiments. It was found that the resistance to heat transfer increased rapidly with increasing proportions of carbon dioxide in the steam and that for concentrations exceeding 5 per cent. the heat transfer rate is largely controlled by the steam side conditions.

Work has continued at the Imperial College of Science and Technology on heat transfer between solids in contact. A new programme has been started to extend the work to intermittent contact and to cover a wider range of surface conditions. Experiments on heat transfer to a fully developed turbulent airstream flowing in a duct at subsonic and supersonic speeds up to a Mach number of 1·6 and a Reynolds number of 40,000 was completed during the year. It was demonstrated that the data could be brought into good agreement with the formulae for incompressible flow in pipes when allowance is made for compressibility effects and the influence of the pressure gradient along the pipe. Simple relations developed for heat transfer and friction were found to fit the experimental data within ± 6 per cent.

Research at the University of Cambridge on heat and mass transfer in the combustion of fuels on solid surfaces has continued.([12]) The theory, supported by considerable experimental evidence, indicates that if the aerodynamic conditions are known or if heat transfer data are available, the burning rate of any type of fuel can be predicted. In addition, a theory which attempts to explain certain flame extinction phenomena is being developed.

Thermodynamic Tables

In the scheme for the production of thermodynamic tables, surveys of data for ethylene and argon and a temperature-entropy diagram for propylene have been received, making a total of eight substances for which reports are available to enquirers.

The collection and correlation of viscosity and thermal conductivity data for industrially-important substances is proceeding. Theoretical studies on the relation of viscosity and thermal conductivity to density and temperature are being made. A general correlation for the viscosity of gases in terms of their critical point properties has been established.

The co-ordinated research programme on the investigation of the thermodynamic properties of mixtures has continued at the National Physical Laboratory, and under extra-departmental contracts at the Imperial College of Science and Technology, London, and Manchester University. Equipment for pressure-volume-temperature measurements is nearing completion at the National Physical Laboratory. At the Imperial College, a new Joule-Thomson apparatus has been perfected and has given reliable results in an indirect method of determining the latent heats of binary mixtures. The Manchester University group have made further isothermal Joule-Thomson measurements on mixtures([13]), and have developed a new expansion valve capable of giving results over a wider temperature range. More theoretical work on the application of statistical mechanics to mixtures is being carried out there.

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NATIONAL PHYSICAL LABORATORY

Some years ago a temporary lecture hall was provided by the conversion of an old wind tunnel building. This proved of great benefit to the whole establishment. Information and scientific meetings are frequently held in it and a series of international symposia at the rate of two per annum has been started. It is intended that one of these symposia each year shall deal with a fairly fundamental scientific subject and that the other will be primarily of industrial importance. Subjects already covered are recent developments in the maintenance of standards, ultrasonic flaw detection, the elastic properties of metals and automatic digital computation. In general the symposia have been well attended by visitors from abroad as well as by representatives of various organizations in this country, and numbers have been limited by the capacity of the hall.

Staff changes have necessitated some rearrangement of the work of the High Temperature Mechanical Properties Section and, in view of the close connection between this work and that of the Metallurgy Division, the Section has now been made part of that Division pending its ultimate transfer to the Mechanical Engineering Research Laboratory four or five years hence.

A significant proportion of the effort of the Laboratory has continued to be devoted to work of direct or indirect importance to defence. Good progress has been made in the construction of buildings for housing new high subsonic and supersonic wind tunnels and in the laboratory for work on ceramics, X-ray crystallography and the application of radioactive tracers to metallurgy.

AERODYNAMICS DIVISION

The main part of the work continues to be long term basic research. Buildings are under construction for housing compressors and new wind tunnels for research on problems of high subsonic and supersonic flow, such as the determination of the characteristics of aerofoils, with and without controls, for high-speed aircraft. For the detailed examination of air flow, modifications of schlieren methods have been developed using a spectrum band for obtaining coloured photographs and a graded filter for improved black and white photographs. A condenser with a ceramic dielectric of high permittivity has been used to give a spark of very short duration which provides enough light for flash photographs. Extensive studies are being made of the interaction between shock waves and the boundary layer at the surface of a body.

To assist aircraft firms in their designs, tests have been made on prototype models of aircraft in the Compressed Air Tunnel especially for determining maximum lift under full scale conditions. Calculations and experiments are being made on swept-back wings, with various plain ailerons, to provide information on the properties of such wings, and methods are being tried for the prediction of these properties in steady and unsteady motion. Improved methods have been devised for calculating profiles having given pressure distribution, with extension to compressible flow (subcritical speeds) and to oscillating aerofoils. Much work has been done on the measurement and calculation of the aerodynamic forces on oscillating wings of finite aspect ratio ; there is evidence that there might be a loss of pitching moment damping at high speeds which would reduce the stability of high speed aircraft and which might induce flutter.

A re-examination of the calibration of the NPL standard pitot-static tube has shown that the pressure at the static holes is about 0·4 per cent. greater than the stream static pressure. It is interesting to note that the application

to the 1912 results of sundry very small corrections, which were not appreciated at that time, shows a probable error of just about this amount. The recent work has led to a proposed new standard design having a section through the nose of the two halves of an ellipse, separated by the total head tube.

A gauge has been designed for measuring pressure differences to an accuracy of a few ten-thousandths of an inch of water. The gauge will be used mainly with pitot tubes of small dimensions and its capacity has therefore been kept small. The instrument will be specially useful for the measurement of low velocities in air ducts and ventilating shafts. Another sensitive instrument designed in the Division is a remotely-controlled traversing yawmeter that can be located in position to a thousandth of an inch and in rotation to 0·05°. This instrument is useful for exploration of flow in fields where velocity changes are rapid.

Among models that were tested for wind forces were flag poles and an arch design for Coronation decorations. Landscape models have been used for determining the best height for factory and power-station chimneys and for finding the shapes of smoke plumes from the chimneys. Flow over ships is being examined to prevent draughts and to lessen smoke nuisance from ships' funnels.

ELECTRICITY DIVISION

Two items of work that have reached an interesting stage during 1953 are the standard frequency transmissions and the investigation of industrial insulating materials. In May the original skeleton programme of standard frequency transmissions was replaced by a complete 24-hour service on three frequencies −2·5, 5, and 10 Mc/s. The signals are modulated at regular intervals so as to provide a standard note of 1,000 c/s, and standard seconds pulses. The errors of the carriers and modulations transmitted do not exceed 2 parts in 10^8. A leaflet giving full details of the service has been issued. The transmissions are made from the Post Office station at Rugby under the call sign MSF and are received and monitored automatically at the Laboratory. The deviations of frequency arising from unavoidable changes in the transmission path have proved to be remarkably small during daylight hours, the records showing that frequencies accurate to 2 parts in 10^8 have been available to most users. At night, the received signals are stronger but subject to variations of ± 2 parts in 10^7. A special transmission at 60 kc/s, limited to 1 hour per day, is being continued because it is free from such effects and thus makes available throughout the U.K. and beyond a single standard frequency with an accuracy of ± 2 parts in 10^8; even higher accuracy can be obtained by using corrections which are published monthly. This transmission should save much duplication of expensive and elaborate equipment in all laboratories where the full accuracy of a primary standard is from time to time needed.

The work on insulating materials consists of a survey of the basic dielectric properties of four representative classes of industrial materials, chiefly the newer plastics, and an examination of the relation between the properties desired in electrical practice—low power factor and a permittivity independent of frequency and temperature—and the chemical structure of the material. The work provides the development engineer with some insight into the limitations of the materials at his disposal and the directions in which improvement is most likely to be obtained. The paper describing this investigation(1) has been awarded the Mather Premium of the Institution of Electrical Engineers.

In the Electrotechnics Section the development of a relatively high-power electronic test set for frequencies from 50 c/s to 4,000 c/s has made good progress. The equipment is required to fill the gap between the audio-frequency electronic test set operating at frequencies from 1,000 c/s to 100 kc/s and the rotating machine test sets operating at frequencies up to 100 c/s. It is intended also to use the new equipment for low-power tests at 50 c/s. The problems associated with the oscillator and amplifier have been successfully solved, and a stable single-channel supply of 700 watts is now available. Work on the development of a double-channel supply with the appropriate phase-shifting apparatus is going forward.

An investigation has been started on the electrical properties of nickel-chromium and aluminium alloys. These materials appear to be suitable for the construction of resistance standards which have to remain accurate when subjected to considerable temperature changes due to self-heating. First results are very encouraging.

In the High Voltage Laboratory, the performance of the high-voltage absolute voltmeter has been investigated and an account is being prepared. The voltmeter has been used up to 400 kV peak, this limit being imposed by the temporary lead-in terminal; it is hoped to replace this bushing by one of more suitable design and so to increase the maximum working voltage to 700 kV peak.

A paper has been published which discusses the surge voltage measuring technique,[2] also one describing a null detector for use in power frequency bridge circuits.[3] The measurements on the light from sparks have been described, and the reconstruction of the equipment for use in surge corona studies is nearing completion.

The investigation of the surge characteristics of modern high voltage cables has been completed and a paper published[4]; the work has been extended to examine the effect on breakdown of conductor shape, paper tape thickness, method of wrapping, etc.

During the year a start has been made with the re-equipment of the HV Laboratory, mentioned in the last report. The general design of the new surge generator has now been decided; it will have an open circuit voltage of 3·2 MV and a stored energy of 77 kW.sec. The installation of the equipment, which is scheduled for completion this year, will require considerable modification of the layout of the Laboratory and extensive civil engineering work. It is hoped that the rectifiers for the experimental million volt d.c. supply will at last be available in 1953. In addition the 25 year old transformers which provide the million volt power frequency supply need replacing and modern equipment less extravagant in space requirements is being sought.

LIGHT DIVISION

The lighting industry and research workers in various fields need lamps of standard design and performance and with the use of more precise photoelectric methods of photometry, the requirements for such lamps are more exacting. The details of a new range of standard lamps of satisfactory design have been agreed with a lamp manufacturer prior to large scale production.

Improved methods are being introduced for the comparison of the directional intensities of lamps and for the determination of the performance of rear reflectors. The increased efficiency and larger size of rear reflectors now being used make it essential to replace the direct point-source comparison method of measurement previously employed.

For certain photometric measurements, particularly at low intensities, a photoelectric method in which the individual photoelectrons are counted has

advantages. Equipment for doing this, including a fourteen stage multiplier tube, has been installed and the potentialities of the method are being explored.

Fundamental work on the primary standard of light and the basic colour-matching data of colorimetry has continued. In a paper([5]) summarizing investigations of the colour mechanisms of the eye by threshold measurements, it was shown that more than three mechanisms have to be taken into account. The spectral sensitivities of the three main mechanisms are representable approximately by linear combinations of the spectral sensitivities obtained by the very different method of colour-matching. Other work on vision has included an approximate determination of the brightness level at which the mechanism responsible for the colourless vision provided by the dark-adapted eye ceases to play any effective part.

The study of the methods of producing narrow band colour filters on the Lippmann principle is nearly complete. A satisfactory method of emulsion making has been worked out which gives without fail the ultra-fine grain necessary for Lippmann filters over a wide range of concentrations both of gelatin and of silver bromide. The method is easily modified for the production of other types of emulsion up to the speed and general characteristics of a process plate. In the production of high resolution filters, necessitating a rather thick emulsion layer (about 200 μ), the only problem as yet unsolved is uniform development through the whole thickness of the emulsion, and work is proceeding in an attempt to perfect the method of so-called temperature development for this purpose.

A paper([6]) describing the measurement of the spectral absorption of a radiometer target from the ultra-violet to a wavelength of 13 microns has been published. This work has included the appraisal of at least one commercial matt black lacquer, whose high and substantially uniform absorption over the whole of this wavelength range makes it particularly useful as a non-selective target coating for radiometers of all kinds.

On behalf of the British Standards Institution, a simple method has been devised and used to measure directly the total heat absorption due to the anodic coating on anodized aluminium sheet, as used in reflectors of electric and other radiators.

For the Joint Fire Research Organization, a determination has been made of the infra-red spectral absorption curve of fibreboard, using a new method probably applicable to a wider range of materials having low thermal conductivity.

Substantial progress has been made with the installation of apparatus for measuring on an absolute basis the spectral distribution of energy from sources of all kinds, particularly those whose ultra-violet output is of special interest.

Results are now awaited on the prototype production and trial, by the Ministry of Supply, of the gold-film-coated, electrically heated windows mentioned in last year's Report (p. 74). Optical beam-splitters have been developed consisting of a sputtered quarter-wave film of bismuth oxide on glass and supplied for trial in commercial interferometers used for gauge testing. Their optical performance for this purpose is greatly superior to that of aluminium or silver films, while they are likely to be at least as convenient and cheap to make.

A major difficulty in the application of interferometric methods to the testing of optical instruments lies in the interpretation of the results. A new technique has been devised, and is being developed, which should be particularly useful in such applications as the comparison of high quality, optically

flat surfaces, the examination of the flexing of plates and in distinguishing oblique from axial aberrations in lens systems. The technique has been termed parallactic interferometry, and a description is in course of publication.

The development of the method of making diffraction gratings suggested by Sir Thomas Merton has widened into an extensive programme and now embraces a group of seven patents administered by the National Research Development Corporation, which has issued licences to two British firms. Interest has also been shown by firms in the U.S.A. Gratings made by the Merton-NPL processes have proved especially valuable in infra-red spectroscopy and are being used in the development of monochromators for chemical analysis and plant control. They are also being applied to accurate linear measurement by a "fringe counting" method especially suitable for the automatic control of machine tools.

In furtherance of these grating developments a lathe of unique design, made by a London firm under the supervision of the Metrology Division, has been acquired, and is undergoing tests. It is a dual-purpose lathe capable of diamond-turning metal cylinders to a high quality finish, but its principal function is to produce screw threads as fine as 30,000 threads per inch, upon a bar 4 in. diameter and 24 in. long, the maximum size that can be dealt with. Such a thread measures over 140 miles in length. It is not yet known if any diamond tool will run such a course without blunting.

MATHEMATICS DIVISION

The continued success of the ACE pilot model has had a major influence on the work of the Division. Reckoned on the most stringent basis over 60 per cent. good time has been achieved over a full year of operation, a remarkably high figure. As a result a large number of problems have been solved for outside organizations and the staff have been kept correspondingly busy programming these problems for solution on the machine.

The bulk of the work has again been for the Ministry of Supply. Apart from security classified problems a good deal of work has been, and is being, done on the stability of orbits in the synchrotron which it is proposed to build for the European Organization for Nuclear Research. To test the practicability of a design intended to effect great economy in the amount of metal used in so large an instrument (measuring a quarter of a mile in circumference!) it is necessary to determine the effect of very slight imperfections in the form of the applied fields. This necessitates the computation of large numbers of orbits in order to estimate the statistical effect and only with a high speed electronic computer is such an analysis feasible.

All the Ordnance Survey Department's work on the solution of stereograms, a problem arising in photogrammetry, has been taken over. Work on traffic control problems for the Road Research Laboratory is now done by their staff on a night shift, an arrangement which has been of great value in relieving pressure both on machine time and on the staff of the N.P.L.

A gratifying interest in the potentialities of the ACE has been shown by a number of aircraft firms and a steadily increasing amount of work is being done for them. This has mainly concerned the determination of critical flutter speeds and programmes have been prepared for the solution of all three stages of the flutter problem. It is interesting to note that a stress analysis computation for one firm involved the solution of a set of 115 equations with 37 right hand sides.

Though the basic units of the new large-scale servo-connected differential analyser had been delivered over a year ago its productive use has been delayed by the difficulty of placing a contract for the installation wiring and

by considerable delays in the delivery of the amplifiers. Meanwhile the old mechanical differential analyser has been used periodically on a series of small problems.

The acquisition in recent years of more up-to-date and flexible machines has enabled the Punched Card Section to tackle problems of a more scientific character. In particular these methods have been successfully applied to random walk problems in nuclear physics and also to analysing various methods of weather forecasting compared with actual weather conditions, the latter work being done for the U.S. Air Force.

The Desk Machine Section has continued to compute mathematical tables both for the Royal Society Mathematical Tables Committee and for internal use. These include generalized exponential integrals, Bessel functions of large argument, Bessel and Legendre functions of large order and Chebyshev coefficients. The table of Multhopp influence functions has been extended and an awkward calculation of pressure distribution in a supersonic flow problem has been solved using the method of characteristics.

A good deal of the research effort of the Division has gone into the development and adaptation of computing technique suitable for the pilot ACE, particularly in the field of linear algebra. Work has also been done on the asymptotic solution of differential equations, in particular on the expansion of Bessel and Legendre functions of large order, and on numerical methods for solving integral equations.

METALLURGY DIVISION

Progress has been made in building an extension to the laboratories, providing improved facilities for work on ceramics, X-ray crystallography and the application of radio-active tracers to metallurgical research. The recuperative gas-fired kiln suitable for temperatures up to 1,800°C completed last year has been put into operation and work has commenced on the development of methods for the study of the behaviour of materials at very high temperatures, such as are experienced in rockets.

Investigation of factors influencing the mechanical strength of solid solutions of copper and silver has been continued. The preparation of single crystals suitable for the measurement of the elastic constants of the metallic lattices has been set in hand. Interest has centred round the relative effects of the valency of the solute atom and the lattice distortion produced by the solute atom. A measurement has been made by X-ray methods of the local distortion produced by gold dissolved in copper, but it is of limited accuracy and refinement of the methods is necessary. The solid solutions of antimony in copper have been found to undergo a reversible embrittlement on cooling at a temperature depending on the antimony content. This behaviour resembles in some ways the embrittlement of steels at low temperature and is to be more fully investigated. Experiments on the deformation of single crystals of brass are proceeding.

During the past few years a very extensive study of the deformation processes occurring during the creep of pure aluminium and some of its alloys has been carried out, and has led to the recognition of important relationships between the rate of grain boundary movement, the total deformation and the size of the sub-crystals produced by deformation. This work has now been completed and a similar study of creep in copper and some other metals has been started to see if the same relationships hold.

Much effort has been devoted to developing the discovery that iron containing quite small amounts of carbon possesses great toughness at low temperatures and high yield stress when it is cooled sufficiently rapidly from

above 900°C. The rates of cooling necessary to yield results of interest to the engineer are greater in pure iron-carbon alloys than can be achieved in bars and plates of ordinary commercial sizes but, by small modifications of composition, materials have been found that combine a yield stress which would be satisfactory in a steel plate 1 in. thick with freedom from brittleness at temperatures well below 0°C. In connection with the embrittlement of mild steel ship plate, a detailed study of the effect of phosphorus on the brittleness of pure iron has been undertaken. The effect of phosphorus on heat-treated high-tensile alloy steels has also been investigated. The results obtained in the first stages of the work on alloy steels suggest that some economy in the use of alloying elements can be effected by sufficiently reducing the phosphorus content of the steel. Many single crystals of pure iron have been made during the year and their deformation and rupture at low temperatures is being examined.

The conditions under which titanium may be reduced directly from titanium dioxide have been worked out and titanium that is workable when hot has been produced. Serious difficulties have been encountered in removing the last traces of oxygen and in obtaining a titanium that can be worked cold, but means of overcoming these difficulties are being studied. An accurate determination of the melting point of titanium has been made and the constitution of titanium-oxygen and titanium-iron-oxygen alloys rich in titanium has been elucidated. Studies have also been made of the titanium-aluminium alloys, in which there is a growing technical interest. In the course of these investigations, much useful development work on the methods of analysis of titanium and its alloys has been done in the chemistry section.

The investigation of the behaviour of high temperatures of steels used in electricity generating stations has continued. The work on carbon steels has been brought to a conclusion with the publication of several papers and the new programme, embracing the study of a range of alloy steels for the new power stations, has been energetically pursued. A number of experimental steels containing 6 to 8 per cent. of chromium, and having better oxidation resistance than the alloy steels at present in use, have been examined, with a view to assessing the possibilities of this type of material.

The High Temperature Mechanical Properties Section of the Laboratory has been incorporated into the Metallurgy Division pending its ultimate transfer to M.E.R.O. In addition to carrying out the creep tests required on the steels for electricity generating stations, this section has developed equipment for carrying out creep tests at temperatures up to 1,500°C. and has investigated the effect of cyclic speed on the fatigue strength at high temperature of mild steel and a number of non-ferrous alloys. It has been shown that for mild steel at air temperature the fatigue strength depends mainly on the number of cycles of stress irrespective of the cyclic speed, but at 400 to 500°C. failures at a given stress may occur after a certain time which is independent of the speed. Further work is in progress to find whether other materials show the same temperature dependence of cyclic speed effect.

A study of the creep resistance at 1,000°C. of molybdenum and its alloys has been completed. Though alloys with improved strength at 1,000°C. can be prepared, they are as a rule too brittle for practical use.

METROLOGY DIVISION

To assist the Physics Division in attaining the highest possible accuracy in hypsometry, the primary standard barometer has been modified so as to permit the measurement of pressures in an enclosed space, and the design

of a transportable primary standard barometer is being considered. Substantial progress has been made towards a new determination of the density of mercury by weighing in it a nearly perfect 9-cm. cube of tungsten carbide.

As in previous altitude record attempts in this country the Laboratory was again responsible for the calculation and certification for the Fédération Aeronautique Internationale of the height attained in the attempt on the Class C world record in May, 1953. The Ministry of Supply advised on statistical problems and supervised the necessary flight tests.

Much assistance continues to be given to the British Standards Institution and, through it, to the International Standards Organization. A number of matters dealt with, for example, units and fundamental data, the presentation of numerical values, and definitions used in instrumentation, are of basic importance and wide concern. Spherical ground glass joints made by a number of manufacturers are being investigated with a view to formulating a British Standard which will ensure their interchangeability. Provisional support has been obtained from the International Standards Organization for a simplified system of barometric units and conventions, and these proposals are being considered by the World Meteorological Organization.

A general purpose micrometer microscope has been designed and a prototype made in the Metrology Workshop. This instrument has a total optical magnification of 50 and its micrometer screw has a pitch of 0·5 mm; one division of the micrometer drum corresponds with 1 μ.

Interest in interferometrical methods of measuring length has been stimulated by the setting up of a Committee by the Bureau International des Poids et Mesures, on which the Laboratory is represented, to study the definition of the metre. In particular the possibility will be considered of using wavelengths of light as the ultimate means of definition.

Evidence that a precision of $\pm$ 0·02 μ (less than 1 millionth of an inch) is attainable in the interferometry of block gauges up to 100 mm. or 4 in. long has been established from comparisons made with two other standards laboratories. Wavelengths of light emitted by a pure isotope of mercury or krypton served as the standards of measurement.

The weights of the 50-ton deadweight standard machine have been adjusted so that the unit of force employed in this machine is now the standard gravitational unit, viz. the weight of a mass of 1 lb. (in vacuo) under standard gravity ($g_s = 980{\cdot}665$ cm/s^2). To make the adjustment, it was necessary to strip the machine and the opportunity was taken to overhaul the various units and also, in the light of demands from industry, to modify the weighing arrangements so that standard loads could be applied in units of 1 kg and 1,000 lb. as well as 1 ton. The 5-ton deadweight standard machine has been extensively used during the year. The secondary standards of load have been maintained and developed and a new 300-ton strain gauge standard has been particularly valuable for verification of compression testing machines. There has been a continual demand from industry for calibrations both of proving rings and other load measuring devices and also of machines tested *in situ*. Weighing units for use in weighing aircraft have been tested in considerable numbers.

The deadweight standard hardness testing machine has been overhauled and its weights adjusted to conform to the standard gravitational unit of force. Co-operation between the Division and a British manufacturer has resulted in the production of Rockwell diamond penetrators complying closely with the exacting requirements of the relevant British Standard (B.S. 891 : 1940). These diamonds when used in the standard machine give hardness values in very good agreement.

To meet the need for small metal aerofoils of high precision for use in high-speed tunnels, a new method of manufacture has been devised which has proved very successful both for two-dimensional aerofoils of constant section and three-dimensional aerofoils of the delta wing type in which the section progressively diminishes from root to tip. In this method, the required form is generated by cutting a number of enveloping tangential planes in an oversized blank and then, with a minimum of hand finishing, removing the slight excess metal at the intersections of consecutive planes, so as to provide a smooth blend. Apart from its sound geometrical principle, this technique has the substantial advantage that a simple but adequate form of inspection can be carried out during the actual manufacturing process. Solid models within the required limits of $\pm$ 0·001 in. from nominal form have been made without experiencing undue difficulty and others have been made with special features such as pressure plotting tubes and a hinged tail plane for flutter research. An account of this work has been published.(7)

An investigation is being undertaken on behalf of the British Standards Institution in order to obtain data for the extension of the ISO tables of work tolerances. A number of work-pieces with both internal and external features, and of various dimensions up to a maximum of 80 in., have been prepared and measured at the Laboratory. From measurements of the work-pieces which are now being made by a number of representative industrial manufacturers, as well as Government establishments, an appreciation will be obtained of the accuracy with which such measurements can be made in the ordinary workshop and a realistic basis thus established for founding a sound practical scheme of tolerances.

A technique has been developed, in co-operation with the Ship Division, for accurately checking the contours of ships' propellers up to 25 ft. in diameter. It employs an alignment telescope in association with a specially developed levelling staff embodying a movable target.

Other items of work have included the design and manufacture of a machine for testing dial indicators, which gives a continuous indication of the error developed in the indicator as its plunger is moved through its complete range of travel, and a self-centering adjustable pneumatic measuring head for internal diameters in the range 2 to 6 in., which allows rapid examination of bores for variation in diameter and is a complementary instrument to the precision bore-measuring machines referred to in last year's report.

The electronic simulator has been considerably enlarged, and has been used for studying the performance of a number of closed-loop control systems. A great improvement in speed and convenience of use has resulted from the development of a unit to enable ink-on-paper records to be made automatically. The unit samples the repeated output (displayed on a cathode ray tube) once per cycle, effectively reducing the frequency to within the capabilities of a standard recorder. Thus the simulator obtains both the advantages of an immediate display and of a permanent record when required.

A theoretical study has been made of certain types of "on-off" control systems. This has resulted in the preparation of standard charts from which the major features of the transient response of a particular system may be obtained very simply.

A programme of work on automatic data reduction is now progressing and includes the development of machines for reading experimental records, for simple computing such as applying calibrations, and for plotting and tabulation of results.

PHYSICS DIVISION

The high temperature calorimeter is now providing data on steels required by metallurgists; a continuous record of the effective thermal capacity of a steel up to 1,600°C. has been obtained, and certain heats of transformation have been measured, e.g. the heat absorption in the σ to α phase change of a chromium-iron alloy.

Inquiries have come in from far afield for thermal conductivity data; among the materials studied have been six graphites from the U.S.A. and a steel which is to be used for comparison purposes by the South African National Physical Laboratory.

A study has been made of the influence of tempering temperature on the thermal conductivity of steel hardened by oil quenching, and a paper has been published giving thermal and electrical conductivities of beryllium. Among the non-metals studied have been several reinforced plastics and various asbestos insulation boards intended for fire resistant partitions.

The study of hygrometers has been continued and a booklet with the title "Measurement of Humidity" has been published in the Laboratory series of *Notes on Applied Science* (see p. 279).

In a joint investigation with the Chemical Research Laboratory the heats of combustion of pyridine and some of its derivatives have been measured. A Collins helium cryostat has been installed for measurements of the physical properties of materials down to temperatures of 2°K. (−271°C.).

An investigation is in progress, under the aegis of the Bureau International des Poids et Mesures, into the accuracy of realization in various national standardizing laboratories of the fundamental interval (0-100°C.) of the temperature scale. For this purpose two platinum resistance thermometers, one from the National Bureau of Standards, Washington, and the other from National Physical Laboratory, are to be measured at each participating laboratory. The measurements at the Laboratory were made during the year and the thermometers passed on to the Physikalisch Technische Bundesanstalt, Brunswick.

Further investigations at the triple point of water have shown that cells made four or five years ago give values which do not differ from those given by newly constructed cells, demonstrating that the "Pyrex" glass containers do not contaminate the water significantly in this period of time. It has been found possible to maintain cells at a constant temperature within 0·0001°C. for a period of five days without re-forming the ice crystals. Since the use of the triple point of water has been extended to test work of the highest accuracy, cells are required in greater numbers, and apparatus has therefore been set up for constructing the cells in the Division.

A number of platinum resistance thermometers having platinum sheaths of overall dimensions 70 × 2·5 mm are being made for use over the temperature range between the boiling points of hydrogen and oxygen (i.e. from 20 to 90°K.). The first of these has been completed and preliminary measurements show that it is very constant.

The primary standard optical pyrometer and platinum thermocouples have been re-calibrated at the freezing point of gold (1,063°C.). The optical pyrometer is now being used in an intercomparison of the temperature scales for temperatures above the gold point, by the exchange of calibrated tungsten strip lamps between the Laboratory and the Australian National Standards Laboratory.

The photoelectric method for the more rapid calibration of tungsten strip lamps for industrial use has proved satisfactory and some seventy lamps have been calibrated during the year. The calibration of each lamp is checked at one temperature by the optical pyrometer.

The new Smith bridge installed last year has shown admirable stability, the principal coils having remained constant to a few parts in 10^7 over the period March to September, 1953. Designs for commercial production of the new type of bridge have been completed by a firm of instrument makers working with advice from the Laboratory, and a small batch of bridges is under construction.

Work for the Ministry of Supply on the reduction of the noise from aircraft and from aero-engine test houses has been continued. In connection with the feasibility of siting helicopter terminals in built-up areas, noise analyses have been made to determine the relative importance of the rotor noise and the engine exhaust noise, in order to assess the improvement which could result from reduction of the latter. Work is also in progress on the noise from pressure jets, the effects of pressure, temperature, diameter and forward velocity being studied. In comparison with other workers' results on model jets, differences have been observed indicating the importance of the initial turbulent condition of the jet. Measurements of the polar distribution of the jet noise from an engine or an open test bed have shown similar results to those of model experiments, the direction of maximum radiation varying from a small angle to the jet axis at low frequencies to 60°-70° at high frequencies.

Arising out of work on behalf of the Medical Research Council on the threshold of hearing and on measurements of performance of audiometers and hearing aids, the Laboratory has, at the request of the British Standards Institution, agreed to maintain the basic standards for the calibration of audiometers in Great Britain. It is hoped that an international agreement on this matter may be achieved in the near future.

A recent feature has been the institution of work on high-pressure physics. One important aspect of this is the study of the pressure-volume-temperature relationships of substances of industrial importance, to meet the need for more complete and precise data in the fields of chemical and mechanical engineering. Work is now commencing on a range of gas mixtures which will be studied in relation to recent theoretical developments on the prediction of the mechanical properties of mixtures from those of the constituent pure substances. Another aspect of the work on which substantial progress is now being made is the establishment of standards for the measurement of high pressures and the calibration of pressure balances to the best available precision.

During the investigation of improved piezo-electric materials, the application of barium titanate to ultrasonic flaw detection has resulted in great improvements in resolution and in avoidance of confused indications when testing on rough specimen surfaces. Development of a dissipative crystal backing using tungsten powder in a resin has proved valuable for the latter and has enabled excellent results with steerable beams to be obtained.

Large barium titanate transducers have been used to determine the thickness of concrete roads by an echo-technique. In an allied field, torsional wave transducers using ferrites have enabled the travel of rotational waves in blocks of, for example, concrete to be timed, thus yielding the modulus of rigidity. Techniques have been developed to enable elasticities of metals, such as iron, to be measured up to 1,000°C.

Transducers have been designed and techniques developed showing the value of high intensity ultrasonic engraving and cutting of brittle materials. In the course of this work, magnetostrictive transducers have been developed which, when suitably matched, appear to have efficiencies of over 80 per cent.

Work has proceeded through the year on the aperture system and mounting arrangements for the 2-MeV X-ray equipment, in order to permit precise measurements at the higher energies in terms of the röntgen. An investigation on scattering and absorption in concrete at these energies is in progress.

There have been intercomparisons, at energies up to 200 kV, of the N.P.L. standard free-air chamber with the corresponding equipment of other standardizing laboratories, and significant improvements in future measurements at the Laboratory are likely to result. Under present arrangements, the Laboratory calibrates sub-standard dosemeters for hospital regional centres. These instruments are then used at the centres to calibrate the dosemeters used clinically; this scheme is now working satisfactorily. Demand for the Laboratory radiation monitoring service continues to increase; in the current year some 29,000 films were issued, mainly to hospitals and industrial workers.

Work on the standardization of radioactive isotopes, and their measurement in absolute terms, has continued actively. Comparisons with other laboratories in this country, and also with laboratories abroad, have been made for several isotopes. In this work, each isotope sets an individual problem, and there is much to be done before the sources of error are fully understood. It has proved possible to revise the British Standard of I^{131}, as from January 1st, 1953, and the maintenance of this standard is now an N.P.L. responsibility. The Laboratory will also issue standards of one or two other isotopes in the near future.

The 10-ton slipping clutch fatigue machine has now completed over 450 million stress cycles. In addition to providing useful information about the drive unit and spring design, this proving time has been usefully employed for fatigue tests on wrought iron and welded steel chains. The original 1,500-lb. slipping clutch fatigue machine has now been rebuilt incorporating an oil pressure feed drive unit, and the machine has so far successfully completed over 70 million stress cycles. The multiple unit fatigue machine has been running almost continuously since it was made, and the fatigue tests on the 1·2 and 1·7 mm diameter screws are now completed; in all, 24 fatigue determinations have been carried out on 420 testpieces, making a total of 3,730 million stress cycles in the short period in which the machine has been operating.

Measurements of movement at both the Tower of London and at Rochester Bridge are being continued and a paper covering this work was published by the Institution of Civil Engineers.(8) The tilt measuring apparatus recently installed on Rochester Bridge is working satisfactorily, but as yet insufficient data have been acquired to correlate the tilt measurements with the displacements measured with the micrometers.

The development of a portable marine torsionmeter for use by the Ship Division has been continued. A Mk. I design was tested at sea and it was found necessary to re-design part of the equipment in order to overcome errors attributed to temperature variations. The Mk. II torsionmeter was completed and tested in the Laboratory towards the end of the year with satisfactory results; however, during a trial at sea, a gauge point failed in fatigue owing to vibration. Modifications are now being made to eliminate possible resonances of the instrument and to increase the fatigue strength of the gauge points by means of which the instrument is clamped to the propeller shaft.

Further work is in progress in the Elasticity Section on the stresses in screw threads using the "frozen stress" method. The investigation is being made for the British Shipbuilding Research Association and includes the comparison of five different forms of stud fastening. For Pametrada an analysis has been made of the stresses occurring in a special form of dovetail joint.

An investigation is in progress on the mechanical strength of industrial lifting chains, particularly those used in coal mining gear. In recent years, chains made of electrically welded steel have come into increasing use, and the tensile-impact machine at the Laboratory affords valuable information on their possible premature failure due to brittleness or imperfect welding. It is found that the shock loading tests sometimes reveal faults in the chains which are not so apparent under the usual static tensile loading. Shock loading tests have also been made on steel 3-link couplings and drawhooks for British Railways.

SHIP DIVISION

The demand from shipbuilders for routine tests has fallen during the year and now represents only one month or so of advance booking. The output of ship models in the Division has continued at the same level (two per week), which has enabled the amount of research work to be increased.

Research on the ship-model comparison has continued in association with the British Shipbuilding Research Association, and a further 20 models of single-screw ships and 5 twin-screw ships have been investigated. Analysis of the data is not yet complete but it is clear that ship results are influenced by the following factors: (*a*) condition of sea and wind, (*b*) accuracy of trial procedure and speed measurement, including tide effects, (*c*) state of ship's bottom as regards roughness and fouling. The cumulative effect of this is that only about one trial in four measures up to the highest standards, and it appears advisable to concentrate on a limited number of selected ships for trial. The further results confirm the previous conclusion that there is a material reduction in resistance due to flush welded joints in the shell compared with lapped and riveted joints. The industry has noted this important conclusion.

Research on friction resistance continues and tests on long pontoon models of very shallow draught are nearing completion. The indications are that the minimum turbulent friction line is lower at higher Reynolds numbers than the generally accepted Schoenherr or Prandtl-Schlichting lines. If this proves to be true, then the effect of roughness on the ship is greater than has been indicated previously. Research has been continued on the velocity distribution in the boundary layer flow behind a plank surface and, based on these results, a method has been developed to correct for scale effect in the propeller wake factor between model and ship. The velocity distribution in the boundary layer is also being studied with a view to using it as a criterion of roughness effects on resistance.

An investigation into the influence of various factors on the side-launching of trawlers has been completed. This investigation was based on observations made during a side launch, and the results are being correlated with observations on several other side launches.

A programme of research is in hand to give information on the effect of tank boundaries on the wave resistance of ship models. The matter is being approached both from the theoretical and the experimental point of view. This question was brought into prominence by the results obtained from the resistance tests of the *Lucy Ashton* models in No. 1 and No. 2 Tanks.

The modifications to the existing Water Tunnel have been partly completed and the flow conditions are much improved, enabling a higher maximum speed to be obtained. It is hoped to complete the modifications and install the new dynamometer before the end of 1953.

Following the Treasury decision in 1952 that the No. 3 Tank project should go on, preliminary design work was completed by the Laboratory and the Ministry of Works. A satisfactory general scheme providing a 1,300-ft. tank has now been worked out, and detailed planning is proceeding.

Research has continued on various projects for the British Shipbuilding Research Association, including an extension of the work on standard series of models and investigations of the resistance of and flow conditions around a model of mathematical shape.

ELECTRONICS SECTION

The ACE pilot model, an automatic high-speed electronic digital computer, made by the Electronics Section in collaboration with the Mathematics Division and the English Electric Co., has now been in regular service in the Mathematics Division since early 1952 and is maintained and " serviced " by a small team supplied by the Section.

This machine is still the fastest computer in service in Europe but is restricted in " memory " or storage capacity. The Section has therefore been designing and constructing an auxiliary magnetic-drum store. A trial model for about 30,000 digits (16 2-position heads, giving 32 tracks), with a satisfactory synchronized drive, has been made and will be added to the ACE pilot model when it has been completed and tested.

The Section has also been engaged on refining and improving the logical design and circuitry of the existing machine with a view to the construction by the English Electric Co. of a fully engineered version, models of which will be supplied to the Laboratory, the Royal Aircraft Establishment and to other users (including the English Electric Co. itself).

Meanwhile the design of a faster machine is being considered, for experience has shown that even the pilot model is not fast enough to meet some existing requirements. More advanced circuitry and logical design will give a four or five-fold increase of speed in a machine working at the same pulse frequency and basically similar to the pilot model, i.e., a serial machine with delay-line storage, and this is contemplated as the next stage of development.

The application of digital computing machine techniques to administrative and commercial purposes, i.e., the mechanization of large scale clerical operations, may prove to be even more important economically than their use for computation. The Section has collaborated with a Departmental Working Party in a preliminary study of this subject and will continue to assist in this development as far as is practicable.

TEST HOUSE

The policy has been continued of encouraging industry to carry out when possible its own routine testing during manufacture and to consult the Laboratory about testing methods and for tests on sample products where appropriate.

It has been noted that volumetric glassware manufacturers are producing better glass, having less striae, and methods of engraving thermometer graduations have been greatly improved. Improvements have also been observed

in the quality of engineers' precision thread measuring cylinders, micrometers, verniers and height gauges. The Laboratory made some tests and advised on the design of bomb calorimeters.

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PEST INFESTATION RESEARCH

The work of the Laboratory continues to be directed mainly to the study of the insects that attack and destroy stored foodstuffs and to the development of methods for their control. In the United Kingdom close collaboration is maintained with the Infestation Control Division of the Ministry of Agriculture and Fisheries, and with the corresponding division in the Department of Agriculture for Scotland, which are responsible for the inspection of foodstuffs and the application of control measures.

The liaison with the Colonies mentioned in the previous Report has been greatly strengthened during the year. As a result of advice given through the Colonial Liaison Officer much more interest is being taken in the problems of insect infestation of stored cereals, etc., in Colonial territories, and already there have been instances of considerable quantities of food having been saved for human as opposed to insect consumption. There is still tremendous scope for further developments in this particular field.

Following are some examples of work in progress at the Laboratory.

BIOLOGICAL WORK

This is at present directed upon several general themes which may be summarized in the questions: Where do infestations come from, and by what means? What physical conditions are required by each species for its survival, and how soon does it die under various unfavourable conditions? What is the rate of development, survival and reproduction, and hence the net rate of increase, of each species under the various conditions in which it is viable? Most of the current items of work are identifiable with one or more of these themes.

While the bulk of the year's work has been on projects started before 1952, some new items have been introduced. These include investigations on *Dermestes frischii*, on the Cigarette beetle (*Lasioderma serricorne*), on the infestation of Durum wheat by mites, on the systematics of *Cryptophagus*, and on the calculation of the rate of population increase. A major item, commenced late in the year, is the investigation of the behaviour and biology of the Khapra beetle, *Trogoderma granarium*.

Two major projects have been concluded during the year and reports prepared for publication. The results of the biological studies on the Spider beetle, *Ptinus tectus*, have been combined with meteorological records to map the areas of the world which would be climatically favourable for the development of this species and in which it should be regarded as a potentially dangerous pest.

The chief results of the investigation of the fauna of dry birds' nests have been:—

1. The insect and mite fauna of such a nest is very similar to that of a neglected food warehouse.
2. Some species of "domestic" pests, such as the Carpet beetle are very commonly found in old birds' nests built on or inside houses, and such nests appear to constitute a frequent point of entry for these insects.

Owing to the more or less well protected situations in which storage pests live, diurnal fluctuations in temperature and humidity are generally less important than they are to animals living in the open. Laboratory experiments conducted under constant conditions give very useful information, sufficient for many practical needs but more knowledge of the effects of fluctuating conditions is desirable. Some information on these effects is already available from experiments conducted in various uncontrolled sites but further work is planned.

STORAGE OF GRAIN UNDER AIR-TIGHT CONDITIONS

It has long been known that insects infesting grain may be killed if the grain is stored under air-tight conditions, but it has usually been stipulated that grain intended for such storage should have a low moisture content.

The conditions of air-tight storage in France were inspected during the year in collaboration with the Ministry of Agriculture and Fisheries. Recently, in France, grain of relatively high moisture content has been successfully stored for several months in air-tight silos. This development has been made largely on an empirical basis without an adequate background of scientific knowledge concerning the physiological responses of normally damp grain and of its associated micro-organisms under conditions of anaerobic storage.

If successful, this method would be of considerable importance in Britain, since it would make it possible for grain of high moisture content, as normally harvested by combine in this country, to be stored in safety, thus postponing or even obviating the need for drying. The Laboratory is therefore making a detailed scientific investigation of the method. Work has begun on a laboratory scale and will later be extended to a semi-commercial scale.

BIO-ASSAY OF TANGANYIKA PYRETHRUM

The pyrethrum growers in Southern Tanganyika sought the assistance of the Laboratory to decide whether seeds of a newly developed strain of pyrethrum plants should be issued for commercial cultivation. The decision

could not be made on the basis of chemical assay alone because the toxicity to insects of some high-yielding strains of pyrethrum has been suspected to be less than that expected from the results of chemical assay. Samples of three strains of flowers were ground and tested biologically as insecticidal dusts. Chemical analyses of the Pyrethrins I and II contents were made for comparative purposes.

Five different methods of biological assay were employed and the results show that different relative potencies are to be expected when comparing the same group of pyrethrum insecticides by different bio-assay techniques. Furthermore, chemical assay on the basis of total pyrethrins gave different results from those obtained biologically.

CONTROL OF BLOWFLIES IN REFUSE

An analysis has been made of the results of the 1951 experiments at the railway sidings where refuse is collected and sorted in North London. It was estimated from soil samples that, at one time during the height of the season, there were some 25,000,000 blowfly larvae in 15,000 sq. ft. of ground covered by tracks. The aim of the experiments was to prevent such larvae from developing into adult flies which could fly away and infest the surrounding districts. Trapping on untreated plots showed that the normal emergence of adult flies from the area would have been about 100,000 per day.

By treating the ground with various formulations of DDT and BHC it was found that some control was obtained at larval, pupal and emerging adult stages. When compared on an equal cost basis, dusts were more effective than emulsions and DDT was better than BHC. The most effective treatment was a twice-weekly application of 5 per cent. DDT dust which gave an overall control of more than 99 per cent. Recommendations, based on the results of the experiments, were adopted in their entirety by the Borough Council concerned and, for a total cost of about £100, emergence of flies from the area was virtually prevented during 1952. The importance of these findings is emphasized by the results of an examination of two large tips where refuse from London is deposited after transport by rail to a rural area. It was found that larvae were falling from the trucks at the beginning and end of the journey and that the refuse was still heavily infested on arrival at the rural tip. It is reasonable to assume that larvae were distributed along the track for the entire journey from London.

DISTRIBUTION OF METHYL BROMIDE IN A LARGE STOW OF BAGGED WHEAT FUMIGATED UNDER GAS-PROOF SHEETS

The fumigation of bagged grain with methyl bromide under a covering of gas-proof sheets has been widely practised in Britain for some years. In Scotland, under the guidance of the Department of Agriculture, Infestation Control, it has become customary to treat very much larger single stacks than have been treated in England. This method of treating large stacks will have important applications in the Colonies. The opportunity was taken, during a visit to the Glasgow area to study the development of the method, of taking gas samples during the fumigation of such a stow containing about 1,200 tons of wheat. Results indicated that a satisfactory distribution of gas was obtained through this very large bulk of grain.

STUDY OF "VACUUM FUMIGATION" TECHNIQUES

In continuing the programme of investigation of different methods of "reduced pressure fumigation" started last year, a series of tests has been carried out with bagged wheatfeed using methyl bromide as the fumigant. The behaviour of the fumigant during tests was studied by determining gas

concentrations in the free space and at different depths within the produce. Each test was carried out on a single bag in a chamber of about 1,700 litres capacity in a room controlled at 15°C. and 70 per cent. relative humidity.

The technique in which air and fumigant gas are introduced into the evacuated chamber simultaneously through a mixing valve until the pressure approaches atmospheric, was found to be no more effective for this commodity than fumigation at atmospheric pressure. The method in which the fumigant is introduced into the evacuated chamber and the pressure is then immediately brought to atmospheric was shown to be slightly more effective than the atmospheric method. A very much more effective penetration of gas into the bulk was obtained in the method in which the fumigant is introduced into the evacuated chamber and a low pressure (about 7 cm Hg) sustained over a period.

Small-scale experiments in which methyl bromide gas was allowed to diffuse through a column of wheatfeed from a reservoir maintained at a constant concentration have been carried out at different pressures and it has been shown that when air is removed from the interstitial space fumigant diffuses much more rapidly through the column. Parallel tests with hydrogen cyanide and carbon dioxide have shown a relationship between rate of penetration and sorption of the gas.

This rapid penetration through the column at low pressures accords with the rapid attainment of high concentrations of fumigant in the bagged wheatfeed during the "sustained vacuum" tests. On releasing the "vacuum" even higher concentrations of gas were obtained in the bulk, further increasing the efficiency of the method. Subsequent tests showed that these high concentrations could be obtained in the centre of the bags by "breaking the vacuum" quite early in the experiment; optimum concentration-time products for a 4-hour period were obtained under the conditions of the tests when the vacuum was released after 1 hour.

Further experimental fumigations have been carried out using bagged whalemeat and bone meal, a comparatively dense and finely divided product containing about 50 per cent. protein. The large amounts of methyl bromide sorbed by this commodity make fumigation in a short period at atmospheric pressure impractical since penetration to the centre of the bags is extremely slow. Satisfactory penetration has been obtained using the "sustained vacuum" method. Amounts of methyl bromide combining with the product have been determined.

EFFECT OF TOTAL PRESSURE ON SORPTION OF FUMIGANTS

Amounts of fumigant sorbed by a commodity may be determined by exposure to known concentrations in a closed vessel, the reduction in the free space concentration during the exposure period being measured.

A series of experiments with wheatfeed have been carried out with exposure periods within the range used in the vacuum fumigation tests, i.e., up to 4 or 6 hours. For a finely divided product such as wheatfeed sorption takes place very rapidly during the first hour or two, the total amount sorbed being roughly proportional to the free space concentration. There may be no subsequent increase in sorption or, if the fumigant reacts chemically with the product, the further increase due to this is at a relatively low rate. Sorption isotherms were determined for different exposure periods and from these the rates of sorption at different concentration levels were deduced.

Results have been obtained in this way in tests at atmospheric pressure and at a total pressure of 7 cm Hg. Tests with hydrogen cyanide indicate

that, for a given mean concentration level, rate of sorption and amount of gas sorbed are unaffected by total pressure. Tests with methyl bromide are in progress.

NATURE OF METHYL BROMIDE RESIDUES IN FUMIGATED WHEAT

Methyl bromide is commonly used as a fumigant for foodstuffs, and although feeding tests etc. have shown that there is no detectable harmful effect on foodstuffs so treated, it was nevertheless desirable to know the precise nature of the products of reaction between methyl bromide and, in this instance, wheat, during fumigation.

Use has been made of " labelled " methyl bromide, the carbon atom of which has been made radioactive. As the reaction is one of methylation, the products themselves contain the radioactive carbon and thus become detectable by their radioactivity.

Earlier work had shown that the greater part of the methylation occurred with the wheat protein and about half of this with the amino acid constituents of the protein which contained oxygen and sulphur groups. The remainder of the reaction occurred with the nitrogen-containing groups of the amino acids. Attention was directed to the identification of the N-methylated compounds. Hydrolysis of the fumigated wheat protein with hydriodic acid caused the protein to be broken down into its individual amino acids, while any oxygen and sulphur methylated groups were split off as methyl iodide. The N-methylated amino acids were quite stable under these conditions and examination of such a " hydrolysate " by chromatographic methods showed that only three such compounds had been formed out of the many hundreds that were possible. Subsequent work has shown that all three appear to be methylated derivatives of the basic amino acid, histidine.

EFFECT OF INSECTICIDES ON THE PHOSPHORUS METABOLISM OF INSECTS

In order to obtain information on their mode of action, the effect of insecticides and fumigants on the carbohydrate metabolism of insects is being studied. During metabolism the carbohydrate (sugar) is broken down enzymically step by step, through various phosphorus-containing intermediate compounds.

By feeding adult houseflies on sugar and a solution containing radioactive phosphorus, the phosphorus intermediates became " labelled " and detectable by their radio-activity. A paper strip chromatogram of a muscle extract of flies fed in this way can be prepared. When this strip is scanned with a Geiger counter a picture of the distribution of these radioactive intermediates is obtained. By comparing the " pictures " so obtained from normal and poisoned insects a good deal has been learned about the poisoning mechanisms of some insecticides.

METABOLISM OF PYRETHRINS ADSORBED BY ADULT HOUSEFLIES

The ability of insects to recover completely from paralysis induced by sub-lethal doses of pyrethrum suggested that the insecticide was being broken down by the insect into some non-toxic compound. An initial study of this problem has been made using radioactive pyrethrins. The results suggest that the pyrethrins, when applied on their own, are destroyed enzymically by the housefly ; but when applied with a pyrethrin " synergist ", a compound known to increase the effectiveness of the pyrethrins, no evidence of destruction by the insect was obtained. It would appear, therefore, that the modification is a defensive mechanism and that the function of the synergist is to hinder this mechanism.

PAPER CHROMATOGRAPHY OF THE PYRETHRIN-TYPE INSECTICIDES AND THEIR DERIVATIVES

For the purpose of analysing mixtures of the pyrethrins and their derivatives on the micro-scale a modified method of paper chromatography was used.

A sensitive colour test was developed for the detection of these compounds on the paper strip after chromatographic analysis, based on the fact that the pyrethrin molecules contain unsaturated linkages. On spraying the strip with neutral potassium permanganate solution, these linkages became oxidized leaving a faint brown colour of manganese dioxide. Further spraying with benzidene acetate solution replaced the brown stain with an intense blue colour corresponding in area and position to the pyrethrin and its derivatives.

RADIO RESEARCH

The increasing application of radio waves for communications and other purposes continues to disclose a whole variety of physical problems which require investigation and solution. The main contribution of the Radio Research Organization is in the field of wave-propagation. Investigations are carried out which lead to a better understanding of the mechanisms of transmission between transmitter and receiver and of the properties of the medium traversed. Transmission may be affected not only by the topography and electrical characteristics of the earth's surface, which are important to a varying degree at all frequencies, but also by the effects of the lower atmosphere at some frequencies and by the ionosphere at others. Conditions in the lower atmosphere and ionosphere are themselves subject to diurnal and seasonal variations of different kinds.

The dependence of propagation conditions on time and position imposes a corresponding spreading in both time and position of the related investigations carried out by the Radio Research Organization. A good example of this is provided by the ionospheric investigations, for which not only are propagation conditions studied over routes extending out to many thousands of kilometres, but hourly measurements are made of ionospheric conditions at the seven observatories distributed over the world.

Another field of research is concerned with properties of materials which are of importance in the technique of telecommunications. The Organization also provides a comprehensive abstracting service. The abstracts have a wide circulation.

The headquarters of the Organization is at the Radio Research Station, Slough. Plans for the construction there of new buildings to replace the present inadequate accommodation are well advanced and building operations are expected to commence in the near future. Meanwhile some work is being carried out at the National Physical Laboratory and under contracts at a number of universities: these include the Cavendish Laboratory, Cambridge, Imperial College and University College, London, and the University College of Swansea. Observations on the ionosphere and measurements of radio noise are made all over the world either by the Organization or by other bodies co-operating with it.

In the following sections no attempt is made to deal with all the items of the research programme but rather to focus attention on those which appear to be of particular interest.

PROPAGATION OF RADIO WAVES

Effect of the Troposphere

In this country at the present time there is great interest in the exploitation of certain parts of the V.H.F. and U.H.F. bands (30–3000 Mc/s) for sound broadcasting, television and other purposes. Now, under certain meteorological and ionospheric conditions the field strength arising at distances far greater than the service range of the transmitter, may be abnormally high. This aggravates the difficulty of allocating frequencies and powers of transmitters to provide an adequate service in a given area without at the same time interfering with reception in other areas. To help to solve this problem the Station has made measurements of the field strengths of distant television stations, relating these to weather conditions and, more specifically, to the variations in refractive index of the atmosphere with height up to a few hundred feet above the earth's surface. These latter are deduced from the variation in humidity and temperature with height as reported by the Meteorological Office. Statistics are built up expressing the proportion of time that field strengths exceed given levels, and experience is gained of the relative significance of different types of refractive index profile in affecting long distance propagation at various distances and frequencies.

The experiments have confirmed the importance of increased bending due to super-refraction and of reflection from elevated inversions in affecting V.H.F. reception conditions beyond the radio horizon; they have demonstrated the relation between the occurrence of these conditions and the general synoptic weather situation; and have yielded statistics which are of value to authorities responsible for the planning of frequency allocations.

These studies, which have in the past mainly related to propagation conditions in the V.H.F. band, have recently been extended to cover observations on 600 Mc/s, making use of a special transmitter installed on the mast of the television transmitter at Sutton Coldfield. At this frequency, the effects of the terrain and obstructions between the transmitting and receiving aerials are more pronounced than at lower frequencies. Accordingly the variation of field strength from place to place is being studied statistically, as well as the temporal variations produced at longer distances by changing meteorological conditions in the lower atmosphere.

The analysis of the data arising from the co-operative radio-meteorological investigation in New Zealand has been brought to a close. Meteorological conditions were more complicated than had been expected and this has reduced the immediate value of the experiment in providing a quantitative check of the theory connecting radio field strength with the relevant meteorological quantities. However, the work has led to an extension of the theory to cover certain of the meteorological conditions met with in practice. The observational material has been published by the New Zealand Department of Scientific and Industrial Research. Five recently published papers relating to V.H.F. propagation research, including the New Zealand report, are listed below.[1-5]

Conditions in the Ionosphere

For very many years the main method for routine measurements of the properties of the ionosphere has been to observe the ionospheric echoes arising from vertically directed H.F. pulse-transmissions. This method leads to difficulties associated with the interpretation of the results for the more nearly glancing angles of incidence at the ionosphere which are necessarily involved in long-distance communications. A second disadvantage is that ideally a very large number of observation stations are required to deal

satisfactorily with properties of the ionosphere which vary quite rapidly with geographical position. In spite of these disadvantages the present system provides indispensable data for operating long-distance circuits, but a method of overcoming these disadvantages is worth seeking.

One method under study is to transmit high-frequency pulses by way of the ionosphere to the earth's surface at remote points; scattering occurs at the surface and some of the energy returns, again by way of the ionosphere, to the transmitting site where it can be examined. If sharply beamed aerials are used this technique enables long-distance propagation conditions to be directly studied in any chosen direction. In practice a common beamed transmitting and receiving aerial is used, rotating continuously about a vertical axis. It is thus possible to examine propagation conditions in all directions from the observing point up to ranges extending in some cases up to many thousand kilometres. The experiments have not yet advanced sufficiently to judge whether the technique will eventually supplant the present well established methods of routine ionospheric observations, but very useful practical comparisons have already been made which indicate that, at the very least, the new technique is of considerable promise as a research tool.

Analysis of the ionospheric measurements made at the time of the total solar eclipse of 25th February, 1952, is well-advanced and the observations made by expeditions sent to Khartoum and Ibadan (100 per cent. and 75 per cent. totality respectively) have yielded information concerning solar and ionospheric relationships which could not otherwise have been obtained. A preliminary statement of certain of the conclusions has been published.(6) For example, it was inferred that the component of the solar radiation giving rise to the E layer of the ionosphere was not emitted uniformly over the sun's disc: one third of the ionizing energy originated in two comparatively small areas having at least 30 times the average effective " brightness ".

Another aspect of the ionospheric research carried out by the Station is seen in the investigation of the effect of irregularities in the ionospheric surfaces in imposing limits on the accuracy attainable in high-frequency direction finding. An account of these studies has been given in a recently published paper.(7)

Low frequency propagation

Turning to much lower frequencies, in the region of 100 kc/s radio navigational aids are in regular use, particularly for maritime purposes. One such system operates by comparing the phase of the waves received at the mobile craft from one transmitter with that from each of two others, the transmitter-frequencies being harmonically related. This requires the assumption that the phase of the signals from each transmitter is known at each point in the coverage-area, from prior computation. Such computation is mainly derived from considerations of how the waves are propagated over an ideally smooth earth with uniform conductivity. It is, therefore, of importance to determine the effect of departures from the ideal conditions, to relate these to changes of geological structure, to investigate in detail what aberrations in the phase pattern occur at a coastline and to see how these various effects are related to any position-errors observed in practice.

High precision phase-measuring methods have been developed and applied to an examination of the effects of geological structure. Generally speaking satisfactory correlation has been found between the phase observed and that expected on theoretical grounds from a detailed knowledge of the spatial conductivity-changes arising from the geological structure. It has

been established in experiments at 127·5 kc/s that the waves travel faster over highly conducting ground than over low and the existence of the expected phase disturbance at the boundary between sections having differing conductivities has been confirmed. A mean phase velocity of 299,230±12 km/sec was obtained over an inhomogeneous path about 180 km in length.([8]), ([9])

RADIO NOISE

Over the past few years routine measurements have been made of the level of atmospheric noise at selected frequencies in the H.F. band since it is in this band that the effects of atmospheric noise are significant in setting a minimum useful value, for communication purposes, to the field strength from distant transmitters. Measurements will in due course be extended to much lower frequencies.

The data accruing from the long-term study of H.F. noise throughout the world have recently been reviewed in a Radio Research Special Report covering the years 1945-51.([10]) It has been instructive to compare these results with predictions of noise-level which have perforce been used in the past and which were based on a consideration of measurements made by a variety of techniques prior to 1945. For depicting the broad changes of noise-level with geographical position and time, the predictions divide the world into zones with noise-levels classified into grades 1 to 5, the boundaries between the zones varying with season. The noise-level is then read off from one of a series of charts; each chart refers to one period of the day, noise-levels for the various grades being plotted as a function of frequency over the band 100 kc/s to 20 Mc/s. The interim conclusions to be drawn from the survey of the 1945-51 data for the band 2·5 – 15 Mc/s are that, while the geographical zoning arrangement used in the predictions is reasonably satisfactory, the predicted rate of change of noise-level with grade is too low in the lower part of the H.F. band and the predicted rate of fall of the night-time noise-level with increase of frequency is too large.

With the continually increasing complexity in the systems used for communication and other purposes, it is important to relate the measurements to systems of transmission other than morse and to extend their scope. One of the characteristics of noise which is relevant in this connection is its "impulsiveness". Thus, for example, at low frequencies the noise consists largely of discrete impulses of high intensity separated by relatively quiet periods while at high frequencies in temperate latitudes the noise is more continuous. Investigations have recently been initiated at low frequencies relating to the specification of the characteristics of the noise-field, its influence on receiver circuits and on the utilization of the information conveyed by radio-systems.

MATERIALS

In addition to the studies described above of factors affecting the signal and noise-fields at the receiving aerial, research has also been in progress on certain materials which may be embodied in the components used in the terminal apparatus itself.

A Radio Research Special Report([11]) has been published discussing selected problems in the preparation, properties and application of materials for radio purposes. This is concerned with problems in the fields of semiconductors, magnetic materials, ceramics and low-loss dielectrics which appear worthy of investigation. The work at the Station is in the semiconductors field where some of the factors bearing on the application of germanium diodes and transistors are under examination. Two main lines

of investigation are being pursued mainly using point-contact germanium diodes. The first involves measurement of the current-voltage characteristics and their variation with temperature; particular attention is paid to the characteristics near the origin and explanations are being sought for the pronounced departures from theoretical predictions which occur in this region. The second line of research is the examination of the noise-spectrum of germanium point-contact diodes biased in the reverse direction; a diode is selected on the basis of its long term stability and the spectral density is examined at a fixed temperature for various reverse currents. The upper frequency used is in the neighbourhood of 10 Mc/s and the lower limit has recently been moved downwards from 0·1 c/s to 0·005 c/s using special techniques of amplification. It has been found possible to resolve the measured spectrum (relating mean-square short-circuit noise current per unit bandwidth, to frequency) into a constant component, an inverse-frequency component and two of the form $B/(1+\omega^2\tau^2)$. The results of these experiments have been considered in the light of complementary theoretical studies.

Work in progress at Imperial College on behalf of the Department includes the study of the relation between the structure of certain types of inorganic compounds and their ferromagnetic and ferroelectric properties.

LIAISON WITH INDUSTRY

The Standing Conference on Telecommunications Research was set up some years ago to provide a link between industry and the radio work of the Department, and includes in its membership representatives of industrial federations and interested Government departments. In addition to providing an opportunity for suggesting items of research work which might profitably be undertaken, and of discussing the results achieved, the Conference considers general fields of investigation which require review; at the present time for example, phenomena occurring at semi-permanent contacts (such as plugs and sockets) are receiving attention by a working party of the Conference. The recent publication of a report([12]) by Prof. Llewellyn Jones dealing with other aspects of electrical contact phenomena (and which previously had received only limited circulation) was stimulated by enquiries made by the Conference.

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ROAD RESEARCH

As in previous years the activities of the Road Research Laboratory have been directed into two main but related fields, namely safety and traffic, and materials and methods of construction. The importance of securing the practical application of the results of this work was stressed in the Fifth Report from the Select Committee on Estimates*, and particular attention is being devoted to this aspect.

SAFETY AND TRAFFIC

Motor-assisted Cycles

A survey of accidents involving motor-assisted cycles has shown that the average age of people injured when riding these cycles was high; some of them were even in the sixties or seventies and were riding their first machine with mechanical controls. The survey also showed that in many of these accidents a car collided with a motor-assisted cycle when one or the other turned right. This type of accident seems to occur because the car driver greatly underestimates the speed of the cycle: this suggests that some clearer indication is needed that a cycle is power-assisted.

Road trials have been carried out on most of the types of motor attachment on sale in Great Britain and these showed that in some cases unduly long distances were needed to stop the machines. Thus at 16 m.p.h. in the rain the figures were:—pedal cycles with rim brakes 48 ft.; motor-assisted pedal cycles with rim brakes 48 to 64 ft.; the corresponding figure for cars is 15 ft. These trials suggested that with some types the controls need to be made quicker in operation and that the whole question of brakes for these machines needs to be considered. Hub brakes were in general better than rim brakes particularly in wet weather.

Some motor-assisted cycles are capable of speeds in excess of 20 m.p.h. At such speeds, trials after dark in which objects on the road were observed showed that the lighting normally provided, similar to that provided on pedal cycles, was quite inadequate.

Motor-cycles

A simple roller-type machine has now been developed for testing the brakes of motor-cycles wheel by wheel.

Cars

Cars sometimes deviate from a straight course when the brakes are applied suddenly during an emergency. This deviation usually occurs when there is unbalance in the braking system between near and offside wheels(1) but

* *Fifth Report from the Select Committee on Estimates*, Session 1952–53. Roads (1953), H.M.S.O., price 7*s*.

experiments have shown that it may occur even in cars with the brakes properly adjusted and balanced if the rear wheels lock appreciably before the front wheels; to stop a vehicle within the shortest possible distance without losing control of direction there must be a slight interval between the locking of the front and rear wheels.

Dazzle

Misaim of headlights is still very prevalent and is the main cause of dazzle. An examination of five types of instrument commercially available for headlight testing and adjustment has shown that they are all capable of aiming headlights to the degree of accuracy required if a great reduction in dazzle is to be achieved. Those instruments that align the lamps with respect to the wheels of the vehicle are of more general use than those designed to work from a well defined central ridge on the bonnet of the vehicle, since many modern vehicles lack this ridge. A "dazzle" meter embodying a photo-electric cell has been developed and is being used in the study of experimental arrangements of headlamp beams and of dazzle conditions on the roads.

A publication summarizing the work on dazzle has been prepared and on the basis of the information obtained the Road Research Board has made suggestions regarding standards of beam aiming and intensity. This work has attracted wide attention and has led to the submission for test, both by commercial firms and by private inventors, of a variety of anti-dazzle devices.

A survey of the headlamps of a random sample of old cars showed that 17 per cent. had intensities which were only one fifth of that considered desirable for safety. The driver of such a car is dazzled by modern lamps even when they are correctly aimed.

Rear Lights

The Laboratory's experiments on rear lights[2] were of assistance in drafting the Road Transport Lighting (Amendment) Bill which has now passed through both Houses of Parliament. The Act will regulate the brightness of rear lights and reflectors and will ensure that in time all vehicles will carry twin rear lights of a specified minimum brightness.

Pedestrian Crossings

Pedestrian casualties on the roads during 1952 showed a marked decrease compared with those for 1951. For Great Britain the decrease in casualties is 5,373 or 9 per cent., and the decrease in fatalities is 335 or 14 per cent.; the decrease for the Metropolitan Police district of London is even greater, being 1,249 or 10 per cent. for pedestrian casualties and 62 or 16 per cent. for pedestrian fatalities. This improvement is associated with the zebra-marking of all pedestrian crossings.

Traffic

As part of an investigation to improve the efficiency of traffic signals, the Laboratory has developed an "automatic delay computer" which calculates the delay at fixed-time traffic signals for any settings of the "green" times and for any traffic fed into it. In operating the computer the traffic arriving at the junction being studied is recorded at the site by means of punch marks on moving teleprinter tape. The tapes are then fed into the computer and the signal phases for least delay are determined. A similar investigation but one of wider scope is being carried on with the assistance of the National Physical Laboratory Mathematics Division using their Automatic Computing Engine: this investigation is concerned with the operation of vehicle-actuated traffic signals.

MATERIALS AND METHODS OF CONSTRUCTION

Soils

Because of the savings in cost that can often be made by constructing road foundations with cement-stabilized soil, interest in this process is growing rapidly and it is now being used quite extensively in the construction of roads carrying light traffic. The Ministry of Housing and Local Government is whenever possible recommending the use of the process for its housing estate roads. The local authorities using the process and the Laboratory have pooled their experience in preparing several publications,[3] notably Road Note No. 15, "Specifications for the construction of housing estate roads using soil-cement"[4], and *British Standard Specification* No. 1924/1953, "Methods of test for stabilized soils". Some 250 engineers attended courses on soil-cement construction given jointly by the Laboratory and the Cement and Concrete Association.

Some soils otherwise suitable for mixing with cement contain organic matter that retards the setting of the cement. Organic compounds normally found in soil are being classified according to their deleterious properties, and simple and rapid methods of detecting their presence are being developed.

An important preliminary to the construction of a road is the investigation of the nature and condition of the subsoils. The Laboratory has designed a soil boring machine[5] for this work which has attracted great interest both in the British Commonwealth and in the U.S.A. It has successfully bored holes up to 2 ft. in diameter and 16 ft. deep in a wide range of soils and is now being made commercially. Its use greatly speeds up such work and it is particularly valuable in dealing with gravels and hard clays where hand-augering is difficult. From enquiries received it is clear that it has a much wider application than to roads and airfields. Thus, where short piles are required for structural foundations in clay, holes for filling with concrete can easily be bored; poles for transmission lines can also be very quickly set up with its aid.

Aggregates

Crushed stone is the main ingredient in bituminous and concrete roads of many types. To study the problems of producers of crushed stone a crushing plant has been set up in a quarry and a screening plant is being operated in the Laboratory. The investigation in progress at present in the quarry is concerned with finding the best way of operating small secondary jaw crushers to obtain the highest output of usable material.

An investigation is being carried out by the Laboratory in co-operation with the Geological Survey and Museum to link up the petrology of roadstones with their properties as revealed by mechanical tests.

Concrete

At intervals in the life of a concrete road the joints between the slabs must be raked out and resealed. The Laboratory has carried out two investigations on this problem of joint maintenance. The first consisted in developing improved types of joint-filling and -sealing material so that less frequent maintenance was needed; the second group is concerned with encouraging the use of machines for this work since they save labour and give a better and cheaper result. As part of this second investigation the Laboratory has conducted and publicized road trials of prototypes; machines now commercially available include (*a*) a rotary pick for clearing out old joints, (*b*) a rotary wire brush for removing loose dust, (*c*) a pressure sprayer for applying a bituminous tack coat to the joint, and (*d*) machines for pouring hot sealing compound.

Two articles have now been published for the guidance of engineers constructing concrete roads.[6] [7] They are based on the work of the Laboratory and show how roads having good riding quality can be laid by the adoption of methods which enable the concrete to be spread uniformly on the formation and by careful attention to the alignment and support of the rails carrying the finishing machines.

Bituminous Materials

Attention is being concentrated on improving the accuracy of operation of asphalt and coated macadam plants so that materials can be manufactured accurately to specification. The first step in the investigation was a survey of selected asphalt and coated macadam plants in commercial use.[8] Arising from this work two improvements in plant operation have been put forward:—a system of air jets to improve the flow of filler from the storage hoppers and an automatic metering device which will apportion the binder in each mix with a consistently high accuracy. The investigation has also led to two other developments. The first is a method of measuring the efficiency of dryers; this is now a draft British Standard. The second is a procedure for determining the degree of uniformity of the material produced by a plant; this involves the use of a special device for sampling the mix as it falls from the mixer, and of rapid methods of analysing the samples obtained.

Laboratory investigations carried out in conjunction with road experiments suggest that the life of a tar-macadam wearing surface may be lengthened by using tars having a high resistance to oxidation. Tars have now been prepared on a commercial scale in which the phenolic constituents active in causing oxidation have been removed by air-blowing and three roads have been surfaced with a series of medium-textured carpets to compare the treated tars with untreated tars.

During the last war the Laboratory was associated with the development of a form of bituminous construction for airfield runways using wet sand in which adhesion of the binder to the sand was facilitated by adding hydrated lime. The same process using wet sand and quarry fines has now been successfully employed by the Laboratory for resurfacing several roads in Scotland and elsewhere, and mixes containing substantial proportions of coarse aggregate have provided good surfacings on heavily trafficked roads. Recommendations have now been issued by the Laboratory for carrying out this process;[9] it is of particular importance in remote areas as the plant required is relatively simple and light.

Co-operation with the British Rubber Development Board

The year saw the beginning of a programme of co-operative research with the British Rubber Development Board to investigate the value of using rubber in bituminous surfacing materials. The two main lines of research are (*a*) laboratory investigations of the rheological properties of rubber-bitumen mixtures, (*b*) full-scale road experiments on the use of rubber-bitumen binders in surface dressing and in rolled asphalt.

SCOTTISH LABORATORY

The work of the Scottish branch of the Laboratory at Thorntonhall near Glasgow is now receiving the support and co-operation of road engineers in Scotland. Thus over 100 engineers attended a three-day conference organized by the Laboratory at Inverness to discuss the problems peculiar to Northern Scotland.

One of the Laboratory's main investigations is concerned with the construction of roads on peats and morainic deposits and another with the modifications required to the techniques of surface dressing and of designing bituminous surfacings developed for English conditions to make them best suited to the different climate of Scotland. One phase of the branch's work on surface dressing is concerned with the testing and calibration of tank-sprayers used for applying the binder to the road.

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WATER POLLUTION RESEARCH

The new Water Pollution Research Laboratory is now being built at Stevenage, and it is expected that it will be ready for occupation by the middle of 1954. When the new Laboratory is ready, four of the five sections into which the organization is at present divided—those at Watford, Garston, Birmingham, and Coventry—will be transferred to the new building. This will greatly simplify the working of the organization and besides effecting economy should lead to an increase in efficiency. The site was chosen so that domestic sewage could be pumped from a large sewer for use in experiments with pilot plant. Experiments of this kind are at present carried out at Birmingham and Coventry, and on a much smaller scale at Garston, near Watford. It seems likely, however, that it will still be necessary to undertake work from time to time in different parts of the country—for example, on particular industrial wastes which may have to be investigated at the factory where they are produced.

During the year there has been a great deal of public interest in the prevention of pollution and this is reflected in the marked increase in the number of enquiries now being received, particularly from industry on the treatment of industrial wastes. One matter widely reported during the year was the increase in the production of foam at sewage-disposal works, particularly those operated by the activated-sludge process, and in rivers to which sewage effluents are discharged. This matter is of such importance that the Minister of Housing and Local Government has set up a Committee, on which the Department is represented, to study the question. Some work on it has been started at the Laboratory, but under existing conditions the amount which can be done is very limited; it is clear, however, that the problem needs serious attention. The Department has also been represented on a Committee set up by the Ministry of Transport to study the pollution of beaches by oil, and to suggest remedies.

TREATMENT OF WATER

For some time work has been in progress on the effects of processes of treatment ordinarily used at water works on the removal from water of small quantities of radio-active substances, particularly those used in medicine and industry. One of the most important of these substances is radio-iodine, I^{131}, which is used extensively in medicine for diagnosis and therapy. It is known that radio-iodine is not removed to any great extent by normal sewage-treatment processes, and it is possible, therefore, that it might be discharged with sewage effluent to rivers used as sources of drinking water. Only a small proportion of radio-iodine was removed from water by treatment with the coagulants normally employed in water works practice. When a very small quantity of silver nitrate was added to the water, however, the proportion of the iodine removed was greatly increased; thus in experiments with continuous-flow plant in which the water was treated with alum and a small quantity of silver nitrate and was then passed through a flocculating chamber and a rapid sand filter, nearly 97 per cent. of the I^{131} originally present was removed. No appreciable quantity was removed during softening of water, either by the lime process or by cation exchange. In continuous-flow experiments with slow sand filters radio-iodine was at first almost entirely removed from water, but after two days' operation the amount removed was reduced to about 60 per cent.

TREATMENT OF SEWAGE

Several plants are now being built in this country to treat sewage by the process of alternating double filtration, which has been under investigation at Birmingham since before the war. During the year work has been continued on the effect of periodicity of dosing on efficiency of alternating filters and it has been shown that a clear gain in efficiency has resulted from slowing down rotating distributors from their normal rate of one revolution in 1 to 5 minutes to one revolution in 30 minutes. The reason for this change in efficiency is of great interest since it should throw light on the mechanism of biological filtration, and experiments are being made, in some cases with radio-active tracers, to study the effect. In the meantime it is understood that one plant is already being installed at a sewage works with provision for driving rotating distributors with geared motors so as to maintain a slow rate of rotation. It had been found in earlier experiments at Birmingham that when the primary humus tank was omitted from an alternating double filtration plant there was only a relatively slight deterioration in the quality of the final effluent and in the condition of the filters. Very similar results have now been obtained with smaller plant at Coventry. It may sometimes be

uneconomic to provide primary humus tanks, and it is hoped that the effects of omitting them will be studied at other works, treating different types of sewage.

It has been reported that the large plant at Luton for mechanical filtration of sewage effluent is working well; this plant was designed from data provided by pilot experiments made by the Laboratory. Small-scale experimental work on the subject is being continued at Coventry; it seems likely that the use of final mechanical filtration will tend to increase, mainly at works where little water to dilute the effluent is available.

Long-term investigations of the nutrition of fungi of importance in sewage treatment are being continued at Birmingham, particular attention being paid to oxygen concentration, trace metals, and vitamins. The work, particularly on the effect of trace metals, is already proving valuable in explaining the distribution of fungi found in filters treating sewage to which industrial wastes containing salts of metals are discharged.

Experiments are being continued at Coventry in association with the Gas Research Laboratory, Leeds University, on the possibilities of treating different types of gas liquor in admixture with sewage. It has been shown that sewage containing up to 3 per cent. by volume of a liquor from the Hinckley Gas Works can be treated without causing any marked deterioration in the quality of the final effluent. This liquor results from the purification of gas by methods, which include electrostatic precipitation of hot tar, recommended by the Institution of Gas Engineers. The Hinckley liquor, however, does not include retort-house liquor, which is normally an important constituent of gas liquors. Consequently the experiments are being extended to find the effect of adding the appropriate proportion of retort-house liquor. These tests are being supplemented by more detailed experiments with fractions of the two liquors prepared at the Gas Research Laboratory, Leeds University.

INDUSTRIAL WASTE WATERS

Some experiments are being made on anaerobic fermentation of liquor from the kiering of cotton. It has been shown that the liquor can be fermented to give a mixture of methane and carbon dioxide. Although anaerobic fermentation of industrial wastes is used to a considerable extent in America, it is very little practised in this country, and information on the possibility of treating various types of industrial liquors containing high concentrations of organic matter is badly needed, particularly for liquors which are difficult to treat by other methods.

Experiments have been made at Garston on the effects of simple and complex cyanides on the treatment of sewage in percolating filters. The most important result is that by gradually increasing the amount of cyanide added, the ability of a filter to destroy cyanide can be greatly increased. Presumably this is due to adaptation of the micro-organisms on the filtering medium. It is proposed to continue the work to see whether it would be practicable and economic to treat industrial wastes containing cyanides by biological filtration without addition of sewage, but possibly with addition of small quantities of nutrients. At present the most effective way of treating these waste waters is by a process of chlorination on which work was done at the Laboratory some time ago. Plants employing this method are being installed at a number of factories.

Work has been continued at Garston in an attempt to develop a standard method for assaying the toxicity of industrial wastes to fish. One of the most important conclusions of this work is that it is very important to maintain the oxygen tension of the test solution within close limits. The toxicity

of a solution of cyanide, for example, is greatly increased by a fall in concentration of dissolved oxygen—even by small reductions at concentrations near the saturation value. This work is being correlated with a survey being made by the Ministry of Agriculture and Fisheries, with some assistance from the Laboratory, of the River Colne near Watford, which receives effluent from a modern sewage-disposal works.

SURVEY OF THAMES ESTUARY

Considerable progress has been made with the survey of the Thames Estuary which occupies a large proportion of the staff of the Laboratory. It has become clear that the factors which influence the concentration of dissolved oxygen in the estuary are very complex, affecting as they do not only rates of oxidation, but also the rate of entry of oxygen into the water from the air. The rate of entry, for example, appears to be affected considerably by weather conditions. It now seems fairly certain that the hydrogen sulphide evolved in the estuary during dry weather is derived almost entirely from the reduction of sulphate under substantially anaerobic conditions. It has been shown that in the presence of catalysts which occur in the estuary the rate of oxidation of sulphide by dissolved oxygen is rapid; the rate appears to be limited by the rate at which oxygen can be absorbed by the water from the air. A large amount of information has now been collected on the volume and character of the various polluting discharges into the estuary; in this survey the various Local Authorities and manufacturers concerned have been extremely helpful.

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 36 Research Associations, four other co-operative industrial research organizations which have not yet reached the status of a Research Association and three organizations carrying out work of special importance to industry.

The drafts of individual reports have been prepared by the organizations themselves and therefore differ somewhat in style and completeness. Although more space has been devoted to the larger Research Associations than to the smaller, some of the reports are selective and do not attempt to cover the full programme of work in hand.

NEW OR REVISED TERMS OF GRANT

The following organizations were offered new or revised terms of grant during the year:

British Cast Iron Research Association.
British Ceramic Research Association.
British Coal Utilisation Research Association.
Research Committee of the Furniture Development Council.
British Gelatine and Glue Research Association.
British Hydromechanics Research Association.
British Scientific Instrument Research Association.
Coal Tar Research Association.
British Whiting Federation Research Council.
Aslib (Association of Special Libraries and Information Bureaux).
Commonwealth Mycological Institute.

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

CAPITAL GRANTS

Two special grants of £100,000 each have been made by the Department: one to the British Electrical and Allied Industries Research Association towards the cost of building new headquarters and laboratories at Leatherhead; the other to the British Coke Research Association towards the cost of erecting an experimental full scale coking plant.

CESSATION OF GRANT

The Design and Research Centre for the Gold, Silver and Jewellery Industries

The Department has made no grant to the Centre during the past 12 months because the industrial income has not attained the minimum level necessary to earn the block grant. This was mainly due to the cessation of the industrial income from the Jewellery and Silverware Council which was wound up on 1st January, 1953. The Centre is at present continuing its activities on a reduced scale.

WINDING UP

The Linoleum and Felt Base Research Council

The Linoleum and Felt Base Research Council was, as foreshadowed last year, wound up in April, 1953, and the balance of funds representing unspent grant repaid to the Department.

BRITISH BAKING INDUSTRIES RESEARCH ASSOCIATION

In the last report it was stated that considerable work had been carried out in preparing scientific data on antioxidants and other possible food additives on behalf of the industry, for submission to the Preservatives Sub-Committee of the Food Standards Committee of the Ministry of Food. The Sub-Committee's report on antioxidants, which has now been published, recommends that butylated hydroxanisole and propyl gallate should be permitted for use as antioxidants in fat. This is likely to stimulate further work at the Research Station on the uses of antioxidants and their carry-through into biscuits, a topic of particular importance to the export industry.

Considerable attention has also been given to the preparation of data on emulsifying agents for presentation to the Preservatives Sub-Committee. This work and the flour improver problem have involved the diversion of much effort from other topics ; nevertheless, it has been possible to extend, to some extent, fundamental research.

NATURAL OILS IN FLOUR AND BREAD

The composition of these oils, in terms of (i) monoglycerides (ii) unsaponifiable matter, (iii) phosphatide complexes, and (iv) other substances, is being investigated. Evidence has been obtained by exhaustively applying chemical and physico-chemical methods that the natural oil from an untreated and unbleached flour contains monoglycerides, about 25 parts per million (p.p.m.) being present in the flour. Thus, the addition of glycerinated fat to bread or other foods does not involve the ingestion of substances foreign to the human system ; indeed monoglycerides have been consumed as long as flour products have been eaten. The unsaponifiable matter in flour and bread oils has been separated by column chromatography. Ultra-violet absorption spectrophotometry has indicated the existence of substances of high absorption intensity in bread prepared from both treated and untreated flours and high flour extraction rate causes an apparent increase in the absorption intensity of the unsaponifiable matter. Indications have been obtained of the existence of a phosphatidic complex in flour oil which has a fundamental influence on the action of crumb softening agents including fat. A number of other substances have been isolated from flour and bread oils during this work and are thought worthly of further investigation, e.g., as natural emulsifying agents.

MECHANISM OF CRUMB SOFTENING ACTION

Further information has been obtained on the effect of fatty acids and certain derivatives and of glycerinated fats containing monostearate (GMS) and oleosterate (GOS) on crumb softness in bread. The rôle of labile water in bread has also been investigated and its influence on the rate of restoring crumb softness to stale bread by refreshening with heat. It is known that crumb softening agents affect the gelatinization of starch so influencing the properties of bread. A start has been made on measuring starch swelling and solubility in the presence of certain simple compounds such as oleic and stearic acids. The results will be applied to oils, fats and monoglycerides so that further fundamental knowledge of their crumb softening action can be obtained.

The difference between the effect of oils and fats in breadmaking is being continued. A study of their viscosities between 25–70°C. showed this property could not be correlated with practical performance. Further work is

envisaged on their relative natural monoglyceride content, and also on their effect on starch. The function of various enzymes on crumb softening is also under investigation.

FLOUR AND DOUGH TESTING

The monthly survey of flours has been extended and a series of tests in collaboration with a panel of cereal chemists has commenced on strong and weak flours, and blends from these flours, to compare results obtained on the Brabender, Simon and Chopin instruments. It is hoped that research of this nature will ultimately lead to workers in this field obtaining data on a strictly comparable basis. Comparative methods of measuring water absorption, particularly on the Simon Research Meter and the Brabender Farinograph, have been reported. A new type of instrument has been constructed to investigate the fundamental properties of dough under linear extension and relaxation. A literature survey and summary of previous work on these properties has also been prepared and made available to members.

BREAD INGREDIENTS AND MANUFACTURE

The Association is collaborating with the Ministry of Food, the Medical Research Council and the Research Association of British Flour Millers in tests designed to ascertain the effect of flour and bread improvers on health and in investigating possible alternatives to Agene treatment. As the Minister of Food has stated, these tests take time to carry out, but a great deal of the effort of the scientific staff is devoted to this problem, and progress is being made as rapidly as possible.

Methods of physical improvement in which atmospheric oxygen also plays a part have also been investigated including a patented "aeration" or "batter" process, modifications of this process, an overmixing technique and a "no-time dough" method. Considerable work has been done on the refrigeration of doughs, greatly helped by the loan of a specially designed refrigerator by a member firm. Morning rolls and small fermented goods can be successfully retarded under certain conditions of temperature and humidity and depending on the recipe up to periods of 48 hours. Bread doughs can also be retarded but the resultant baked bread is not always of a satisfactory commercial standard and further work is required on this problem.

Under present-day conditions there is no difficulty in obtaining fresh yeast but, in certain circumstances, yeast might have to be kept for longer periods and storage tests have therefore been carried out under conditions of temperature and humidity applicable under normal bakery conditions. When stored in a refrigerator in a closed jar to prevent evaporation yeast retained its full efficiency up to 4 weeks and with relatively slight deterioration up to 6 weeks.

A series of tests have also been performed to ascertain the effect of water chlorination at normal and excessive levels (5 p.p.m. or 17 times the normal maximum quantity) and of water-softening treatments, on dough making. It was found that no normal treatments as at present practised have any effect, adverse or beneficial, on the resultant bread.

PURITY OF MINERAL OILS IN GREASING OPERATIONS

The use of mineral oils for greasing operations is permitted by Statutory Instrument No. 614 of 1949 provided that the quantity of mineral oil present in the final product does not exceed 0·2 per cent. by weight. A method has been developed for determining the quality of mineral oils and this method has been described to the Society of Public and other Analytical Chemists

and will shortly be published. This research, amongst others, has been carried out to give the public and the baker the greatest measure of confidence when the use of mineral oils as processing aids proves necessary.

PREVENTION OF MOULD AND BACTERIAL DEVELOPMENT IN BAKERY PRODUCTS

Conditions and suitable agents for the successful inhibition of " rope " and mould growth have been further investigated. A precise and careful study has been carried out in collaboration with the D.S.I.R. Low Temperature Research Station at Cambridge on the influence of baking conditions and, in particular, of baking temperatures on bacterial survival, using an organism similar to that responsible for " rope " development in bread.

Proving cloths of nylon and the conventional cotton material have been impregnated with calcium propionate, an anti-mould agent, and have been examined for mould resistance in a member's bakery, but the results have been disappointing, inasmuch as little marked improvement in mould resisting properties was observed and frequent laundering still appears the best palliative. Other methods of mould control are under investigation.

Tests on mould-inhibiting paints extending over two years in collaboration with member firms have shown the importance of a hard, easily cleaned paint surface and of careful preparation of the materials to be painted.

EMULSIFYING AGENTS IN CAKES, BISCUITS AND OTHER PRODUCTS

The effect of glycerinated fats on sponges from whole and dried eggs and on Madeira cakes has been studied. In sponges the use of the correct type of glycerinated fat brings about an improvement in keeping quality and appearance, and also a remarkable saving in time of whisking sponges mixed by the " all in " method. In Madeira cakes the improvement is less marked and the tendency for instability in batters caused by glycerinated fat products when incorporated as aqueous emulsions is still being studied.

The use of glycerinated fat products, lecithin and emulsions in hard dough and soft dough biscuits has been investigated. Shelf life is affected to some extent, but under certain conditions particular types of glycerinated fat and lecithin in hard dough biscuits and lecithin in soft dough biscuits may be useful.

Extensive studies on the physical properties of synthetic whipping creams using a wide variety of emulsifying agents have been carried out. Tentative suggestions regarding the mechanism of the various phenomena have been reported to members.

QUALITY TESTING BY TASTE AND BY PHYSICAL INSTRUMENTS

The use of tasting panels has become a routine practice as a result of the work on consumer preference reported last year. For physical testing of quality an apparatus has been devised for measuring the volume of biscuits and is under practical test. A simple instrument has also been devised for measuring oven spring. An apparatus for measuring the volume of 28 oz. loaves has been designed on the same lines as the one originally designed for 14 oz. loaves.

USE OF PLASTIC MATERIALS

Specimen plastic confectionery trays from various manufacturers have been tested but have been found to suffer from the disadvantage of too great flexibility, difficulty in stacking and high price. This last can be attributed at least partially to the fact that the standard sizes in which the sheets of

plastic are normally manufactured apparently cannot be cut economically to produce the popular sizes of tray needed to fit existing equipment and fittings.

LIAISON AND INFORMATION SERVICES

The Association's *Abstracts* and *Bulletin* have continued to appear alternately each month during the year, and the first three issues of a new type of publication *Research Reminder* have been sent to members. This is intended to sum up the results of research work in a form in which they can be directly applied in the bakery, confectionery department or biscuit factory. Visits by many members have been welcomed at the Research Station and the staff have continued to visit member firms in all parts of the British Isles. Enquiries from individual members continue to increase as the scope of the Association's capacity to serve members becomes more widely known.

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 £8,000.

The income of the Association for the last completed year was £47,448.

THE BRITISH BOOT, SHOE AND ALLIED TRADES RESEARCH ASSOCIATION

Previous reports have frequently referred to the Association's work on the improvement of fitting qualities of shoes arising from foot measurement surveys and studies of last design; to its work on shoe materials, directed towards the raising and maintenance of qualities and the development of new materials; and also to its productivity studies in shoe manufacture which have been made widely known. Work in these three main fields has continued and advances have been made in each of these three principal directions of shoe science development.

SHOE SIZING

At the time of writing an important comprehensive survey of women's feet is in progress. This survey is expected to correct and refine earlier work on the women's foot population which yielded the striking results embodied in what has become known as the precision grade of shoe lasts. To survey women's feet with the desired measure of representation in all age groups is difficult to organize because an appreciable group of the population, the housewives, is somewhat inaccessible. By contrast it is possible to obtain foot statistics from children easily because they are assembled in schools, while young adults are in the services and in factories and it is not difficult to obtain representative statistical groups in these ages; the middle and older age groups are more difficult to reach.

Women's Institutes and Housewives' Associations are co-operating in the present survey and there is a fair degree of success in country villages where the survey team have established themselves in the village halls and warning has been given with sufficient publicity to the villagers a day or two beforehand. Apart from housewives, a number of large firms have provided facilities for members of their staff to take part in the survey, and

in addition the staff of the Department of Scientific and Industrial Research has co-operated, both at the research establishments and at Headquarters. It is expected that by next year some important and perhaps far reaching results will be emerging from this survey.

MATERIALS

The year has witnessed intense activity on the part of rubber and plastics manufacturers in devising new products for application to footwear. Resin-rubbers, in which rubber is reinforced with synthetic resin to modify its rubberiness and to improve its characteristics for shoe solings, are one example. Microcellular rubber, in which the compound is aerated with minute cells to communicate lightness and shoe comfort, is another illustration.

Plastic materials are continually being developed and some of them have found extensive use in certain grades of shoes. In this connection the Association's guidance has been sought and much has been done, in collaboration with the producers of these various materials—who are themselves members of the Association—to get the materials right for shoes before embarking on large scale trials. In this way both the shoe industry and the public are being protected from any troubles and annoyances which might arise from unsuitable use of new and untried materials.

Apart from this work on the new synthetic materials, attention continues to be devoted to leather, the traditional shoemaking material. In collaboration with tanning firms, an investigation into leathers, especially leathers for insoles of welted shoes is in hand with the object of improving this important component especially with respect to its durability and resistance to the deterioration caused by foot perspiration.

Also during the year the Association has joined with the British Leather Manufacturers' Research Association to form a committee composed of equal numbers from the two Research Associations with the special object of studying matters of mutual importance to the two industries.

PRODUCTIVITY STUDIES

The work of the Association's Industrial Division has achieved outstanding success during the year. There have been two further labour productivity reports similar to previous ones relating particularly to the manufacture of children's shoes. There have also been reported detailed investigations into the complicated problems of closing room efficiency. The closing room in a factory is the department in which the uppers of shoes are sewn together by machines operated mainly by women and girls.

These reports on efficiency surveys are comprehensive and detailed, making them works of reference of permanent usefulness to shoe factory executives concerned with the organization of the factory departments to which they relate. Productivity surveys lead the methods' engineers to ideas for improvements. The seat bedding and assembly machine, mentioned in last year's report is an example of this. During the past year about 100 of these machines have been supplied and the demand is growing very satisfactorily.

Investigations are continuing into the economics and usage of materials for both bottoms and uppers of shoes. Leather is a very variable material, differing widely in quality from place to place in the hide and from hide to hide, and the requirements for different parts of shoes vary greatly. Amidst all these variables the problem is to ensure a minimum of waste and the best use of the materials. This is obviously important since cutters of leather in the shoe factory may cut as much as £100–£150 worth of material for each £1 of wages, so materials economy is equally as important as labour economy.

An investigation into the economics of bottom stock cutting has been reported during the year. This work was based on surveys carried out in ten factories, five shoe factories and five cut sole factories. Studies of this work and appreciation of its full significance are not yet complete but sufficient is known to say that the efficiency comparisons between firms within each group, and between the groups, are most instructive and are likely to inspire important new developments.

The investigation into the economics of upper materials usage is not quite so far advanced as the bottom stock investigation but it can be said that this equally important investigation has made very good progress and a report should be available next year.

Every item in the Association's programme of work is directed towards the advancement of technology for the making of better shoes and cheaper shoes. In the words of last year's report, the purpose of footwear science and technology is to provide the community as economically as possible with shoes to clothe the human foot comfortably, healthily, elegantly and durably.

Forward looking members of the Association are fully aware that improvement and efficiency of production, without regard to the efficiency of the shoes produced, cannot amount to more than half of the main task and that the dual efficiency both of the shoes themselves and of their manufacture is required. Even that is not all: the benefits of efficient shoes efficiently produced may be largely lost if distribution is inefficient and good shoes are put on to the wrong feet. The problem is one of large scale operational research—the operation of shoeing the population as a whole—in which the interest and co-operation of the public can play an important role. During the year the Association has appointed a Distribution Committee specially to supervize work on distribution problems.

SPECIAL PURPOSE FOOTWEAR

Reference was made last year to the development of footwear for specialized industrial and service uses. A particular example is the special assault boots designed by the Association and made under their supervision with the assistance of local firms for the successful Mount Everest expedition. From the Association's point of view the importance of this experience lies in its being a good example of functional design on the basis of scientific knowledge of materials and foot functions. Conventional and traditional shoemaking would not have dared to make so unconventional a design in so short a time (putting the slow trial and error approach out of the question) for so important an occasion.

In the light of the known physical properties of the materials, (all of which were very carefully chosen in relation to the requirements which the boots were to fulfil,) such risks as were taken in the design were calculated risks and not unknown. The Association has often referred in reports and writings of various kinds to scientific design, or drawing board design, or functional design, and its possibilities in the shoe industry's development. The Mount Everest assault boot project provides a good illustration of its application.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1948, to 31st December, 1952, a block grant of £8,000 per annum was made provided £15,000 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 January, 1953, to 31st December, 1957, the block grant is £10,000 per annum, provided £25,000 is received from industry, and the additional grant £80 for each additional £100 contributed by industry up to a maximum of £8,000.

The income of the Association for the last completed year was £45,263.

BRITISH CAST IRON RESEARCH ASSOCIATION

With the appearance of the June, 1953, issue, the B.C.I.R.A. *Journal of Research and Development* completed its fourth volume and eighth year of publication. During this period 191 papers were published, 22 during the current year. The B.C.I.R.A. *Bulletin,* has completed its eleventh volume and thirtieth year of publication. In addition to abstracts of foundry literature and other customary features, it has issued reviews of published work on shell moulding, the hot blast cupola, quality control, the die-casting of iron, and other subjects. To meet demand, the Proceedings of two Conferences organized by the Association on "Foundry Sands", and "Fuels in the Foundry", have been collected and published as complete volumes similar to those on "Malleable Cast Iron and Heating, Lighting and Ventilation for Ironfoundries". Thirteen hundred copies of the publication *Typical Microstructures of Cast Iron* have now been sold. The ninth post-war conference was held at Ashorne Hill in October, 1952, on the subject of "Economy in the Foundry."

RESEARCH DEPARTMENT

Gaseous Elements

Work on the influence of gaseous elements in cast iron has continued at an increasing pace. In order to assess the influence of melting practice and raw materials, visits to 14 selected member-foundries were made during the year and significant differences in oxygen and nitrogen contents of the product were detected. In the laboratory the most significant advance has been in connection with nitrogen, shown to have a powerful carbide-stabilizing effect. This has considerable influence on the annealing time of malleable cast irons. Increasing nitrogen increases the chilling tendency and the stability of pearlite. In grey cast irons, increasing nitrogen modifies the graphite, improving the mechanical properties. The effect of nitrogen can be neutralized by the addition of a small amount of aluminium and it appears that the well-recognized graphitizing influence of small aluminium additions attributed in the past to deoxidation, can be almost entirely related to the removal of nitrogen. A method for the chemical estimation of total nitrogen has been studied and published. A theoretical study has been made of the factors influencing the oxygen content, and experimental work has begun on both oxygen and hydrogen.

Nodular Cast Irons

Reference was made in last year's Report to the subversive effect of certain elements in the production of nodular cast iron by the magnesium process and the neutralization of the effects of these elements by adding small amounts of cerium. A number of other subversive elements have since been studied, including cobalt, thorium, thallium, uranium, tellurium, zirconium, selenium, vanadium, chromium, tungsten, zinc, tantalum, niobium and boron. It has been found possible to produce nodular graphite structures with cerium-free mischmetal in which the major constituent is lanthanum, and small additions of the same material were found to be capable of neutralizing subversive elements in the magnesium process in the same way as cerium or cerium mischmetal.

Mechanical and Other Properties

An investigation on the impact testing of flake graphite cast iron has been completed and a report submitted for the International Foundry Congress in Paris, September, 1953. Work has shown that it is possible to detect a transition temperature range in flake graphite cast irons similar to that occurring in ductile ferrous metals. The embrittling effect of silicon and phosphorus on the impact properties of nodular irons has been demonstrated and appropriate maxima have been determined. The results obtained can be interpreted in terms of two transition temperatures, one related to the energy required to propagate a crack, and the other related to the energy required to initiate a crack; the former measured by the notched bar impact test and the latter by the unnotched impact test. A keyhole notched specimen revealed both transitions. A paper on this subject, together with one on the mechanical properties of cast irons at low temperatures, has been submitted to the American Society for Testing Materials, for their symposium on low temperature properties. The impact properties of blackheart and whiteheart malleable cast iron have also been studied. An extensive programme on fatigue properties of nodular cast irons has been completed and awaits publication. The notched fatigue strength of pearlitic flake graphite irons has been raised by one-fifth by rolling at the root of the notch and there is a significant increase in life, due to surface rolling, at stresses above the fatigue limit. A detailed examination of micro-hardness testing and the limitations of the available equipment has been made.

A comprehensive account has been prepared of the effects of composition and structure on electrical resistivity.

Moulding and Core Sands

To obtain fundamental data on the scabbing defect, load/deformation curves have been obtained on various types of sand in compression at temperatures obtained by dielectric heating. Materials such as coal dust and pitch minimize the scabbing tendency. Equipment for the production of shell moulds has been constructed and a device for the automatic clamping of shells for pouring has been developed and described.

Preliminary work on the flowability of sands has been completed. Short courses on sand testing and control referred to in earlier reports have been continued and during the period seven such courses have been held. The total number of industrial representatives who have attended these courses now approaches 200.

Analysis

Considerable progress has been made by means of co-operative effort with the chemical laboratories of members' foundries towards improving methods of sampling and analysis, and methods have been evolved and published on the estimation of residual elements interfering with the production of nodular graphite structures. Spectrographic analysis has been mainly concerned with bringing into operation the A.R.L. Quantometer, a direct-reading spectrometer. Additional work has concerned the improvement of spectrographic analysis of slags and the influence of microstructure on reproducibility. The influence of microstructure on the reproducibility of results is of importance because the spectrographic response from a metal is sometimes found to depend on its microstructure.

Shrinkage and Porosity

The production of sound castings has been examined from the point of view of changes in mould dimensions when molten iron is poured into a mould. It has been shown that greensand moulds dilate and that the

casting follows this dilation, which increases with the moisture content of the mould and is related to the migration of moisture from the mould/metal interface.

Solidification phenomena have been examined in relation to soundness, and transient heat flow from metal to mould has been analysed in terms of the electrical analogue.

Enamelling

Work on the blistering of enamelled cast iron has continued, comprising an extensive investigation of machined and unmachined cast iron surfaces. This work has been carried out with the co-operation of nine foundries producing cast iron enamelled ware. It has been shown that machining does not eliminate blistering. A report has been published on the mechanism of blister formation.

White and Chilled Castings

Work has been completed on the effect of melting temperature on chill formation, the function of inoculation and the effect of melting stock. The effect of casting temperature and cooling rate down to casting temperature have also been studied for both plain and alloy irons. The influence of oxygen has been examined. Results indicate that nucleation is probably the principal factor influencing chill depth and that oxygen has little influence.

Malleable Cast Iron

The sulphur-manganese balance in whiteheart malleable cast iron has been studied and the advantages of fully balanced composition with respect to sulphur and manganese have been shown. A practical objection has been removed by appropriate adjustments to total carbon and/or silicon content. The influence of hydrogen on the annealing atmosphere in blackheart malleable cast iron has been investigated. It has been shown that hydrogen has a powerful carbide-stabilizing influence during the annealing operation. It also reduces the nodule number and eliminates the susceptibility of the iron to increase in nodule number by slow heating.

OPERATIONAL BRANCH

During the year under review the Operational Research Team made 170 visits to the foundries of member firms. Some of the larger foundries are now being visited, and the time taken for the examination accordingly increases.

FOUNDRY ATMOSPHERES AND HYGIENE

The control of respirable dust from pedestal grinding wheels by means of a specially designed extractor unit dealing with dust at its point of origin, referred to in the last Report, has reached a stage at which active negotiations are in progress for its manufacture for industry. Two papers have now been prepared and presented and two short films prepared. An active programme of work on air flow in the neighbourhood of knock-out extraction systems has been commenced to establish the basic conditions for evaluating the efficiency of extraction systems and various forms of dust filter. Co-operation has been established in this field with the British Steel Castings Research Association.

DEVELOPMENT DEPARTMENT

In order to assist users desiring new castings, certain prototypes have been made in trial materials sufficiently rapidly to enable satisfactory tests to be made before commercial manufacture. Examples include a television

screen mould, a magnetic casting in annealed nodular iron, a 30 per cent. chromium iron extrusion die, and automobile cam pallets. Where the production of such castings is within the Association's capacity, a very useful purpose is served in cases in which special material, requiring special treatment, or for entirely new applications in industry, is involved. Where complex and heavier prototypes are required, members of the staff visit the foundries concerned.

Work on corrosion protection, both in the field of marine propellers and water mains buried in corrosive soils, is now at the stage of treatment by the Development Department and the methods employed involve cathodic protection by magnesium anodes. In the case of marine propellers, substantial protection has been achieved. In the case of pipe lines, soil resistance has required an appreciably higher current than was previously thought necessary.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st July, 1948, to 30th June, 1953, 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. The same terms apply for the period 1st July, 1953, to 30th June, 1954.

The income of the Association for the last completed year was £111,563.

THE FRUIT AND VEGETABLE CANNING AND QUICK FREEZING RESEARCH ASSOCIATION

The year that has elapsed since this Research Association took over the work of the University of Bristol Research Station at Chipping Campden has been one of internal reorganization. A Research Committee has been formed, with three advisory panels—on Canning, Quick Freezing and Engineering respectively—and it is through the work of these panels that contact is kept with the scientists and technologists in the canning and quick freezing industries. A start has been made on the re-equipment and modernization of the laboratories, and the scientific staff has been increased. The number of technical enquiries dealt with during the year, and the number of visits paid by members of the staff to canning and quick freezing factories, have been fully maintained, and the quality inspection of canned fruits and vegetables which was a service given by the Research Station to the industry for many years, has been continued.

RAW MATERIALS AND PROCESSES

Variety Trials: Canning and Quick Freezing

Studies on the suitability of new varieties of fruits and vegetables for canning and quick freezing have been in progress for many years and are still undertaken each season. The fruits and vegetables for these tests are grown in the Research Station garden, or obtained from horticultural research stations or growers; they are each tested for at least four seasons and from five or six orchards or plantations. The varieties of strawberries tested recently have included Auchincruive Climax and thirty-five of the new Cambridge varieties; the raspberries have included a New Zealand strain of Lloyd George, St. Walfried, and twelve of the new Malling seedlings.

Stone-gum in Victoria Plums

Previous investigations, designed to find the cause and, if possible, suggest a remedy for this disfiguring defect in Victoria plums, were extended last season to include an examination of the effect of rootstock. Fruit from three types of rootstock—Pershore, Myrobalan and Common Plum—were obtained from six sources and the degree of internal gummosis recorded. There was some indication that trees on Common Plum stock gave less gumming than on either of the other rootstocks. The effects of rainfall, and of spraying the trees with boric acid, had been noted in earlier trials and a further series of field tests has been planned after consultation with horticultural research stations. Work on the composition of stone-gum and on the mechanism of its production is being undertaken at the Department of Biological Chemistry, Bristol University.

Texture of Green Peas for Canning and Quick Freezing

For a number of years past studies have been made of the changes occurring in sugars, starches and higher carbohydrates during the ripening of green peas. These have been correlated with the quality of the canned product, the best index of quality proving to be the content of alcohol insoluble solids. For two years the degree of maturity of the raw peas has been estimated by means of an instrument known as a *tenderometer*, which records the shearing force required to drag a sample of peas through a standard grid composed of laminated plates. Work now in hand includes estimation of initial texture by means of a *maturometer*, which measures the pressure necessary to puncture a definite number of peas under standard conditions. The adoption of a simple method of measuring the degree of maturity of peas would enable canners and quick freezers to purchase their raw peas on a basis of quality.

Texture of Processed Peas

The effect of variety and conditions of growth on the texture of harvested peas used for canning as processed peas has been examined for several years past in collaboration with the Home Grown Threshed Peas Joint Committee, and has yielded results which should prove to be of value to canners. Work on the mechanism of toughening of the peas—particularly in relation to their content of phytin and pectic substances—is in progress and attempts are being made to control the texture and improve the quality of this important canned product.

Taints Produced by the Use of Sprays

The production of taints by the use of insecticides and fungicides on crops required for canning or quick freezing has been studied in collaboration with the National Vegetable Research Station, Wellesbourne. Benzene hexachloride (BHC) was used as a seed dressing for carrots at various strengths and samples of the clamped carrots were canned and then judged for degree of tainting by a tasting panel. The results were positive for all degrees of application of the dressing. Further tests on BHC and on other sprays are now in hand.

CHEMICAL STUDIES

Corrosive Properties of Victoria Plum Syrups

Internal corrosion of containers involves the canning industry in heavy losses each year and, though much work has been done towards finding a practical method of reducing these losses, the problem still remains a serious one. In order to study the more fundamental aspects of the corrosion process co-operative research has been planned with the research department of an

industrial firm and the British Iron and Steel Research Association. The work undertaken at Campden includes a study of the relative corrosivities of Victoria plums from six orchards over a period of four or five seasons and an attempt to isolate and identify the main accelerators of corrosion in the canned product. This work has been in progress for a year.

Analysis of Tin in Canned Foods

An investigation has been made into the determination of tin in canned food, particularly in the presence of copper, and some modifications in the analytical procedure have been suggested.

Surface Film on Aluminium

Treatments producing surface films containing fluorine and chromium in small quantities have proved reasonably successful for protecting certain types of aluminium containers. Films of various thickness have been analysed for their content of these two elements.

BACTERIOLOGICAL STUDIES

Heat Resistance of Bacterial Spores

The resistance of the spores of twenty strains of flat sour bacteria (*B. stearothermophilus* and *B. coagulans*) at pH6 have been determined with various degrees of precision. Investigations into the order of death of bacterial spores under moist heat were continued using the results obtained with some of these strains.

Antibiotics; Nisin

Studies with the antibiotic nisin have included the development of a convenient method of assay using a strain of *B. stearothermophilus*, attempts to obtain solutions of high potency, and tests of the effects of nisin on the spores of spoilage bacteria.

PROCESS EVALUATION

A method has been devised whereby the sterilizing value of a process of any degree of complexity may be calculated, for conduction packs, covering conditions when the processing temperature is varied, up or down, during the process. A corollary is a method of evaluating the "coming up time" of a retort in terms of time at processing temperature. These methods will be published shortly.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st April, 1952, to 31st March, 1957, a block grant of £6,000 per annum is made provided £9,000 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 £5,000.

The income of the Association for the last completed year was £22,944.

THE BRITISH CERAMIC RESEARCH ASSOCIATION

The British Ceramic Research Association, formed in 1948 by the amalgamation of its two predecessors, now includes the whole of the ceramic industry in its activities. There are divisions dealing with pottery, refractories, and heavy clay materials; special sections for fundamental work, fuel technology, and engineering; and, following the erection of new laboratories, facilities for pilot scale work are also being provided.

Since the increased facilities became available, the use of the premises as a focal point for the industry's technical discussions has been progressively encouraged. There have been visits by several Trade Associations and meetings have been held by a number of technical and scientific societies.

POTTERY

The definition and control of the properties of the raw materials used in the pottery industry continues to be a major task for the Association. During the past few years attention has been focussed mainly on clays, and a considerable amount of data has been obtained with respect to both ball clays and fireclays. The work has provided the information necessary to guide maufacturers in their selection of clays but it is now being carried a stage further. Attempts are being made to estimate quantitatively the constituent elements in a clay by direct means. Methods have been developed for extracting the various types of organic matter; the measurement of the quartz content by differential thermal analysis is being investigated; and a study of the rate of decomposition at constant temperature is being used to give information regarding the kaolinite fraction.

Cornish stone is an important fluxing material in pottery bodies, and the various grades are being studied in co-operation with the suppliers. A technique has been developed to give a mineralogical analysis of a sample, which adds significantly to the information obtained from the chemical analysis. Many samples have been collected from the quarries, and their chemical and mineralogical properties, together with their behaviour in conjunction with other ceramic materials, are being related to their naturally-occurring position in the rock formation.

Previous work on the treatment of bone, used in the china industry, has now been extended to include a detailed study of the constitution of bones from various sources in an attempt to determine the nature of the variations which occur. The work on raw materials also involves studies on flint and china clay.

A substantial proportion of pottery is made by the slip casting process, this being of particular importance to the tableware and sanitary industries. In this process, the control of the rheological properties of the slip is a matter of great importance. The various factors involved have been examined in the course of an investigation partly in the laboratory but mainly in the factory. The principles involved in a satisfactory system of control have been worked out and put into operation in a number of works. In order to make for better understanding of these slips, the behaviour of which is anomalous, and to establish the basis of better instrumentation, a fundamental study is in progress of the rheological behaviour of clay-water suspensions. A rotating cylinder viscometer has been designed and built, giving continuous recording of the torque as the speed is changed, and so showing the rate of build-up and breakdown of the thixotropic structure. Parallel to this, another fundamental investigation is concerned with the casting process itself. Closely controlled conditions, including specially prepared slip and plaster moulds, enable the factors affecting the casting rate and the nature of the cast to be assessed.

In the study of pottery bodies, attention continues to be given to the improvement of durability and the development of increased strength. An electrical porcelain body of high strength has been made and has been successfully adopted by the industry. To the measurement of resistance to impact has been added a method for the direct measurement of resistance to thermal shock. In order to complete the available data on thermal properties, an apparatus has been built and is now in use for the measurement of thermal diffusivity. Means are already available for the measurement of thermal expansion, specific heat and elastic properties, so that a more basic approach to the problem of thermal endurance can now be made.

The behaviour of pottery bodies under exposure to gases and vapours, and water vapour in particular, is being examined. The size changes resulting from the adsorption of water are now much better understood, and some reduction in the effect has been produced by the use of magnesian materials in the body. The rate of adsorption and de-sorption at various temperatures is being measured in an attempt to throw more light on the mechanism of spit-out.

A wide programme of work on glazes includes a study of the characteristics of systems containing no lead. The apparatus designed to measure the viscosity of glazes at enamel kiln temperatures is now giving satisfactory results. Visual estimation of the optical properties of glazes and colours is being supplemented with the use of modern techniques enabling more precise measurements to be made. Colours are being measured by means of a tri-chromatic colorimeter giving results on the internationally agreed C.I.E. System ; and an apparatus has been built for the measurement of the reflectivity of glaze surfaces at various angles, thus providing data for an assessment of gloss.

Following several years' work on the performance characteristics of new types of dryers being used in the industry, laboratory work has now been commenced on the drying process itself. An investigation is being made of the distortion which can occur when plastic clay is dried under certain conditions ; of the equilibrium vapour pressure of water in association with clay ; and of the migration of water through clay.

A good deal of emphasis is being placed in the Association's work on the development and standardization of suitable tests for use in the pottery industry. A considerable number of tentative standards have already been issued, and others form the subject of present experimental work. New methods of analysis of materials, incorporating also the use of physical methods, are being examined and good progress has been made in reducing the time taken for the necessary tests.

REFRACTORY MATERIALS

Investigations of refractory performance carried out on behalf of the iron industry have entailed numerous visits to blast furnace and ancillary plant. During 1952-53 fourteen blown-out blast furnaces were inspected and samples of brickwork were subsequently received in the laboratory for chemical, X-ray and microscopic examination. The action of slag on the brickwork in the flue of a blast furnace stove has been studied as has also the corrosion of ladle linings in which iron is desulphurized by the soda ash process. In both these cases the joints appear to be attacked preferentially to the bricks and a considerable part of the problem is to find suitable jointing material. Recommendations have been made based on previous laboratory work. In connection with the use of carbon blocks for lining blast furnace hearths, attempts have been made to measure the thermal conductivity of carbon blocks before use and after reheating to 1500°C. A definite increase in conductivity was

demonstrated but accurate values could not be obtained with the apparatus since it was not found possible to prevent completely the oxidation of the test panel.

Considerable attention has been given by the steel industry to the development of an all-basic open hearth furnace in which bricks are used not only for the hearth and side walls but also for the roof, in which position it is still customary to use silica bricks. The Association has devoted much time to the study of chrome-magnesite and magnesite-chrome bricks, having in mind their application in steel furnaces. Investigations of the phase system MgO-FeO-Cr_2O_3-Fe_2O_3, now in progress, are essential to an understanding of the reactions occurring when chrome-magnesite bricks are fired and undergo service. A study of the inter-diffusion of magnetite and magnesiochromite has shown that magnetite diffuses into magnesiochromite many times faster than the magnesiochromite into the magnetite. The investigation is being pursued in the expectation that it will throw light on the bursting expansion which occurs when chrome-magnesite bricks are attacked by magnetite in steel furnaces. Tests of chrome ores from different sources have shown that the bursting expansion tendency is dependent on the physical structure as well as the chemical composition of the ores. Details of direct trials of chrome-magnesite and magnesite-chrome bricks in furnace roofs supplied to the Association lead to the conclusion that the design of the furnace roof, and the method of working the furnace are extremely important in determining the stresses that develop in the bricks in use, and the consequent life of the furnace and output of steel. Experiments are in progress to match with British materials a German fire brick which is giving good service on the Continent for lining steel ladles. The German brick tends to expand in service and has an apparent porosity as low as 12 per cent.

Continuing with the programme for improving silica refractories for the carbonizing industry the relative importance of the large grains and of the matrix in influencing the properties of silica bricks is being studied. As raw materials a high grade quartzite of low alumina content, a lower grade quartzite of high alumina content and a glass making sand of high purity are being used. Vertical gas retorts containing experimental panels of British, French and South African silica bricks in the flaking zone have been examined, cold, after 4 years working. The British bricks had flaked most and the South African bricks least. This is the same order as the porosity and permeability of these materials. In other vertical retorts commercial sillimanite bricks have been used to replace the customary silica bricks in the top 10–15 feet, but after six months working the flaking away of the surface of the sillimanite bricks has been observed in a manner similar to that which commonly occurs in silica brick retorts. Inasmuch as the thermal expansion of retort carbon and sillimanite bricks are not very different, the earlier conception of the mechanism of flaking, based on the dissimilarity between the thermal expansion of carbon and silica brick, will have to be modified.

In the pottery industry the roofs of tunnel kilns in which glazed ware is fired become coated with glaze which gradually accumulates until the surface is fluid at top temperature, drops form and drip on to the ware. Finely ground zircon mixed with 10 per cent. china clay forms an adherent wash from which glaze does not drip. The indications are that zircon washes will find a regular use for coating glost-kiln furniture and that the roofs of new kilns could be advantageously built with zircon bricks in certain zones.

HEAVY CLAY PRODUCTS

A few further surveys of the properties of typical brick making clays have been made. These are the alluvial, lacustrine and laminated clays of the North of England, and more recently from the Kouper Marl series.

There is for every clay an optimum moisture content for extrusion, and this, as well as the subsequent shrinkage during drying and firing, affects the porosity and strength of the fired product. Similarly, when moist clay dusts are shaped by pressing, there is an optimum value for the water content for each value of the pressure applied if maximum consolidation is to be achieved. A study of the inter-relation of the different factors is being made. Further basic knowledge in this direction will help works control and should lead to improved quality.

When a clay suspension is allowed to settle the volume of the sediment is characteristic of the clay. Trials indicate that this simple test may be of distinct value to the heavy clay industry for control purposes.

The possibility of reducing the soluble salt content of bricks by additions of small quantities of sodium carbonate has been investigated and in some cases has been demonstrated. Some promising results have also been obtained in the use of small additions of sodium chloride in an attempt to reduce the bursting effect caused by the presence of nodular limestone in clay.

FUEL AND KILNS

For the heavy clay industry the main effort of this section has been devoted to efficiency tests on various types of kilns and the utilization of waste heat. This work is still in progress. The data are required before the next phase of the work, the development of new kiln designs, can proceed.

In the pottery industry, the change over to the use of continuous firing requires more and more understanding of the operation and design of tunnel kilns. Among the more difficult tasks is the firing of china in tunnel kilns and close studies have been made of several of the kilns now operating in this field. Increasing use is being made of the methods developed by the Association for testing kilns, and many firms are now making their own continuous temperature recordings by passing thermocouples through with the ware.

A programme of work concerned with economy in the use of gas has been put in hand, and the generation and use of steam and electricity are constantly being investigated.

ENGINEERING

The preparation of clay by processing in a pug, and the subsequent extrusion, is of interest to most sections of the ceramic industry, and long term work is in progress to throw light on features of design and operation which make for the production of a homogeneous extruded column. In the course of this work, a device has been developed for controlling the moisture content of the clay by means of a valve operated by the thrust on the screw. The device has proved satisfactory on a works scale trial. A test for abrasion resistance has been developed and has been used to compare various kinds of metals used in components of presses and other equipment.

In the pottery section, further progress has been made with the gold lining machine, which can now be used with burnished gold and on a wider range of shapes than hitherto. In the development of a glaze-spraying machine, a system has been devised which recovers a very high percentage of the over-spray, and thus removes one of the serious drawbacks of this technique. Part of a machine for the sizing of tiles by electronic means has been built at the Research Station; and a machine has been made for the production of cup handles by injection moulding in a porous metal mould.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1948, to 31st December, 1952, a block grant of £30,000 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 £25,000.

For the period 1st January, 1953, to 31st December, 1957, the block grant is £30,000 per annum, provided £80,000 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 £169,938.

THE BRITISH COAL UTILISATION RESEARCH ASSOCIATION

The early part of 1953 brought to a close the period of main development of the Leatherhead Research Station: the conditions of war, and post-war, had necessarily delayed this achievement considerably. In the early part of the year the domestic appliance researches were established in a new building designed especially for the purpose, and this was formally opened by Sir John Charrington in the course of the Association's Second Open Day in June.

Expansion in membership has continued steadily during the year, and every possible effort is being made to accelerate it, in order to ensure sufficient additional income to keep pace with the Association's research programme. The main objectives of this programme are broadly, to improve the efficiency of using particularly those coals that give difficulty in industrial or domestic practice through their properties or condition; to improve the basis of domestic use; to ameliorate some of the more serious problems associated with coal burning such as emission of smoke or dust, and the volatilization of mineral matter and its subsequent deposition on plant surfaces; and finally to investigate fundamental problems, chemical, physical or mechanical upon the solution of which real improvements in practice depend.

COMBUSTION OF COAL BY CYCLONE SYSTEMS

The main purpose of the work carried out on cyclone combustion under an arrangement with the Department has been to discover principles of design for a combustion chamber of suitably limited size for operating under pressure with a gas turbine. The wider potentialities of cyclone burning, *per se*, as a method of burning low-grade fine (but not pulverized) coals has led the Association to augment from its general resources the research grant received for the work. Two experimental combustion chambers have now been constructed and operated at atmospheric pressure. The first serious problem encountered, namely, the accretion of solidified ash around air inlets has been overcome as a result of many changes of design: in the latest chamber coal containing 20–28 per cent. ash has been burned at rates of up to 1,000 lb./h for reasonably long periods and 90 per cent. of the ash removed from the chamber in fused state: the problem of ash accumulation in the gas dilution chamber remains to be completely solved and insufficient is known at present as to the range of types of coal giving satisfactory performance. An industrial firm under contract with the Ministry of Fuel and Power (and also a member of the Association) has now begun experiments in applying the design data gained to conditions of pressure combustion. It is obviously important that the hot gases delivered to a turbine are clean enough to avoid the formation of deposits on blades.

So far attention has been focused on the possibilities of gas cleaners of the cyclone type and the development of cleaners to give the highest possible cleaning efficiency for an acceptable pressure loss has been carried out mainly by determining the effect of design changes on collection efficiency. By the use of facilities made available by the National Gas Turbine Establishment two different types of cyclone have been tested at pressures and temperatures up to 4·5 atm. and 750°C. and the results indicate that except at velocities lower than those likely to be used on a gas turbine, the performance at the higher temperature and pressure can be predicted from the results of tests at atmospheric temperature and pressure which are easier to carry out. In both the cleaners tested under gas turbine conditions the dust is removed in a "blow-down" of 1 per cent. of the gas flow, but in one, swirl is imparted to the gas by vanes at one end, and the other has a long and narrow tangential inlet and outlets at both ends. The latter has given higher collection efficiencies.

EXTERNAL DEPOSITS AND CORROSION IN BOILER PLANT

The trend of the past few years towards a greatly increased use of pulverised fuel firing has brought with it a sensible amelioration of the problems of external deposits and plant corrosion in power stations. Moreover it has been found possible to remedy conditions appreciably by providing stoker-fired plant with auxiliary firing of pulverized fuel: experiments have shown that auxiliary firing with smoke-forming heavy oil fuels is also remedial. It is possible, however, that an extension of the use of higher steam temperatures and of coals richer in chlorine and sulphur may reverse this favourable trend. As part of the research programme of the Boiler Availability Committee attention is being focused particularly on the effects of the characteristics of fuels, e.g. content of sulphur, chlorine and ash; the characteristics and conditions of burning pulverized fuel; and the temperature of exposed metal surfaces. Experiments with a laboratory-scale pulverized-fuel combustor with coal containing 3·5 per cent. sulphur have shown that the deposition of sulphuric acid on surfaces exposed to flue gases attains a maximum rate at about 12·5 per cent. carbon dioxide in the gases; it increases with rate of firing and decreases considerably when the ash content of the coal is raised from 12 (by addition of, e.g. dolomite) to 30 per cent. Complementary studies have been initiated of the factors affecting (*a*) the volatilization of alkali minerals from coals burned in beds or in suspension and (*b*) the corrosion of steel at 500–700°C. by sticky deposits of acid sulphates. The effect of the chlorine content of coal on rate of deposition has recently been observed on large-scale plant with a specially devised high-temperature probe. Period tests on stoker-fired boilers have shown that the introduction of banks of tubes (metal temperatures of 900–1,100°F.) in the gas passes has no significant influence on the production of sulphuric acid.

MECHANICS OF PARTICLES

The full assessment of gas-borne flue dust has two aspects, namely the concentration and the particle size characteristics of the dust. Considerable progress has been made in developing a cyclone probe. Sampling is conducted under conditions as close as possible to isokinetic; collecting efficiency is 97–98 per cent. The instrument is collapsible for insertion into a duct and can be easily and speedily handled. Experience has emphasized the value of statistically planned procedures of sampling. A tentative code of procedure for sampling from large ducts has been prepared.

Assessment of size distribution has been approached in two ways; namely on collected samples, and by size grading of the dust while air-borne. Appreciable progress has been made in collaboration with a member towards

developing an automatic method of sizing particles collected on a microscope slide. A research instrument is now available for scanning particles down to 10 μ in diameter and the technique is being extended to particles smaller than this. Size separation while particles are air-borne has been accomplished in the laboratory but the method is not yet applicable to conditions of testing plant. A promising alternative method of using centrifugal separation is under investigation.

In the programme of field tests on industrial pulverizers, in progress under the guidance of the joint Committee of the Fuel Research Station and the Association, the data so far obtained have proved on analysis to be insufficient to support any particular theory of mill operation; further tests are in hand covering a wider range of coals. The active studies of the mechanical properties of coal, which are fundamental to grindability and other problems, are not yet at a suitable stage for report.

DOMESTIC HEATING

The new laboratories cover a total ground floor area of over 6,000 sq. ft.; special constructional features include removable ceilings to facilitate simple erection of flues of any desired type or size, removable partitioning and a central horizontal flue system with provision for "connecting in" at almost any desired point. Facilities include metal working and instrument workshops. A calorimeter cabinet approaching room size has now been set up for the complete assessment of the room-heating performance of appliances under conditions analogous with those of actual practice.

Experiments have recently begun on determining the efficiency of open fires when burning at low rates such as when they are banked: an apparatus has been devised for continuously weighing the appliance whilst under test.

A series of field tests has been carried out to compare the performance of two types of appliance when used in typical households, and to see how closely the results agree with those obtained by bench tests in the laboratory. The results obtained were of such value that similar tests, on a larger scale, are to be conducted in the coming winter.

An electrostatic precipitator has been developed through which the whole flow of flue gas can be passed without appreciable pressure drop, and which deposits all the smoke on to light concentric cylinders where it can be weighed. Thus all the uncertainties of sampling are eliminated. Comparisons of gravimetric and optical smoke densities are being investigated.

The work on forced-circulation central-heating has proceeded, with particular attention to the development of a suitable circulating pump of low cost. The air-lift principle has been successfully applied in one form of circulator, but a more promising development has been found in certain modified types of small centrifugal pump.

STEAM RAISING

The investigation of the effects of coal properties on boiler performance, using a chain grate stoker, has been completed and the results published.* Work has commenced on the supplementary programme using a coking stoker, but results are not yet available. Semi-scale studies are being undertaken to examine the effects of undergrate air distribution on combustion and the pattern of heat release.

It has been confirmed that the turbulence of gases at entry to a bank of smoke tubes can affect the coefficient of heat transfer as much as 25 per

* MACDONALD, E. J. and MURRAY, M. V. *J. Inst. Fuel*, 1953, **25**, 308.
GUNN, D. C. *Heat. Vent. Engr*, 1953, **27**, 25.

cent. so that where the condition of turbulence is unknown, prediction of heat transfer can be seriously in error. For this reason, investigations of heat transfer in smoke tubes, previously undertaken in special plant, have been transferred to the Economic Boiler, where the conditions of turbulence, though unknown, are likely at least to resemble those existing in practice.

The measurement of steam wetness by a method avoiding sampling has been accomplished by fitting into the steam main a centrifugal moisture separator and measuring the water collected and the rate of flow of steam.

More investigatory work than in the past has been carried out in the field. In particular, the causes of high temperatures in the side flues of Lancashire Boilers are being examined: it has been found that these can be due to accumulations of dust in the furnace tubes, and to stratification of the combustible gases and air. The effect of baffles on both factors is being studied. Another field investigation is the examination in breweries, in collaboration with a member, of the causes of the considerable variation in the fuel used per barrel of beer brewed.

GAS PRODUCERS

Amelioration of the problems of tar deposition and means of improving quality of gas have been the main objectives of work on the gas producer. An electro filtration device has been applied to collecting samples of tar from industrial producers and a simple distillation test has been found to give a rough but useful criterion of the nuisance tendency of these tars. A small scale producer (150 lb./h maximum gasification) has been used for experiments using special blasts. Significant improvement in gas quality is likely to require possibly radical modifications of plant and process and coupled with such development means of evaluating gases with possibly enhanced tar or other hydrocarbon content will be required. Extension of the programme along these lines is envisaged.

The process of pelleting slurry on an oscillating tray, which has emerged from the Association's work during the past two years, is now the subject of a licence arrangement with the National Coal Board, and is being developed by the Board in connection with pit-head steam raising. It was first intended as a means of preparing slurry for gasification in plant of conventional type and this aspect has been receiving further attention. This method of pelleting with a tray promises to be of interest for applications to several materials other than coal. For example, the British Iron and Steel Research Association in contact with B.C.U.R.A. are examining the possibility of applying it to the preparation of iron ore for sintering.

CHEMICAL STUDIES

In studies of the chemical nature of solvent extracts of coal, fractions have been obtained in useful quantities by new partition chromatographic techniques. A start has been made with the determination of infra-red spectra of a series of coals and their extract fractions which may lead to conclusions as to structures present and the chemical relation of extract residue. A light-scattering photometer and differential refractometer for use in measuring molecular weights of fractions of extracts have been built, and promising results are now being obtained by osmotic pressure measurement also. The course of the slow oxidation of coal at low temperature in air is being examined by analysis of the products at regular intervals. It has proved possible to moderate the reaction between chlorine trifluoride and coal to obtain fluorinated products that are liquid or semi solid at room temperature.

A monitored Geiger-counter X-ray spectrometer and a Debye Scherrer camera have been set up, for use in identifying and assessing clay minerals in coals, and a method has been devised for determining the carbonate minerals. The optimum conditions for treating coals with oxides of nitrogen to reduce smoke production during their combustion have been studied; it has been observed that caking and swelling of coals are reduced at the same time.

MATHEMATICAL TECHNIQUES

Statistical examination of experimental results is a normal practice in most of the Association's researches, as indeed it is in research generally: apart from this, certain special mathematical activities are of interest. The pore structure of the coal is being studied with the aid of an abstract model conceived mathematically. With this it is hoped to be able to estimate the molecular density of a substance adsorbed by the coal, at any given depth in the coal. The problem has been solved in a two dimensional case, but computational complexities in the three dimensional case have not yet been entirely surmounted.

A nomographic method of rapid statistical analysis which may be of appreciable value in field work has been developed.

As part of the Association's general studies of mineral matter in coal, a component (mathematical) analysis is in hand of 1,000 analyses carried out in connexion with the King-Maries-Crossley formula: the object is to ascertain any sub-relations between factors in the K.M.C. formula.

INVENTIONS

A number of arrangements in regard to inventions have been negotiated during the year. These cover the manufacture and/or the application of: the Dewpoint Meter, developed for diagnosing conditions favouring the formation of external deposits on boiler surfaces; a machine for making laboratory glass apparatus; a suction pyrometer for use in boiler flues etc. and capable of high accuracy up to 1,450°C.; a refractory baffle of simple design and easy installation in the furnace tubes of shell type boilers to increase efficiency of heat transfer; a process for joining and filling carbon bodies; a free-standing convector open fire capable of easy application to existing fireplaces. The arrangements have all been made with members of the Association.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1948, to 31st December, 1952, a block grant of £50,000 per annum was made provided £150,000 of grant-earning income was received from industry, and an additional grant of £75 for each additional £100 contributed by industry up to a maximum additional grant of £45,000.

For the period 1st January, 1953, to 31st December, 1957, the block grant is £45,000 per annum, provided £190,000 is received from industry, and the additional grant £50 for each additional £100 contributed by industry up to a maximum of £30,000.

The income of the Association for the last completed year was £301,881.

BRITISH COKE RESEARCH ASSOCIATION

The programme of research in any particular year is based on selected items taken from the comprehensive plan of research on problems relating to the production and utilization of coke from coke ovens which was devised in the early days of the Association's existence; the studies fall into two general groups, namely technical problems and fundamental research work of long term significance.

The coking industry is located in certain well defined regional areas, determined largely by the availability of coking coal, and as might reasonably be expected, research work undertaken prior to the formation of the Association in 1944 had acquired to some extent distinctly regional characteristics. Now that the Association is carrying out collective research on behalf of the coking industry, there is a tendency towards more centralization but it has been felt desirable to maintain the inherent regional characteristics, which has been facilitated by the presence of research stations in Sheffield and South Wales, by the continuance of the work carried out by the Northern Coke Research Committee at King's College, Newcastle, and the maintenance of support for the Royal Technical College, Glasgow.

The recognition of the value of the modern coke oven plant as a producer of gas in large quantities is leading to the extended application of coke ovens in the gas industry and it is pleasing to report that the Gas Council has now become an associate member of the Association.

LARGE SCALE TEST OVEN PLANT

Reference was made in earlier reports to the desirability of erecting a full scale test oven plant in order that much of the practical and technical research work before the Association could be dealt with adequately. Appreciable progress has been made in the detailed planning of this project and it is now anticipated that the plant will be in operation within about three years. This is a project of appreciable magnitude as the plant will operate on a full industrial scale. There will be a continued trend towards concentration of the Association's research facilities and full benefit will be derived from the studies which have taken place on a smaller scale with test ovens which have been available pending the erection of the full scale plant.

TEST OVEN WORK AT PONTYPRIDD

The Association has always appreciated the great importance of test oven work in carbonization research and for this reason has given much attention to the use of a small movable wall test oven at Pontypridd where the work has provided important results of obvious practical significance. The first programme of work on swelling pressures carried out over the past few years at Pontypridd has now been brought to a conclusion and the full results have been made available to the coking industry. The programme included a thorough survey of British coking coals with respect to their coking pressure characteristics. As a result of this work it is now possible to assess accurately the properties of coking coals from the point of view of potential danger to coke ovens due to the development of excessive coking pressures. Such coals can thus be avoided or their properties modified and controlled.

Attention has now been turned to fundamental research on the mechanism of carbonization using the movable wall test oven. Investigations have been initiated concerning the softening range of coals, the rate of progress and the width of the plastic zone, the relation between fissuring and conditions of carbonization together with the rate of gas evolution and its path through the charge.

A further investigation has been commenced in order to determine more clearly the dependence of coking pressure on the sizing of the charge. This relationship will be studied under conditions of varying size range, moisture content and oil addition.

STANDARDIZATION OF COKE SIZE SPECIFICATIONS

Experimental work has continued in connection with the establishment of the test sieving machine developed by the Association as standard equipment at all coking plants; the five grades which are to be recommended to the industry for consideration and ultimate general adoption have now been determined. A detailed examination of the procedures to be adopted throughout the industry for sampling and size analysis of coke has been carried out, and a series of tests performed at a number of coking plants has led to the resolution of the problems involved in recommending a practical procedure capable of yielding satisfactory results. The object of the work has been to measure the true size of the coke produced as opposed to nominal sizes measured by commercial screens. A report has been issued describing the theoretical aspects of this work and setting out the details of the application of the method recommended. The results obtained on the test sieving machine have been used in devising this method for the control of commercial screening.

COAL BLENDING FOR CARBONIZATION

A series of investigations into coal blending employing the 5 cwt. capacity test oven has been carried out. It has been shown that certain Yorkshire coals can be upgraded for carbonization by the addition of durain to an extent similar to that obtained when Durham coking coals were added. To enable a greater number of tests to be performed in a given time experiments are to be continued on a smaller scale. To this end two further test ovens of ¼ cu. ft. and 1 cu. ft. capacity have been designed and built, and carbonization trials in these ovens are proceeding. As a necessary part of this work a small scale shatter tester has been developed and extended trials have been satisfactorily carried out. The combination of the small scale test ovens and the shatter tester should provide sufficiently reliable data to form a basis for the rapid prosecution of the full scale blending trials envisaged when the large scale test oven project is completed.

INFLUENCE OF CHEMICAL AND PHYSICAL PROPERTIES OF COKE ON BLAST FURNACE PRACTICE

Work on this subject has been pursued jointly with the British Iron and Steel Research Association. Investigations concerning the breakage of coke have shown that it behaves somewhat differently from other solid materials in the early stages of breakdown. This has been attributed to fissuring and the study has been continued of the proportion of residue to complement for rapid breakage of the same sample of material. Much of this work has been extended to cover breakage at elevated temperatures; the upper limit so far attained being about 1,000°C. It appears that up to 1,000°C. the temperature of coke prior to breakage has little or no effect on the size distribution of the product although coke broken at high temperatures requires less force for crushing than cold coke and produces a greater amount of complement.

The study of pressure/volume relationship of coals heated through the plastic range has been continued by carbonization experiments employing dielectric heating. By estimating volatile matter evolution on a volume basis

and at the same time obtaining measurements of pressure generated during carbonization, it is hoped to obtain fundamental data concerning plasticity and plastic layer formation during carbonization.

To gain further knowledge of the reactions taking place in the lower part of the blast furnace, investigations into the behaviour of coke in the presence of molten slag have been carried out. Studies of the slag/coke contact angles and carbon/FeO values have been made and it has been found that coke is only wetted by molten slag with difficulty at temperatures of the order of 1,500°C.

TESTING AND ANALYTICAL WORK

Standard tests are being developed for determining the efficiency of certain items of the coking plant sequence, i.e., electro-detarrers, precipitators and benzole scrubbers. The work is of special importance because of the application of these methods to acceptance and performance tests on the large number of new coke oven plants which will come into operation in the course of the next few years. Laboratory investigations on the standard method for the determination of naphthalene in coke oven gas have been satisfactorily concluded and works trials of the method evolved have been commenced; the method has been designed to avoid errors due to the escape of initial naphthalene through the system due to poor gas-liquid contact and through dissociation of naphthalene picrate. Laboratory investigations on a method for the determination of benzole in coke oven gas have been commenced and a standard method suited to the needs of the coking industry for the determination of dust in cleaned blast furnace and producer gas is also being developed.

Investigations have been carried out on the subject of coke breakage with a view to determining its cause, so that a test for shattering can be devised on a sound fundamental basis as opposed to the largely arbitrary tests now used. The work has indicated that as sizing of the coke becomes less the absolute difference between different types of coke becomes smaller. A specification for the shatter test machine has been circulated to the industry as a first step towards the specification for the physical testing of blast furnace coke. Investigations into methods of sampling from hopper wagons have resulted in alternative improved methods being devised which have been incorporated in printed standards and distributed throughout the industry.

FUNDAMENTAL STUDIES

Fundamental work has continued in the laboratories at Newcastle, where an investigation into the apparent molecular weight of the pyridine-soluble constituents of coal has shown that these soluble constituents comprise substances with a wide range of molecular weights and that both the amount and molecular weights of the soluble constituents may vary according to the nature and rank of the coal. Sedimentation experiments with the ultra-centrifuge and examination of the pyridine-soluble material by the electron microscope have shown that despite indications of the existence of large molecules in the solution no evidence can be obtained of either colloidally dispersed particles or high polymer substances. Fractionation investigations have yielded a continuous series of fractions from the pyridine-soluble constituents of Durham, Northumberland, and North Wales coals. Further studies have been made of the molecular weight changes exhibited by the soluble constituents of coal when heated through the coking temperature range.

The reactivity of carbon has been further investigated through the study of the reaction :—$CO_2 + C = 2CO$. A complete analysis of the composition of the gas phase has enabled an estimate to be made of the amount of oxygen

held by the carbon. The rate of reaction with pure carbon has been studied together with the catalytic effect of metallic impurities. Further studies of the sorption of gases on carbon have been made to examine the influence of specific surface area of carbon upon its relative reactivity towards oxidizing gases. Adsorption, crystallographic and analytical data have been collected with a view to relating specific surface areas with carbon structure. Magnetic studies of coke structure have been carried out in apparatus allowing measurement of magnetic susceptibilities at temperatures between −196°C. and 1,000°C. in high vacuum. Both the magnetic susceptibility and temperature dependence of the susceptibility have been shown to be dependent upon the temperature of formation. A survey has been completed of recent theoretical studies relating to coke structure.

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 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 £20,000.

The income of the Association for the last completed year was £60,264.

THE BRITISH COTTON INDUSTRY RESEARCH ASSOCIATION

During the past year, the basic structure of the Association has undergone a major re-organization for the first time in its history. Reference was made in the last Report to the Statutory Levy by which it was proposed that the Association's industrial income should be assured, as far as its cotton interests were concerned. The proposal was accepted by all sections of the industry, the necessary legislation was passed by Parliament in February, 1953, and the Levy became effective from April 1st. The new arrangements include re-constitution of the Association's Council, which is now fully representative of all sections including for the first time doublers, condensor spinners and merchant converters. Firms interested in rayon and synthetic fibres, many of whom have been members for many years, are eligible for membership on a voluntary basis, subject to payments that would have been due had their interests been in cotton.

These facts are quoted as they provide undoubted proof of the usefulness of the Association to the industry it serves. The principle of a research levy was approved at a time of most severe trade recession when voluntary agreement to such a levy would have been forthcoming only on a basis of complete confidence in the Association's work and faith in its future as an essential part of the industry.

The wider basis of membership will involve some changes in the scope and direction of the research work, to meet more directly than hitherto the needs of sections of the industry now represented for the first time in any considerable numbers. Experience during the first year or two will decide the extent of the re-orientation required.

In view of the extreme importance at the present time of securing the fullest application of existing knowledge, the emphasis in the succeeding paragraphs is on the Association's varied activities designed to encourage this, and no attempt has been made to cover its whole programme of research.

SHIRLEY DEVELOPMENTS LIMITED

The new exploitation company, Shirley Developments Limited, set up by the Association late in 1951, is quickly establishing itself as a most valuable means of achieving one of the first essentials in rapid application, i.e. ready

availability on the market of the products of research, such as new instruments and machines. After some not unexpected teething troubles the company is now well established in its own premises in Manchester, and with its own staff. It has taken over from the Association the sale of most of the testing instruments devised in the laboratories in the past. It has already increased the sale of many of these to the point where it has become possible for the company to make independent arrangements for their manufacture, thus relieving the Institute's machine shop of a load which had seriously impeded progress on research projects from the laboratories. The company has also taken over the responsibility of drafting agreements and making arrangements for exploitation of patented machines and devices, thereby again releasing the administrative staff at the Institute from much work which, though necessary, was not conducive to research productivity.

MOBILE WEAVING EXHIBITION

Mention was made in the last Report of a mobile exhibition of results of research affecting the spinning trade. This experiment proved to be so successful that a second exhibition has been prepared, this time to cover the interests of the weaving section of the industry. The new exhibition, which is on a somewhat more ambitious scale than the spinning exhibition, will be shown in five different districts during the coming winter. There can be no doubt that this new visual method has justified itself in renewing interest in past work and by appealing to a new group which has perhaps been little influenced by lectures and publications.

LECTURE COURSES

At the same time a further extension of the lecture system has been planned. In addition to lectures to textile societies and kindred organizations, the Institute staff have, for some years, delivered so-called "Shirley Lectures". These are private lectures to groups from member firms, in which confidential advances which cannot be discussed in public lectures are freely presented. These have been well received, but since they are individual lectures they must obviously be limited in their scope. It has now been decided to institute courses of instruction for the staff of member firms, on the practical application of research results. The courses will be held at the Institute, and the first will deal with "Cardroom Planning". On the principle that people value more what they pay for than what they get for nothing, these courses will be available only on payment of a small fee.

PRODUCTIVITY STUDIES

Work on problems affecting deployment of labour, mill efficiency and productivity has proceeded apace, and two confidential publications during the year have dealt with the productivity of ring spinning frames and with warp preparation respectively. As might be expected, the amount of consultative work arising out of investigations in this field is always increasing, and it is a problem to know how to meet the twin needs of basic investigation and day-to-day consultation. Nevertheless, the field is being extended to include fundamental investigations into quality control, and pilot studies have been carried out of the average levels and ranges of variation of factors that may be expected to affect processing efficiency. It has been possible to deduce the most economical manner in which to carry out such studies, and the work will be extended with the help of Conditional Aid funds.

MAN MADE FIBRES

The addition in 1928 of a Rayon Section to the Institute's work, has enabled the Association over a period of twenty-five years to build up a great store of experience on the processing of rayon on cotton machinery. Much

of the work, even before the last war, was devoted to investigations of yarns and fabrics made from rayon staple alone and mixed with cotton. The introduction of the synthetic fibres has found the cotton industry ready to take advantage of their inherent possibilities and the Institute has perforce carried out much of the introductory work on the satisfactory processing of synthetic fibres such as nylon and " Terylene " and new regenerated fibres such as " Ardil ". Now that their potentialities are well established it is becoming possible to see more and more clearly the advantages they possess and the fields in which they are most likely to achieve success. But this means that the Association's interest in them must increase with time rather than decrease as their use within the industry becomes more wide-spread. In conformity with this, an extensive programme of research into the processing and behaviour of blended fibres, extending the earlier work on rayon and cotton blends, has been started and has now reached the stage where fruitful results may be expected within a reasonable time.

Work of this sort needs, for success, to be based on sound methods of investigation, and the present programme was preceded by work designed to provide satisfactory methods of detecting and estimating amounts of different fibres blended intimately together, and the distribution of fibres in for example, blended yarns, since quite different results may be obtained from identical quantitative mixtures, according to the distribution of the fibres. The object of the programme is not solely to produce new effects, but to establish a sufficiently fundamental understanding of the behaviour of blends, and to be able to provide at short notice the information necessary to achieve any desirable combination of qualities.

HEALTH HAZARDS

The work of the Association extends also to conditions within the industry affecting the well-being of the operatives Much work has been carried out in recent years on the problem of dust in the cardrooms. It is, of course, always desirable to provide a clean and pleasant atmosphere in which to work, but when the dust is also thought to be the cause of a particular occupational health hazard, it becomes doubly important. The work carried out at the Institute has been published in the *Journal of Industrial Medicine,* and has resulted in recommendations for dust removal which are commonly accepted as the best answer to date to this health problem.

Similarly, a programme of work on behalf of the Committee on Mule Spinner's Cancer has resulted in recommendations by the Committee which, it is firmly hoped, will abolish the hazard from the industry. It is expected that these recommendations will shortly be the subject of legislation to ensure that the proposed safeguards are universally employed.

SOILING OF TEXTILES

Dust is a many-sided problem, not least in the soiling it produces, and the Association has been engaged on a fundamental study of the problem of soiling of textiles. This has already led to interesting and unexpected results. Incidentally, it has established new methods for estimating the efficiency of air filtration plants, and enabled the Institute to advise on ventilation and air-cleaning problems.

MACHINERY DEVELOPMENTS

Space does not permit more than a mention of developments such as the new anti-lashing-in device for preventing the spoiling of expensive colour woven goods by wrongly coloured broken threads being woven into the pattern; of the work on continuous vat dyeing; of the investigations into calendering and mangling, which are providing far-reaching results; of the

development of the Shirley Hopper Opener, designed to precede, in the machinery sequence, the Shirley Opener Unit now in course of commercial manufacture. Much could be said too, of the rapidly growing success of the Shirley Automatic Size Box in which there is world-wide interest, and the Accelerated Drying Device, of which more than 160 have now been installed, and which is being successfully applied commercially to jute dressing machines, and of many other developments which have come into the stage of commercial exploitation within the last year or two. All these and many other projects are being energetically pursued, with the result that the contributions of the Association to the industry are becoming ever more numerous and wide-spread, and show no signs of decreasing in the foreseeable future.

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 is made provided £180,000 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.

For the period 1st April, 1954, to 31st March, 1957, the block grant will be £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 £364,503.

CUTLERY RESEARCH COUNCIL

During the period under review the Council passed from the early organizational and policy making phase to the point where long range objectives were established and investigational work could commence. As stated last year the programme of research has been limited to three major items: metallurgical research to determine data on the best cutlery compositions and heat treatment; research to improve the quality of materials; and research to improve the performance, life and dimensional tolerances of the dies used in forging. Later it is planned to undertake long term programmes concerning production practice generally, but so far the main effort has been directed to relatively short term projects such as those described below, which are designed to assist industry in the immediate future. Simultaneously the issue of the *Research Bulletin* has been arranged on a quarterly basis and technical enquiry work has continued at a steady rate. Over 100 such enquiries have been dealt with in the past year.

TABLE KNIFE HANDLES

An investigation of table knife handles led to the issue of advice to members concerning methods of minimizing band corrosion in the blades of table knives which have had their hollow metal handles attached by hard soldering. It was also decided to investigate the formation of plastic handles by injection moulding direct to the tang, starting with attempts to improve bolster accuracy.

ECONOMY IN KNIFE BLANK MANUFACTURE

An investigation of the stages of manufacture of a table knife blank revealed that about 29 per cent. of the starting material was heavily worked and then blanked off as scrap, and it is clear that in some blank manufacture upwards of 20 per cent. of the starting material is scrap. This represents a cost of at

least seven shillings per gross, and has had some bearing on a decision to investigate a proposed new method of manufacture, in which it is expected that the percentage scrap will be substantially reduced.

REPAIR OF FORGING DIES

It has been demonstrated that many cracked and chipped cutlery forging dies can be successfully repaired by atomic hydrogen welding methods. In the case of a large die, the cost of a new die can be approximately equal to the average annual contribution per member to Research Council funds, whereas the normal welded repair costs about 5–10 per cent. of the same figure. Furthermore, members have been advised as to how such repairs can be arranged without incurring any capital costs in purchase of welding equipment.

OTHER INVESTIGATIONS

Sample die blocks of a composition expected to prove more satisfactory than the material commonly used have been issued to a number of members for works trials, and an instrument for rapid checking of the thickness of steel sheet under warehouse conditions has been developed. This is expected to reduce difficulties occurring during pen and pocket knife manufacture due to gauge variations in the (hot rolled) sheet.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1952, to 31st December, 1954, a block grant of £3,000 per annum is made provided £4,000 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 £3,000.

The income of the Council for the last completed year was £14,000.

THE BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

The British Electrical and Allied Industries Research Association covers all aspects of the electrical industry, its main support coming from the supply industry (British Electricity Authority and Area Boards, North of Scotland Hydro-Electric Board, N. Ireland Electricity Board and Commonwealth undertakings) and electrical manufacturers (including cable makers). In addition the suppliers of materials, such as special steels, magnetic materials and insulation, aid E.R.A. researches. Users such as the Transport Commission are members, as well as a number of specialist organizations and also the Institution of Electrical Engineers as a founder member. The Ministries of Fuel and Power, Supply, Agriculture and Fisheries and the Admiralty make large contributions to special researches.

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 substantial amount of fundamental research is carried out.

GENERATION OF ELECTRICITY

Wind Power

The wind power survey of the whole British Isles has shown many favourable sites, and studies of wind structure have given the data needed by designers of wind-driven generators. The 100 kW generator in Orkney has

been in service but modifications are in hand before permanent commissioning. Another 100 kW generator of novel design has been made for the British Electricity Authority but not yet erected. Designs for larger units are in hand with a view to early construction. By the courtesy of the College authorities the College of Aeronautics is housing a testing station for medium-sized windmills and the Ministry of Fuel and Power and member firms have assisted the Association in obtaining 3 units of up to 10 kW and 2 more up to 8 kW are expected. Generators for local supply to farms or homesteads will also be studied. Interest abroad in this work has grown rapidly and useful international co-operation has developed. An aspect of this is the study of the characteristics of generators suitable for a given type of economy such as may occur in desert areas, islands and countries where local fuel is scarce but with different kinds of needs for power and heat. A wind speed of 125 m.p.h., the highest so far recorded in the British Isles, has been observed at the E.R.A. station on Costa Head, Orkney.

Fuel Cell for Direct Generation of Electrical Energy

As reported last year, research is proceeding under Professor Fox at Cambridge into the development of a gas cell for the electrochemical generation of electricity. This work, which is supported by the Ministry of Fuel and Power, has made definite progress on fundamental problems aimed at securing an adequate life at a high rate of performance. In parallel and associated with this the British Electricity Authority and Ministry of Fuel and Power are supporting investigations on systems alternative to the gas cell.

Underground Gasification

The Association is assisting the Ministry of Fuel and Power on possible electrical methods in preparing coal seams for gasification *in situ*.

TRANSMISSION, DISTRIBUTION AND INSTALLATION

D.C. Transmission

The main studies with the E.R.A. model D.C. transmission link simulating H.V. operation are complete and reports are available on all the more important aspects of system operation and co-ordination. A proposal has emerged for using the fourth cable of the projected cross-Channel power link between the B.E.A. and Electricité de France for a trial D.C. transmission. The remaining three cables would carry the main A.C. power transfer as initially intended. An idea of this magnitude has many problems but a co-ordinated study is in hand.

Network Analysis

Although the E.R.A. network analyser for the transient and steady-state solution of network problems on one equipment of low bulk and cost has already been in service, its formal inauguration will probably take place at the end of 1953. Experience of the kind of problems most often presented required the extension of remote controls to speed up very greatly the steps by which the solutions can be approached. Studies of automatic computers in general have shown the advantage of a network analyser to lie in the field of problems which have to be presented in engineering rather than mathematical terms, so that the parameters must be readily variable in the direction in which the best engineering solution becomes apparent during the course of the analysis. The analyser will therefore not be completed with its full quota of components until experience after inauguration at somewhat reduced scale has proved that sufficient time-saving devices have been incorporated.

The statistical examination of the incidence of fires in wiring installations has not yet conclusively established a probable limiting safe life, but has disclosed other information of interest and is being continued to cover three years to December, 1953.

Research on safety in explosive atmospheres continues partly at the Safety in Mines Research Establishment, where large-scale facilities exist, and partly at Perivale with special laboratory equipment. The present investigations cover the mechanism of ignition and the minimum electrical energy in relation to intrinsic safety; the determination and statistical evaluation of safe gaps in flameproof gear; and investigation of the possibility of higher pressures when an explosion occurs in a running motor as compared with the pressure in a normal flame-proof gear test where the motor is tested at rest.

The E.R.A. Dispersion Meter, which measures absolutely moisture in insulation, is in commercial production. The Portable A.C. Discharge Detector, also in commercial production, not only detects discharges but resolves the discharges from different kinds of void and gives the energy dissipation per discharge, which greatly aids the estimation of probable life of insulation in service. A simplified portable power factor meter is being developed. Laboratory and field work continues on the practical interpretation of results in various circumstances.

Radio and Telecommunication Interference

The Association continues to give assistance to the Committees advising the Postmaster-General on regulations for radio interference under the 1949 Wireless Telegraphy Act. Regulations for the radio-interference suppression of ignition systems have been published and recommendations made on refrigerators. A committee on small motors has been set up. Work continues on the possible extent of interference from H.V. transmission lines and on simple methods for the economical design of screening enclosures effective over a wide frequency range.

The manuscript of a text book on telephone interference and harmonics is complete and will shortly be published.

Cables, Conductors and Wiring

Important though unspectacular is the determination of the currents which can individually be carried by the types of small cables used in domestic wiring, which are at present rated in fully loaded groups. This will permit the maximum use of material. Ratings have been calculated for cables carrying current at 400 c/s used in special cases as for high-speed tools. Long-term tests to assess the suitability of the use of light alloy conduits and fittings as earth-continuity conductors are complete. Determination of ratings for 33 kV cables now standardized, and re-calculation of ratings for lower voltage cables to take account of the increased temperature rises now permissible, are in progress. A rapid method for measuring the thermal resistivity of the soil is to be recommended for routine use so that buried cables may be used up to their full current carrying capacity. The huge capital invested in buried cables makes marginal improvements of great importance.

Increase of the stringing tension of overhead line conductors would reduce the cost of supports. Stringing tensions are limited by the possibility of damage from fatigue due to vibration, which will be studied with equipment to obtain records of vibration over long periods and to play them back rapidly for examination. A radio-link is also contemplated for the examination of vibration on energized lines.

A long-term exposure test on insulator spindles has been set up to ascertain the importance of particular removable causes. A programme on arc-protective devices is in hand at Queen Mary College.

Switch and Control Gear

In tests at a high-power proving station new apparatus has been used to measure the conductance of the arc during the current zero. Detailed information obtained over periods of 5 to 10 microseconds is being compared with similar data from the E.R.A. synthetic testing method, in which severe conditions are momentarily injected at the current zero. The study of the mass flow in air blast breaker nozzles has established relationships between nozzle geometry, gas pressure and current. The study of switching transients at various sites on the B.E.A. 132 kV network has made good progress. The arc-chute breaker, patented last year, has been tested at 6·6 and 11 kV at a high-power proving station. The analysis of the energy losses in the steady arc in hydrogen and in air gives remarkable agreement between theory and experiment.

Work on fuses has dealt with small overcurrents at 11 kV and with the interchangeability of low voltage fuse links. The heating capacity and contact erosion of 400 V, 150 A, 3-phase contactors has been investigated and the results have partly been incorporated in proposals for the revision of British Standards on contactors and partly in changes of design by different manufacturers. The new Standards have not yet been decided and commercial changes in design are not yet stabilized.

Transformers

The costs of instrument transformers rise very rapidly above 100 kV. For use on the new 275 kV Supergrid the capacitor transformer has been developed as a voltage transformer and a proto-type set of three has been installed. For similar reasons novel, indeed, revolutionary, methods of measuring currents at high voltage are being studied.

Lightning and Switching Surges

All Electricity Area Boards now send reports of supply interruptions and damage to equipment from lightning. The reports are analysed and correlated with thunderstorm activity as reported by some hundreds of voluntary observers.

Statistical data on switching and other surges are obtained by means of an automatic equipment which records the conditions on all three phases whenever the conditions on any one phase exceed predetermined limits of abnormality. Hundreds of records are now available and some of the more important have been compared with results obtained with the practical conditions simulated on the E.R.A. network analyser.

UTILIZATION

Rural Electrification

Good progress has been made in the researches on the drying of grain, seeds and fodder crops, and a new laboratory was brought into use to study the basic requirements of drying. A new and simple form of grain moisture meter has been developed and gives good results. Preliminary tests on destroying pests in grain by high frequency electric fields are scientifically encouraging but economic problems remain to be overcome. A mains-driven electric tractor has been maintained in operation for field station cultivations and new designs of flexible cable for it were studied. Research

on flash illumination for laying poultry has shown that it has a beneficial effect on egg production. Electric weed-killing investigations continued to show success with weed seedlings and work was started on the eradication of bracken by electrical means. A dairy heat pump for the combined purpose of milk cooling and water heating is being developed. The experiments on the use of electricity in horticulture, particularly for soil warming under frames and in glasshouses, and on artificial illumination, showed good results and a new study on the best values for soil and air temperatures was started. The double-glazed glasshouse, used in space heating experiments, showed that its reduction of heat losses is likely to justify the higher cost of the glasshouse. The Ministry of Agriculture and Fisheries continues to support these researches. The Open Days at Shinfield, inaugurated by the Parliamentary Secretary to the Ministry, attracted considerable attention in the national press as well as in the technical press of the electrical and agricultural industries.

Space and Water Heating

A study of large electric floor-heating installations is providing energy consumption and temperature distribution data for single and multistorey buildings. These figures are of particular interest in view of the peak load problem. A comparison between the response of two systems, one using buried water pipes and the other buried electric conductors, has also been made. It has also been established that a dual-purpose heat pump cooling a domestic larder and providing at least 500 gallons of hot water per week for one-third of the normal electricity consumption is a practical possibility. General heat pump investigations continue; the 10 h.p. installation at Shinfield has now operated satisfactorily throughout two heating seasons using only the earth as a heat source. Progress in the investigation of " latent-heat " storage is encouraging. It has been found possible to store heat and release it at constant temperature over a period consisting of some hundreds of six-hourly cycles. The bulk of material necessary is much less than for specific heat storage, as with water concrete, etc. Methods of control are being studied.

Electric Equipment of Automobiles

Work on the low voltage surface discharge ignition system proceeds. Investigations on the effect of small amounts of circuit inductance on the amount of metal transferred between platinum contacts in low voltage circuits show the existence of hitherto unsuspected transient arcs. The practical importance has justified extension to other metals such as silver and palladium.

The Welding Arc

The electrical characteristics of the inert gas metal arc welding process (the " self-adjusting arc ") have been studied. Though comparatively new this is of increasing and marked industrial importance. Consideration of the stability of the arc has led to the formulation of criteria for both A.C. and D.C., whereby the degree of " self-adjustment " of arc length is considerably greater than in current practice. This is a substantial improvement in the application of the process. Methods of complying with these criteria in practice, either by suitable design of new welding plant or by the addition of auxiliary equipment to existing plant have been proposed and are being followed up. The E.R.A. invention permitting low voltage radio-interference free welding by the argon arc process has been further pursued industrially; one important application is in the production of aluminium sheathed cable.

MATERIALS AND COMPONENTS

Insulation

New information on the breakdown of insulators in short times at high electric stress has been obtained by development of an electronic switch which removes the test voltage within 10 micro-seconds after failure. Breakdown channels have, for the first time, been preserved for investigation in their initial condition. The results confirm earlier indications that gaseous discharges can be rapidly propagated through solids in high enough electric fields. An important practical corollary is that greater improvement in high voltage insulation can be obtained by careful elimination of gaseous discharges, than by the introduction of new solid materials. New work has started on the types of failure occurring in oil-impregnated capacitor dielectrics, which it is hoped will lead to an increase in the permissible loading of large capacitors. The breakdown of insulating liquids *per se* is being studied by seconding staff to Birmingham University. A study of the disintegration of phenolic mouldings is in progress, which should lead to specifying the best combination of resin and filler for resistance to attack by discharges.

Advances in understanding of breakdown mechanisms have been made public in two papers presented by members of the Association's staff to the recent Institution of Electrical Engineers symposium on insulation.

A good deal of work has been carried out on halogen – substituted dielectrics and on silicone resins which offer the possibility of moisture and discharge resistance, high temperature and high frequency use with low losses. These and other resins combined with new fibres such as glass, nylon and "Terylene" give the newer laminates where mechanical strength can be added to good electrical and thermal properties with corresponding economies in electrical apparatus. A new type of dielectric comprising a film of dry aluminium oxide has been developed in the laboratory to the point where the exploitation of a commercial capacitor can be envisaged.

The impulse electric strength of the insulation used in V.H.V. equipment, studied at the National Physical Laboratory for the Association has been incorporated in many of the design features of the new 275 kV Supergrid.

Resistors

More reliable behaviour of moulded carbon resistors can be readily obtained by greater care in the normal wax impregnation. The wax is found to control the ageing of the plastic binder, and not, as originally believed, only the resistance to moisture.

Semi-Conductors

The enquiry into the shortage of semi-conducting materials has been extended to germanium. A great increase in output will be needed to meet industrial requirements. The silicon rectifier offers promise since silicon is so abundant.

FUNDAMENTAL RESEARCH

The Association has continued its programme of fundamental research both in its own laboratories and under contract at Universities. A general theory of electrons in dielectrics has been established as far as concerns the method of approach. A good deal of experimental and theoretical work is devoted to the relation between permittivity, loss angle and structure including the structural characteristics of high permittivity dielectrics. This work has shown the importance of texture in determining the properties of a

dielectric. A member of the staff has gone to Rio de Janeiro for a period as a U.N.E.S.C.O. adviser, where he is working on some essential mathematical relations in the theory of linear phenomena.

At Liverpool University important studies have been made of the temperature distribution and excited states in stable and unstable arcs and on the various ionization processes in different gases. Studies continue at Perivale on arc discharges with cooled electrodes and the physics of heavy current transient arcs as occur in switchgear; in addition further evidence has been analysed on the discharge theory of novae in astrophysics. The work at Oxford on the hollow cathode is complete, a new mechanism of ionization by resonance radiation has been discovered and work has begun on cathode mechanisms in discharges.

INFORMATION AND LIAISON

The Technical Liaison Service has proved of considerable value in membership matters and also in dealing with the increasing number of members' problems in which some investigation is required but which are not broad enough for a research programme. The loans of journals arising from the weekly abstracts have reached 6,000 per annum, and in addition translations and bibliographies are provided on request. A regular series of colloquia instituted at Perivale has benefited from the participation of leading experts and has been well attended by members. Provincial meetings with local member groups are being arranged and an extension of the colloquia to private conferences dealing with particular researches is under consideration.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st September, 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 £269,937.

THE BRITISH HAT AND ALLIED FELTMAKERS RESEARCH ASSOCIATION

The programme of research, which was revised in the current year, shows an increase in the number of technological projects engaging the staff of the Association. Provision has been made in the programme for maintaining a service to members for dealing with day-to-day problems and for the information bureau to be continued. The members, in the current year, have shown an increased interest in the library service which has continued to augment its facilities. A sustained interest in fundamental projects can be reported and the bulk of the following summary is chiefly concerned with indicating the benefits that have resulted from a study of the physical properties of felt. This programme was initially started simply to provide the industry with some knowledge of the materials they manufacture.

FELTING MACHINERY STUDIES

The first programme on the efficiency of the multi-roller felting machine is now complete and a report is in course of preparation for issue to members. This work has been followed up by a survey of bumping machines and a comparative study of dyeing machines, both of which are well under way.

The latter programme, which is concerned with the measurement of degradation of the material during dyeing, has already shown that there are advantages to be gained from using the type of machine in which the dye-liquor is pumped through the felt.

INCIDENCE OF FAULTS IN MANUFACTURE

Arising from the day-to-day problems submitted to the Association, and with the ready concurrence of members, a scheme has been put into operation to determine the incidence of faults in manufacture. In the main, they are largely surface faults which make it necessary to turn the hoods or in some cases to reject them completely. The manufacturer, in either instance, suffers financially by actual loss of production or by an increased labour charge so that any information leading to a reduction in the number of faults is of direct economic significance to the industry. The programme, which requires limited supervision by the Association staff, is therefore designed to pin-point the chief sources of trouble and promises to give interesting results. So far, only a preliminary examination has been carried out which has shown that a classification into four main types of fault is possible. The incidence of each of these types in normal production batches was sufficiently high to warrant a detailed investigation. Three of the types of fault, characterized by isolated regions of high density felt, were found to occur with a frequency which varied from one series of machines to another and are consequently believed to be machine faults. The remaining type of fault which shows as a mottled appearance, is thought to be due to the incomplete blending of furs with different felting and dyeing properties and is independent of the processing machinery. Trials are now proceeding to establish the truth of these deductions. Steps will then be taken to eliminate their causes by making separate studies of the sequence of machine processes and, in addition, by investigating the influence of furs of known characteristics.

CARROTTING OF FUR

Work has continued on the study of the mercuric-carrotting of fur and a programme has been initiated this year to study the effect on fur of acid solutions at high temperature. The programme, which is designed to study the adsorption of acid, the dissolution of keratin and changes in the chemical structure of the fibre, has so far been confined to adsorption.

PHYSICAL PROPERTIES OF FELT

The Association has from the beginning studied the physical properties of felt as a product of the industry and as a raw material for a variety of end-products. This project was embarked on simply to provide information, without expectation of returns or application to technology, and yet it is true to say that the results have had more far-reaching effects on the work of the Association and consequently on the industry than any other research project.

The first outcome of this work was the provision of a quality yard-stick incorporating measures of felt quality, a processing factor and a fibre or raw material factor. Whilst the bulk of the work was carried out on hat felt the results have been shown to apply to mechanical felts. A further development of this, which has been worked out in the current year, is a system for the representation of felt quality by means of a simple index figure. This index has, up to the present, been applied only to hat felts and eliminates differences that can be attributed to different form weights and non-significant differences in the values of the quality factors. By using this index, manufacturers can now compare the quality of felt of different weights and prepared by different methods, which was not possible before. As the index is based on the average values for the industry, the manufacturer has a simple means of telling whether or not his material is above or below average.

A second important outcome from the measurement of the physical characteristics was the discovery that felt produced commercially was anisotropic. By relating these directional properties of the felt to the processing it was further shown that the properties depended on the methods of felting employed and could be altered by modifying the procedure. The importance of this to the industry is obvious since in use felt has to undergo stretching treatment especially in blocking and embossing. The directional properties of felt were found to arise from directional felting, i.e., preferential shrinkage in one direction, and a fundamental study has been started on this phenomenon.

The availability of the new methods for determining felt quality has enabled the Association to undertake technological research with confidence that the results have some meaning. Such a study, completed this year and published to members, was the effect of apron settling on multi-roller planking. In the comparison that is being made of the effect of the different dyeing machines, the new system of index numbers is being applied to the resultant felts. In particular, the fibre factor previously mentioned is being used as the criterion of degradation. The system of quality index numbers is also finding application in technological studies relating to felting rates and Hafra numbers and in process control experiments.

The original project still continues, a new programme having just been started on the air-permeability of felt.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st April, 1952, to 31st March, 1954, a block grant of £7,000 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 £5,000.

The income of the Association for the last completed year was £19,524.

THE RESEARCH ASSOCIATION OF BRITISH FLOUR MILLERS

Collaboration with the National Institute of Agricultural Botany in the testing of wheat harvested from trial plots has been continued. In view of the progressive disappearance from cultivation of wheat varieties especially suited to biscuit manufacture, a search has been begun among these wheats for new hybrids capable of replacing the old varieties in this character.

The positive effects of late spring nitrogenous manuring on the nitrogen content of grain from winter wheat has been established and experiments are in progress to establish the form in which this nitrogen enrichment occurs. It seems probable that it represents additional protein not distinguishable from that normally occurring in wheat, and feeding trials on rats suggest that its nutritive value is also equivalent.

MILLING PROBLEMS

The decontrol of the milling industry has raised a number of technical and practical problems which have led to investigations of an advisory nature. They have centred mainly (i) on the possibility of obtaining, in white flour milling, a flour made on the divide system which would be equivalent to straight run 80 per cent. flour in both nutritional and baking quality and (ii) on the technical problems associated with the addition of enrichment mixtures containing vitamins and minerals to the lower extraction flours which will be milled

following decontrol of the industry. The technical and scientific issues raised in both these questions have been satisfactorily solved. On the first problem a graph has been constructed which will enable a miller to decide on the extraction he should mill in order to obtain any required amount of white flour and a flour identical with the traditional 80 per cent. extraction flour. His requirements will, of course, vary from time to time. With regard to the enrichment of white flour a specification has been prepared, which has now been circulated by the milling industry to manufacturers, for the preparation of a master mix. Millers will simply add this to the white flour stream at the rate of 1 oz. per sack of 280 lb. In view of their nutritional implications the solutions of both these problems were agreed with the Ministries of Food and Health and the Medical Research Council. Other subjects, of practical importance to the industry, which have been investigated include studies on the effect upon flour quality (i) of obtaining different extractions from various wheats and (ii) of the degree of removal of screenings from wheat.

MOISTURE CONTENT OF GRAIN

The moisture content of the grain is of importance in flour milling operations and it has become increasingly realized that the milling behaviour of wheat at a specified moisture content may vary greatly according to the way in which the moisture is held. Work on different aspects of this problem has therefore been continued with the object of achieving a more detailed picture of the mechanism of the penetration and distribution of water within the grain than has been available hitherto. In the first place work has continued on the investigation of the movement of water through different layers of the grain and within the endosperm. For this a direct method has been used, viz. microscopical observation of the movement of water from a capillary tube pressed against the particular layer or surface of the grain which is being studied. Of the various outer layers of the grain it has been found that the testa presents the greatest barrier to the passage of water. Movement within the endosperm is influenced mainly by the texture of the endosperm ; it is twice as rapid in mealy grains as in vitreous grains of the same variety and is similar in grains of different varieties if the texture is similar. A second approach has been to study the distribution of moisture by examination of small particles dissected from specified points within the endosperm of vitreous grains. The moisture content of these particles has been assessed by density measurements involving a method of suspension in water saturated mixtures of carbon tetrachloride and cyclohexane. The particle is protected from moisture changes by enclosure during dissection and subsequent handling in a film of mineral oil. Preliminary data, applying this method, indicate that moisture movement into the cheek centres of Manitoba grain is 85 per cent. complete in 24 hours.

FLOUR IMPROVERS

Now that the use of the improver Agene is to be discontinued, a subject of major importance for the milling industry is the question of alternative methods of improving the baking quality of flour to a level to which bakers and consumers are accustomed. This is a many-sided problem and involves primarily the questions of possible effects on nutritional quality, or the production of toxic substances, as well as the technical problems concerned with application of any given methods by the industry. The effect of different improvers, in relation to the nutritional and toxicological aspects, is being studied jointly with the Medical Research Council, the Ministry of Food and the British Baking Industries Research Association by extensive feeding tests with experimental animals. In the U.S.A. Agene has been replaced by chlorine dioxide. As this improver is technically suitable an extensive investigation has been made of its interaction with flour and the results of this

investigation have recently been published.* Particular attention was given to the interaction with the protein and lipoid components of flour. It was found that some of the amino acid residues are modified but these modified substances are present only in trace amounts and there is at present no evidence that they are deleterious at these levels. It was also found that chlorine dioxide oxidizes some of the tocopherols naturally present in flour and the significance of this in relation to Vitamin E content is being examined in greater detail. Other methods of improvement rely mainly on physical treatments or on combined physical and mild chemical processing such as the aeration process in which air or oxygen is whipped into a rapidly agitated dough. Various aspects of these essentially physical methods of improvement are being investigated. As a longer-term project some fundamental work is continuing on the biochemical mechanisms underlying the striking physical effects produced by small concentrations of the chemical improvers.

BIOCHEMISTRY OF WHEAT

Work is continuing on the fractionation of some of the components of the proteins in the flour, and, in collaboration with the Physics Department of Birkbeck College, an attempt is being made to apply X-ray analysis to the protein components of the flour. In the field of enzyme studies work continues on the investigation of the lipoxidase system in flour, as this may be of importance in connection with the ageing and also with the long-term storage of flour.

A knowledge of the distribution of essential nutrients in the different anatomical parts of the cereal grains is of fundamental importance in relation to nutritional questions, and has important implications for milling practice. For some years this has been a most effective field of investigation and has led to a more precise knowledge of the location of members of the B group of vitamins within the wheat grain. This work has recently been extended to rice and maize with studies of the distribution of nicotinic acid in these two important cereals.

An important part of the work of the Association is connected with the behaviour of different flours in the dough stage of breadmaking. Apart from the study of the physical properties of doughs, which is an essential part of this work, a study of some of the biochemical changes occurring during panary fermentation has been initiated.

OATS AND OAT PRODUCTS

Research has continued on the problems associated with the rodent contamination of oats and oat products. Methods of preventing the access of rodents to stacks are being studied under field conditions. On the analytical side a method has been worked out for the detection of fragments of rodent hair, mites and insects in oatmeal and oat flakes.

The question of maintaining a satisfactory flavour and aroma in oat products is one of considerable importance to the industry. From the research point of view the study of flavour is one of the most intractable and subtle problems. Progress in this difficult field has however been made by a close study and analysis of the conditions obtaining in the kilning of oats. With an experimental kiln it is now possible to arrange conditions which favour the production of the desirable flavour.

SORGHUM MEAL

At the request of the Colonial Products Advisory Bureau and of the Human Nutrition Unit of the Medical Research Council a laboratory investigation

* MORAN, PACE and MCDERMOTT. Interaction of Chlorine Dioxide with Flour: Certain Chemical Aspects. *Nature*, **171**, p. 103.

has been made of the possibility of improving the mechanical production of meal from Nigerian sorghum. It has been shown that if the sorghum is conditioned to about 18–20 per cent. moisture content it may be handled with a slightly modified simple wheat flour milling system to give 70–80 per cent. of a fine meal of good appearance and nutritive value. Arrangements are now being made for tests on a larger scale.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st July, 1952, to 30th June, 1954, a grant of £32,000 per annum is made provided £14,500 of grant-earning income is received from industry.

The income of the Association for the last completed year was £46,407.

THE BRITISH FOOD MANUFACTURING INDUSTRIES RESEARCH ASSOCIATION

The programme of research is balanced to cover the interests of the various sections of the membership, grouped according to their particular manufacturing interests. Work is in hand on some forty-eight subjects, ranging from long-term fundamental investigations to immediate practical problems bearing on the preparation, processing and marketing of foods. Suggestions for the inclusion of projects in the programme are made by research committees representing each membership group, i.e. bakers' prepared materials, cocoa and chocolate, jam, margarine and compound cooking fats, meat and fish products, pickles and sauces, and sugar confectionery. Other suggestions arise from problems submitted by individual members, or result from visits made by the research staff to factories, or from the study of the results obtained by workers in other fields of research. A research Co-ordination Committee consisting of the Chairman of Council, the Director of Research and the chairmen of the research committees is finally responsible for drawing up the balanced programme of research.

Apart from specialized work applicable to particular types of product, there are several aspects of the Association's work which are of interest to the whole membership, or at least to a number of sections of it. For example, the development of limit tests for metallic contamination suitable for routine factory control has received much attention, particularly recently in the case of lead in view of the proposals for the introduction of stringent limits for this metal. Other examples of investigations of general interest are :— the measurement and recording of the colour of foods (on which a report was recently issued and which is of importance in the maintenance of standards and the study of colour-changes during the storage life of many products) ; the development of techniques for the assessment of flavour in foodstuffs ; and a survey of the state of knowledge on the non-enzymic browning of foodstuffs, prior to the initiation of research into certain aspects of the subject.

PRESERVATION AND PROCESSING OF FOODS

Some of the current lines of investigation of more specific interest are described below:—

Bakers' Prepared Materials

The interests of this group cover a number of manufactured, semi-manufactured and mixed products supplied in bulk to the bakery, flour and sugar confectionery trades, such as marzipan, meringue powders, piping jelly and lemon curd. Thus, investigations cover the properties of dried egg,

albumen and albumen substitutes, the jellying behaviour of agar-sugar mixtures, the gelatinization of starch, and the prevention of fermentation in marzipan.

Cocoa, Chocolate and Sugar Confectionery

Although represented by two groups of the membership, many of the interests of chocolate manufacturers and sugar confectioners overlap. The control and standardization of the fluid properties of molten, tempered chocolate, so important in the efficient manufacture of chocolate-coated confectionery and in the improvement of the shelf-life of the finished products, has led to much study of the rheological properties of chocolate, of instruments for measuring its viscosity, and of the nature of the "tempering" process. The effect of various emulsifiers on viscosity is under investigation, as are also methods for the measurement of particle size in chocolate. The particle size is of importance in determining the smoothness of chocolate to the palate and affects viscosity. Increased knowledge of the size-distribution of sugar particles in chocolate could eventually lead to a closer control of the grinding process and hence to more economical methods of manufacture.

Jam

A thorough study of the solubility of sugars in relation to the keeping qualities of various types of jam has been completed in past years. Much work has already been done on the gelling properties of fruit pectins and recent investigations of the effect of storage conditions on the strength of pectin gels could lead to important applications in practice. The effect of manufacturing methods (such as sieving of plums in the manufacture of jam) and of the variety of soft fruit on the flavour of commercial jams have been the subjects of recent reports. Close links have been established with the horticultural experimental stations and much valuable information on the commercial suitability of new varieties of strawberries and raspberries has been made available at an early stage in the development of high yielding and disease-resistant types.

Margarine and Compound Cooking Fats

The measurement of the physical properties of margarine and compound cooking fats in relation to the method of use is of considerable importance. The properties which are desirable if margarine is to be spread on bread may differ from those required in a margarine to be worked into a cake-mixture. The Association is engaged in collaborative work on the measurement of these properties, an essential pre-requisite of any modifications in the manufacturing or compounding process which may be shown to be necessary in the production of improved products.

Meat and Fish Products

Apart from the continuance of investigations into micro-biological problems connected with curing processes, a study is being made of undesirable colour changes that occur on occasion both in cured meat and in fresh chopped meats. This involves a study of the behaviour of myoglobin and its derivatives under various conditions.

The gradual replacement of the open pan method of producing salt by the vacuum method has necessitated a comparative examination of the two types. They differ in two aspects, one chemical and one physical. The need for the removal of certain impurities from the brine used in the vacuum process results in a salt which is slightly alkaline, while the method of crystallization in this process affects the packing density of the salt and its rate of solution.

The implications of these changes have been studied in relation to the meat curing industry but the full significance of the effects cannot be assessed until the new type of salt has been in use for some time.

Pickles and Sauces

Public demand for the milder-flavoured types of pickles has led to an investigation of alternative methods of ensuring that pickles of comparatively low acid content will keep in good condition during distribution and during use by the consumer. In turn this investigation has led to a study of the nature of the changes which occur in vegetables and fruits, and which result in an undesirable softening of the tissues.

INFORMATION SERVICES

The Association maintains an extensive library of books and periodicals covering the whole field of the science and technology of food manufacture and increasing numbers of members make use of the fund of information available on problems affecting their interests. Enquiries by letter, telephone or by personal visit are welcomed.

Apart from the issue of *Research Reports* which give the results of investigations carried out as part of the research programme, matters of interest from many sources are communicated to members as *Technical Circulars. Scientific and Technical Surveys,* which give the general state of knowledge on particular subjects are issued from time to time. The *Journal,* at present issued twice yearly, records the Association's activities, including lists of reports, etc., issued, brief accounts of Panel Meetings and examples of answers given to members' enquiries which are judged to be of more general interest. On occasion, the *Journal* contains articles contributed by research workers of the Food Investigation Organization and others.

In January, 1953, the Association's *Abstracts* from current scientific and technical literature, which had been issued till then at irregular intervals, became a monthly publication. Some 1,400 abstracts taken from some ninety publications are being issued to members yearly. Many more are indexed in the library files and are available for consultation or as sources of information in answering enquiries.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1952, to 31st December, 1953, a block grant of £9,000 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 £6,000.

For the period 1st January, 1954, to 31st December, 1956, the block grant will be £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 £42,361.

RESEARCH COMMITTEE OF THE FURNITURE DEVELOPMENT COUNCIL

No change was made during the year in the establishment of the Research Department at Redhill, although some changes of personnel took place. One furniture manufacturer appointed a student to the staff of the Research Department for a period of six months, for training in research methods.

PERFORMANCE TESTS FOR FURNITURE

The development of performance tests for furniture has progressed throughout the year, and the British Standards Institution (B.S.I.) has already published standards based on those for dining-type chairs, cabinet goods and tables. A draft standard for bedsteads has been approved by the relevant B.S.I. Technical Panel. The performance test for upholstery has been completed and has been issued for comment by B.S.I.

Briefly the tests involve the submission of pieces of furniture to a series of cycles of loadings which are so devised that, if an article sustains them without fracture or movement in excess of a defined extent, the consumer can be sure it will remain functionally efficient under normal usage for a reasonable period. The standards incorporating these tests do not attempt to control all features of pieces of furniture, but are restricted to those features which the ordinary consumer cannot judge for himself; they are mainly concerned to ensure that the article will remain in the same condition as that in which it was bought.

A valuable feature of the tests is that they provide manufacturers with a method of assessing the effectiveness of new methods of construction, which will help them, for example, to see if more economical methods can be achieved without loss of strength, or if greater strength can be achieved without increase in price.

The B.S.I. has initiated a Certification Marking Scheme for firms electing to produce in accordance with these standards. By the end of August, the scheme had been joined by firms which are estimated to produce the following proportions of the total output of the products concerned:

Cabinets (e.g. wardrobes, chests, bookcases etc.) ...	About two-thirds
Dining-type chairs	Over a half
Dining tables	About a half
Kitchen tables	Nearly a quarter

RESEARCH PROGRAMME

The current programme includes the following investigations, some of which have been carried forward from last year:—

(*a*) The strength and life of joints; dowel or mortise and tenon; effect of moisture content: influence of corner braces.
(*b*) A comparison of the elasticity and durability of the various methods of providing resilience in upholstered seats.
(*c*) The problems presented in spray polishing and finishing.
(*d*) The hinging of wardrobe doors.
(*e*) A study of carcase rigidity: variations in rigidity: influence of moisture content: complex failure of joints.
(*f*) Deflection of panels and the influence of the boundary conditions of the panel, tongued and grooved, or rebated.

Work on the height of underframes of chairs was brought to a satisfactory conclusion, and a report on it has been made available to the industry; as a result of this investigation, the importance of the height of underframes has undergone a reassessment.*

* MERRICK, M. J. *Research Department Report No.* 1—The Effect of the Height of Stretcher Rails on the Diagonal Strength of Frames.

TECHNICAL INFORMATION SERVICE

During the year the Technical Information Service has continued to collect and co-ordinate information likely to be of value to the industry and to the research department. During the period of three years in which the Service has been in operation, a subject index of approximately 20,000 entries has been built up including a register of over 2,000 wood-working machines which are available to manufacturers in this country.

The *Technical Bulletin,* which contains abstracts of published literature and reports on the items of more general interest to the industry, is sent to those furniture manufacturers who have expressed a desire to have it and is also available on a subscription basis to employees in the industry and firms engaged in other industries having mutual interests. In addition to the *Bulletin* an illustrated news letter has been published which besides references to technical matters, such as are included in the *Bulletin,* also includes news items relating to work study, safety, education and trade statistics. This is sent free to nearly 3,000 firms who are registered with the Council.

In addition to these publications, *Information Reports* on the following subjects have been prepared and made generally available, 1,500 copies having been distributed:

1. Mothproofing of Wool.
2. Dipping of Furniture and Furniture Components.
3. Moulded Shapes for Furniture.
4. Pre-Boring for Woodscrews.
5. Glues used in the Manufacture of Furniture.

Further *Information Reports* on Dermatitis, Utilization of Woodwaste, and Electrical Methods of Glue-setting are in the course of preparation. Shorter reports and bibliographies are prepared as required on individual subjects to meet the needs of registered firms, whose enquiries cannot always be answered simply by a letter or a loan from the library.

It has been found very desirable to establish close contact with the industries supplying equipment and materials to the furniture industry by visits to exhibitions and the factories of such suppliers, both at home and abroad. The Technical Information Officer has visited the Hanover Heavy Industries Fair, the Swiss Industries Fair at Basle and the Milan Fair; during the course of this tour, visits were paid to a number of factories and research organizations in the vicinity of these fairs. The contacts thus established have proved to be most valuable. In addition the British exhibitions having any connection with furniture manufacturing have been visited.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1950, to 31st December, 1952, a block grant of £3,000 per annum was made provided £5,000 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 £3,000.

For the period 1st January, 1953, to 31st December, 1955, the block grant is £5,000 per annum, provided £8,000 is received from industry, and the additional grant £75 for each additional £100 contributed by industry up to a maximum of £3,000.

The income of the Committee for the last completed year was £14,000.

THE BRITISH GELATINE AND GLUE RESEARCH ASSOCIATION

September, 1953, marked the completion of the first five-year period of the Association, although the laboratories have been operating only during the last three years. While some success has attended efforts to increase the membership of the Association, there is still considerable scope for expansion. This applies in particular to firms using gelatine and glue, for whom the growing body of information and experience available from the Association will be increasingly valuable.

The first substantial results from both the fundamental research programme and from empirical studies have been reported in the past year, and are already throwing fresh light on many of the industry's problems. Variations in the industrial process for gelatine and hide glue have been known for some time to affect the economically important physical properties (jelly strength, viscosity, melting point) to different extents. The relation of these properties to molecular structure has not been clear, but the recent work described below is an important step in their explanation. As soon as the structural reasons for variations in the physical properties can be elucidated it will be possible to examine those factors in the manufacturing process causing structural modification.

FIRST RESIDENTIAL CONFERENCE

In April, 1953, the first Residential Conference of the Association was held at Hulme Hall, University of Manchester. Those present included representatives of gelatine and glue manufacturing firms, of firms using gelatine and glue, and of Government laboratories, Research Associations and university departments.

The Conference Lecture was given by Dr. G. R. Tristram (University of St. Andrews) who reviewed recent progress in protein research. The remaining nine papers were given by the senior members of the Association's staff, covering the range of research work already carried out by the Association. Summaries of the more important of these papers are given below.

PHYSICAL PROPERTIES OF FRACTIONATED GELATINS

A new technique for fractionation of gelatin has been developed, based on the solubility in aqueous sodium chloride solutions of the complex formed between gelatin and sodium dodecyl sulphate. The fractions obtained differ in dilute solution viscosity, which has been used as an index of the molecular weight. Sufficient weight of material has been obtained for measurement of the concentrated solution viscosity, gel melting point, and the gel rigidity as a function of concentration and temperature. At low temperatures (0°C.—10°C.) the rigidity of gels at a concentration in excess of 5 per cent. is approximately constant for the fractions of any one gelatin. It is therefore independent of molecular weight. This result contradicts previous work reported in the literature, which suggested that the rigidity depended on the weight average molecular weight. At low concentrations and at temperatures approaching the melting point some effect of molecular weight becomes apparent. It will require considerable further work before all the implications of these results have been satisfactorily worked out.

CHEMICAL COMPOSITION OF BONE, BONE GLUE, AND GELATIN

Compact bone tissue has been shown to consist of mineral matter, with a protein of the collagen family as the main organic constituent. No free

sugars or fat have been detected but a mucopolysaccharide has been isolated, the protein component of which is not in the collagen family. In addition a protein resistant to boiling water has been isolated.

A slightly modified version of the apparatus devised by Moore and Stein for the determination of amino acid composition by chromatographic separation has been completed and is in use. The first analyses of gelatin largely confirm previous figures derived from analytical methods or from microbiological assay.

The fluorodinitrobenzene technique of F. Sanger has been applied to the determination of the amino end group of gelatin and of its degradation products. This enables a first approach to be made to the kinetics of the degradation process.

CHEMICAL MODIFICATION OF GELATIN

As part of a systematic series of studies on the derivatives of gelatin, it has proved possible to secure specific methylation of the carboxyl groups of gelatin. The more highly methylated derivatives are unstable. The method of titration curves has been developed as an overall analytical technique for the ionizable groups on gelatin, and was successfully employed with the methylated gelatins.

TESTING METHODS

The commercial testing method for the grading of gelatine and glue as gelling agents, although well established, has been shown to give rise to serious inaccuracies. The sources of error have been very thoroughly examined and an instrument has been designed and commercially manufactured to check the performance of the testing machine (the Bloom gelometer). In addition batches of gelatine and glue have been standardized and issued to assist laboratories in maintaining correct values. The increased reliability which is now possible will be of particular value to user firms.

Discordant results in tests for total bacterial count for edible gelatines have been shown to result, not from inaccuracies in the determinations themselves, but in the difficulty of securing representative samples. This originates from a very uneven distribution of bacteria among the grains of a powdered gelatine. A statistical procedure has been suggested enabling a mean and standard deviation of the mean for the total count to be obtained, which will enable different laboratories to compare results.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st October, 1948, to 30th September, 1953, a block grant of £4,000 per annum was made provided £6,000 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 £4,000.

For the period 1st October, 1953, to 30th September, 1955, the block grant will be £6,000 per annum, provided £8,000 is received from industry, and the additional grant £100 for each additional £100 contributed by industry up to a maximum of £4,000. For the next three years the terms will be further modified.

The income of the Association for the last completed year was £20,555.

THE HOSIERY AND ALLIED TRADES RESEARCH ASSOCIATION

Although the Hosiery and Allied Trades Research Association was formed as recently as June, 1949, the help and collaboration it has always received from its industry has already enabled it to make very substantial progress in its investigations into the many problems related to the manufacture and use of hosiery products. During the past year the Association's income, which is based on the number of operatives employed by the members, has been reduced when compared with previous years by reason of the recession in trade experienced by the whole of the textile industry. The reduction has not been sufficiently large, however, to halt the building-up of the organization or to call for any curtailment in its activities.

Improved research facilities have been provided during the year; the range of knitting and auxiliary machines has been increased to include every type used by the industry in manufacturing its varied range of products, and new research equipment has also been added. The need has been felt for improved workshop facilities to enable more equipment needed for research to be constructed and more prototype instruments to be made for factory trials. The Council has therefore sanctioned the building and equipping of a new workshop which it is expected will be completed early in 1954.

TECHNOLOGICAL INVESTIGATIONS

The Association has continued to help its members in eliminating day to day production difficulties. Requests for help in this way have increased in number considerably during the year and this increase reflects the value which the members place upon this service. The increased knowledge which the Association has gained from its research has enabled it to deal more quickly and decisively with these requests for help.

During the year the Association has continued to devote much of its effort to improving hosiery materials and processes in order to increase the industry's competitive ability in world markets. Outstanding progress has been made towards providing the hosiery manufacturer with a much more accurate control over the quality and dimensions of his fabrics and garments as they leave the knitting machine. Up to the present many of the fluctuations in quality and dimensions have been caused by factors over which the hosiery manufacturer had little or no control; such factors include the condition of the yarn as it is delivered to the knitting factory, the tension under which the yarn has been wound on the spinner's package, changes in moisture throughout the yarn, and variations in temperature in the factory. The Association's investigations, commenced some time ago, showed that all the disturbing factors fall into line if the rate at which the yarn is fed to the knitting needles is always maintained in exact synchronization with the speed of knitting of the machine; the factors referred to upset this synchronization. A practical means of indicating when synchronization is lost has now been devised, when the machine can be adjusted to restore the balance, and this device can be attached to existing machines. In a further development intended primarily for new knitting machines the synchronization is maintained automatically by the machine itself. These devices have been attached to circular knitting machines in the laboratory and have proved very satisfactory: preparations are now being made to use them in works trials before making them available to members. Meanwhile, methods of applying them to flat knitting machines are being studied.

Based on the same principle of control, an instrument has been devised to allow accurate adjustment of the feeders relative to each other on multi-feeder knitting machines and this enables improved quality fabrics to be obtained. The old method of feeder adjustment was lengthy and by no means reliable; the new instrument allows rapid adjustment and detects even slight differences in balance of the feeders. The instrument has been used in trials in many hosiery factories and has proved its value. Arrangements have been made to manufacture it in substantial quantities.

Research into other hosiery manufacturing processes has enabled the Association to give practical help to its members. A number of new items of equipment and instruments have been devised, which will eventually be offered for use in the factories. Two devices which will help in achieving the very precise machine setting required in the manufacture of modern fine-gauge fully-fashioned hose have been developed. During the knitting of highly elastic yarns it is difficult to avoid fluctuations in tension which detract from the appearance of the finished product. Equipment has been designed and constructed with the object of eliminating these fluctuations. This can be attached to the knitting machine and is proving satisfactory in factory trials. Research on the scouring of knitting products is providing information which can be applied in the factories. Part of this work was a study of the lubricating oils used during knitting, and in consequence it is possible to recommend oils which are not only good lubricants but easily removable from the fabrics. The appearance of garments and fabrics knitted from cotton yarns should be improved by an efficient method of removing cotton "seeds" which has been developed and is, at present, being tried out on a production scale.

FUNDAMENTAL INVESTIGATIONS

Fundamental research has continued on the properties of hosiery yarns. Methods of measuring the bending and torsional properties of the yarns, which are all-important in determining the characteristics of the final knitted fabrics, have been devised and are now being used in practical investigations.

As a result of these investigations the hosiery manufacturer should be able to select yarn materials, yarn constructions, fabric constructions, and processing conditions, for specific applications of knitted products with greater certainty. This work on yarns is now being linked up with a fundamental study of the properties of knitted fabrics. One object of the work is to provide information which will lead to a more accurate prediction of the behaviour of knitted fabrics under conditions of processing, wear, and laundering.

The hosiery industry makes use of practically every type of fibre and the Association is carrying out investigations on the natural fibres which have been used for so long in knitted fabrics and on the newer synthetic fibres which are becoming increasingly available. As regards the latter, the Association is working in close collaboration with the leading producers of synthetic fibres in order that precise hosiery requirements can be taken fully into account during their further development. Help has been given to members in knitting yarns containing the newer synthetic fibres and in evaluating fabrics and garments made from them.

TRAINING FACILITIES

The Association has continued to encourage members to send representatives to the research station for training in the application of research results to particular operations. Under the scheme started three years ago a course of training, covering a period of 12 months, has been given to a further

six young people selected from the industry during the past year. These people have now returned to their respective firms and, in practically every case, they have been given positions of added responsibility. Now that the benefits of this special training are becoming fully appreciated there is keen competition for the studentships each year.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st July, 1949, to 30th June, 1954, 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.

The income of the Association for the last completed year was £49,972.

THE BRITISH HYDROMECHANICS RESEARCH ASSOCIATION

There has been a steady expansion of membership and activities of the British Hydromechanics Research Association during the year. The laboratory at Harlow, opened in 1951, is producing useful results, and a wider range of industry is taking advantage of the specialist knowledge of fluid mechanics accumulated by the staff of the Association.

RESEARCH PROGRAMME

The work of the Association is supervized by four main research committees dealing respectively with the following fields of work:—

(A) General problems in fluid flow.

(B) Centrifugal and allied pumps and turbines.

(C) Positive displacement machinery.

(D) Seals and glands.

The projects on which work has been carried out include: pressure surges in pipelines and flexible hoses, hydraulic friction in pipes and fittings and losses in ventilation systems, hydraulic measurements, development of sensitive manometers and automatic pressure controllers, hydraulic conveyance of solids, spillway models, flow conditions at inlet and discharge of centrifugal pumps, performance of valves in reciprocating pumps, stuffing box and radial face seals. The following two projects are selected for special mention.

HYDRAULIC TRANSPORT OF SOLIDS

Sand and gravel and mineral ores have been transported over relatively short distances by hydraulic pipeline for many years, as also has fine coal. In view of the urgent need for reducing fuel transport costs and of increasing mine output, the method is now being critically examined by the National Coal Board to see if it has economic or other advantages over existing methods.

Owing to the paucity of reliable experimental data and the large number of variables involved (sizes of pipe and coal, densities, concentrations and velocities), it has been impossible to predict the optimum operating conditions, and the corresponding capital and running costs. The Association has accordingly undertaken an extensive investigation of the basic hydraulic process and the determination of the relevant design data.

The experimental equipment comprises a three-inch transparent pipeline with horizontal, inclined, and vertical lengths, together with pumping and measuring facilities. A closed circuit six-inch line is under construction for the determination of the behaviour of larger pieces.

A method has been found of co-ordinating effects of the different variables on a non-dimensional basis, and although more fundamental work is required to explain the exact mechanism of the process it is now possible to estimate the pressure drop along the pipe in practical cases. The results so far obtained indicate that hydraulic transport of coal for distances of at least several miles will be economic, provided the technical problems of plant design can be solved.

An even more promising application would be vertical transport, possibly from the working face to the surface, particularly in mines where the capacity of the winding gear is a limitation on mine output. One of the practical problems to be overcome is the actual pumping of the mixture of solids and water up to the necessary high pressure. The Association is developing a feeder for injecting the solids into the water which has been previously raised to the necessary high pressure by conventional means. Tests on a model up to 1,000 ft. head have been promising and further work on a large scale is proceeding.

DESIGN OF PUMP SUCTION SUMPS

Within recent years it has become generally recognized that suction sumps must be properly designed if uniform entry of water into the pump is to be achieved, and in particular the necessity of avoiding vortices is now appreciated. In their mild form these vortices only slightly affect the performance of the pump, but when severe, their effects are very pronounced. Not only does the water retain its rotation after entering the suction pipe but it may entrain sufficient air from the free water surface to affect seriously the output of the pump. Moreover vibration arising from the intermittent nature of the air entrainment often leads to early failure of pump bearings.

The most common way of avoiding severe vortices is to allow a good depth of water covering the suction pipe, and on important installations this method is adopted for safety. As a consequence, however, many sumps are unnecessarily deep and often involve considerable excavation expense.

Laboratory experiments with small and medium sized sumps disclosed that the vortices originated in non-uniform flow of water entering the sump, and that although the suction velocity and the submergence of the inlet played a large part in determining the severity of the vortex, the general flow pattern in the sump was the over-riding factor. The ideal sump is symmetrical with the water flowing uniformly towards the suction pipes. In general, sumps should be as small as possible, consistent with avoiding drawdown of the surface, and should be so shaped that areas of dead or slowly moving water are avoided.

Comparative tests with sumps and pipes of different sizes revealed that geometrically similar installations behave similarly if velocities in corresponding places remain the same. This results in a model being operated at a higher Froude number than the prototype but surface effects arising from this seem to be negligible.

From the data obtained in these experiments it is often possible to predict the behaviour of a given sump; in other cases the necessary information may be obtained from a relatively inexpensive model.

ADVISORY SERVICE

The policy of the Association is to provide a specialist service in fluid mechanics to as wide a range of industry as possible, and to maintain close connections with consultants and academic workers.

The staff dealing with the advisory service has been augmented to cope with the increasing number of technical queries received. In many cases the problems have been solved from existing knowledge, but in others they have led to new research projects.

More than 100 research reports, technical notes and translations have been published and about 200 technical queries answered.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st October, 1948, to 30th September, 1953, a block grant of £5,000 per annum was made provided £7,500 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 £5,000.

For the period 1st October, 1953, to 30th September, 1958, the block grant will be £9,000 per annum, provided £18,000 is received from industry, and the additional grant £75 for each additional £100 contributed by industry up to a maximum of £9,000.

The income of the Association for the last completed year was £29,952.

BRITISH INTERNAL COMBUSTION ENGINE RESEARCH ASSOCIATION

In celebration of the tenth anniversary of its incorporation, the Association held a luncheon at which Lord Woolton, Chancellor of the Duchy of Lancaster, acting Lord President of the Council, was the principal guest.

Constitutional changes, referred to in last year's report, have resulted in the setting-up of a new and smaller Council; this body has been engaged in a general review of the Association's activities, and of means whereby wider support from the industry can be encouraged. In this review the comments of existing members on the research programme as a whole have been invited and a good response has been obtained.

Certain patents arising from the Association's research work have been assigned to the National Research Development Corporation for exploitation. Those so far assigned relate to rotary compressors, engine indicators, fuel injection systems, pistons, valves and engine operating cycles.

GENERAL RESEARCH

A limited investigation of the effects of the more important variables in large fuel injection systems of conventional design was completed. The hydraulic system developed at the laboratory for driving fuel injection pumps has been applied to the three-cylinder test engine used for high-pressure turbocharging studies, with good results, and continues in use. The special fuel injection pump delivery valve for the elimination of secondary injection has been developed further to meet unusually severe conditions encountered in one particular application.

Attention has been given to the problem of the rapid corrosion of the external surfaces of fuel injection nozzles. This, in the past, has often caused serious difficulty. In the light of fundamental work on combustion, a series of tests has been made which showed that the trouble was due to operation of the nozzles at too low temperatures and was therefore easily avoidable.

The development of instruments continued mainly to meet the needs of the research on noise. New equipment produced for this purpose included an improved selective amplifier designed for rapid operation, a pre-amplifier for crystal microphones, and a condenser type microphone and pre-amplifier. Items made to meet other laboratory requirements included a pre-amplifier with integrating circuit for torsional vibration measurements, a signal measuring unit and a voltage control unit for use with a Nernst lamp in spectrometry. An investigation has been made of the various methods of indicating pressures in fuel injection systems.

Participation in the Institute of Petroleum's work on the ignition quality of diesel fuels continued.

Further work on the six bearing testing machines included tests of new combinations of shaft and bearing.

TORSIONAL VIBRATION

The evolution of a new method of calculating crankshaft stiffness and its application to a number of crankshafts with very satisfactory results, was reported last year. The accuracy of the method has been proved further by comparing the calculated values of equivalent length of a number of other crankshafts of various designs with the values measured in static torsion tests.

The effects of gears on the torsional behaviour of engine systems have been examined theoretically and some experimental work on this subject commenced.

The investigation of various factors affecting vibration stresses has been continued with studies of the effects of balance weights and additional flywheels.

Further work has been carried out in connexion with harmonic components of crank effort, couplings of special designs, and vibration dampers.

A torsional vibration handbook is being prepared which will include the findings of the research work so far completed.

PRESSURE-CHARGING

The results of tests of twelve pressure-chargers of the positive displacement type are being summarized and correlated. The Bicera compressor has been developed further to meet a wider range of applications.

Studies of the conditions in a turbo-charged four-stroke cycle engine have continued. The hydraulic system of injection pump operation developed earlier and now in use on this test engine has proved valuable in permitting a ready variation of injection conditions.

NOISE REDUCTION

A preliminary study of the sources of noise in an engine valve operating mechanism has been completed. The several components of induction noise have been established and the attenuation produced by an air filter has been studied. Work on exhaust noise is continuing.

COMBUSTION, FUELS AND LUBRICANTS

Progress has been made in the development of the technique for studying the combustion process by infra-red spectrometry. In the same connexion, an investigation has been made of the distribution of the fuel spray in the combustion chamber of a compression ignition engine.

The testing of means of combating the ill effects of lower grade fuels for compression-ignition engines has been carried further. The running time of the engines used in this work now totals 25,000 hours. Various tests have been made in other engines and in rigs to determine the causes of the high wear rates experienced.

INFORMATION SECTION

Fourteen research reports have been issued to members, and the reports dealing with the Bicera compressor and the corrosion of fuel injection nozzles have been published in the technical press. Five translations have been issued. The abstracts from British and foreign publications have continued to be issued weekly on foolscap sheets and 5 in. × 3 in. cards, and have dealt with 940 items during the year. The abstract sheets include a list of patents, selected from the Official Journal (Patents), and notes on forthcoming meetings and text-books purchased. Increases have been recorded in the number of requests for information, in the number of books, periodicals and other documents issued on loan by the library, including those obtained through other libraries, and in the number of special bibliographies issued. Collections of selected abstracts on subjects of special interest have been maintained up to date.

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 is made provided £25,000 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 April, 1954, to 31st March, 1955, the block grant will be £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 £57,560.

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION

The British Iron and Steel Research Association serves one of the largest and most complex industries in the country. Formed eight years ago, its work ranges from the assembly and preparation of raw materials, through the basic processes of manufacture to the shaping and forming of the finished products, and the properties and qualities of those products. The names of the Association's five separate divisions are self-explanatory: Ironmaking, Steelmaking, Mechanical Working, Plant Engineering and Metallurgy. A great deal of the research is done in the Association's own laboratories, the largest group of which is in Sheffield. Here the new buildings which were begun in 1950 have been completed and were opened by H.R.H. the Duke of Edinburgh on 19th November, 1953. At Swansea there is a laboratory working on steel coatings, in the area where the tinplate industry is largely centralized. The north-east coast laboratories at Normanby are doing research on ore preparation and ironmaking in one of the largest ironmaking districts in the country. Much of the Association's work however is, and can only be done in the steelworks themselves, and the staff are often working side by side with steelworkers trying to solve a particular problem under everyday working conditions. There is also close collaboration with Universities and other Research Associations, to whom work is often contracted out. A few of the more striking developments from the Association's very wide programme of research are described below. They reflect the economies which it is trying to achieve for the industry.

PROLONGING THE LIFE OF INGOT MOULDS

Consumption of ingot moulds varies from 10 lb. to 70 lb. per ton of steel in different works. At 2*d.* a lb., every 10 lb. of mould metal costs £1,600 per week on a throughput of 20,000 tons of steel. The results of many years' practical research work on mould economy in co-operation with members are shortly to be published, and show how many economies can be effected. For instance, the quicker the moulds are stripped the longer they last. At one works, the life of standard semi-closed top moulds declined from 158 to 118 in less than eighteen months. Longer stripping times were found to be the cause, and when this was corrected, the life of the moulds returned to its former level. Mould life is lengthened when the mould is allowed to cool down to between 50°C and 100°C during the interval between uses. The phosphorus content in the steel of the mould has been examined, and at one works a study of over five hundred $3\frac{3}{4}$–4 ton moulds showed that an increase of phosphorus by 0·10 per cent. within the range 0·06 to 0·23 per cent. increased the average mould life by about 7 per cent. though moulds of 10 tons capacity or over should not have more than 0·06 per cent. phosphorus. The effect of design on mould life is very great, and the report contains recommendations for an ideal design, emphasizing that any variation from drawing size, however small, can have a very adverse effect. The recording and supervising of ingot mould use, taking into account conditions of service, composition, properties and design provides information which can clearly result in substantial savings. One new shop, for instance, began with a consumption of 58 lb. per ton, which was cut to 34 lb. during eighteen months.

WIRE DIE MEASUREMENT

In the drawing of wire, the angle of each die through which it passes is most important, as it affects the pull needed for drawing. In addition, if the angle is not correct, the soap which is often used as a lubricant will not flow between the die and the wire; a greater pull will be needed and the wire may be scratched. A simple, accurate instrument, the "Profiloscope", has been developed and is being sold commercially. The die angle can be measured to an accuracy of $\pm\frac{1}{2}°$ within a few seconds and can be read off very easily. Between 5 and 10 per cent. machine working time is frequently lost by replacement of worn tungsten carbide dies, and in one case this was estimated to cause a loss in output costing some £35,000 to £40,000 a year. Control of quality by such an instrument can enable wire drawing works to plan batch replacements economically, considerably reducing this expenditure.

RECOVERY OF ZINC FROM DROSS

A metallic sludge, compounded of zinc and iron, continually forms at the bottom of galvanizing pots, through which steel sheet passes to receive its zinc coating. This dross, as it is called, usually contains about 94 per cent. zinc and 6 per cent. iron. In order to prevent it coming in contact with the sheet during galvanizing, and thereby spoiling the coating, the galvanizer has periodically to remove the dross from the bath. A method has been devised that can be applied in any works, whereby iron-free zinc, suitable for use in the galvanizing bath, can be recovered from the dross. In the process, the dross, with some aluminium, is added to a bath of lead and the whole melt is heated to about 750°C. The iron combines with the aluminium and floats to the surface as an alloy, while the lead, which dissolves the zinc, sinks to the bottom. The iron-aluminium compound is skimmed off and the zinc-lead solution is allowed to cool to a temperature at which the zinc

crystallizes out on top of the molten lead. The zinc is then removed, while the lead can be used again for the next operation. It is now possible to recover 95 lb. of pure zinc from each hundredweight of dross.

AUTOXIDATION PLANT FOR WASTE PICKLE LIQUOR

Government legislation preventing steelworks from disposing of their waste pickle liquor in rivers has given an added incentive to the plans for recovering sulphuric acid from this liquor, mentioned in previous reports. A pilot plant is now ready for action at a Swansea steelworks, the method of operation being as follows. The liquor left after descaling the steel consists of a mixture of water, a little sulphuric acid and much dissolved iron sulphate. The steelworks concerned will evaporate this liquor, leaving ferrous sulphate monohydrate, which will be passed on to the Association's autoxidation plant, to be roasted in a special furnace. During the roasting, sulphur dioxide is given off and passes into an autoxidation tower, together with air, while water flows downwards in the other direction; the tower contains a small amount of manganese sulphate to speed up the reaction in which the sulphur dioxide, air and water combine to form a solution of sulphuric acid. The acid flows out of the bottom of the tower into a settling tank and is ready for pickling without further dilution. A by-product of the roasting of the monohydrate is fine iron oxide, which it may be possible to put into a blast furnace.

CONTINUOUS STRIP THICKNESS MEASUREMENT

The work on methods of gauging continuous strip has reached a new stage with the development, in conjunction with a member firm, of a new instrument. An adaptation of the loadmeter, described in a previous report, this "gaugemeter" measures the thickness of the strip continuously as it passes through the rolls. Derived from a measurement of initial roll setting and mill load, the measurement is indirect and is, in fact, made by the rolls themselves. Since all the measuring apparatus is well away from the strip, it cannot be damaged by a cobble or other mishap. The roll force and the screw setting are continuously measured, while the strip thickness is electronically computed from them. The result is displayed on a calibrated dial in any chosen part of the mill. It can indicate accurately the thickness at one or both edges of the strip or a mean thickness across the width of the strip. An industrial instrument is now being built for installation on a member's continuous hot rolling mill. Comparatively cheap, fast and safe, the "gaugemeter" should, if it fulfils its present promise, be of great value in the work of cutting down off-gauge strip to a minimum.

CRANE CAB DESIGN

One of the most important workers in the iron and steel industry is the driver of the overhead travelling crane. Yet many cranes are so designed that he has to lean out of his cab to see what he is doing. This is mainly because of the size of the electrical controllers, which are often placed directly in front of the driver. The large, unwieldy handles, which usually operate in wide, horizontal sweeps, have to be wide apart so as not to interfere with one another. This tires the driver and slows him down. Inspection and maintenance too are often found difficult. New and more compact types of control have been designed, with much shorter axes than conventional types. These can be placed with their axes horizontal, so that the levers in their central position are vertical. In addition, a joystick control of the two main travel motions can be provided. For this, the axes of the two controllers are placed horizontally and at right angles, and their handles are combined in one joystick. The operator moves his single handle in the direction he wants the hook to go. Diagonal hand movements will move

bridge and cab at the same time. The new designs include handles which are short and end in knobs, these being easier to operate than "sword handles". The new designs of controller have been tested in steelworks cranes and some have operated satisfactorily for a year or more, completing more than three million operations. Much useful research has also been done on seating, working height and areas, visibility, foot controls and the position of the cab. In the Association's London engineering laboratories at Battersea, steelworks considering new cranes can try out their ideas on a special "mock-up", incorporating the new controllers and approximating as closely as possible to working conditions.

CONFERENCES ON PRODUCTIVITY

The Iron and Steel Productivity Team which, led by the Association's director, visited the U.S.A. in May and June, 1951, published its report in June, 1952. This measured for the first time the difference in productivity between the iron and steel industries of the U.K. and the U.S.A. It was previously known that American productivity was higher, but the report made it possible to see why, and also what could be done about it. During the year the Association has contributed to the task of implementing the report by organizing, with the Iron and Steel Institute and local metallurgical societies in the various steelmaking districts, a series of technical conferences. Four have been held during the period under review, of which the first was a good example. This took place on October 1st, 1952, and was attended by executives from plants accounting for more than 90 per cent. of the open-hearth steelmaking capacity of the country. Members of the productivity team spoke on the application here of the report's recommendations and their findings were vigorously discussed by the 114 delegates who were present. Of immediate practical use has been a confidential report compiled by the Association and issued to all steelmaking firms in the U.K. It gives the productivity and driving rate figures of all melting shops in the country for 1951 compared with figures for 1950 given in the Productivity Report. Firms are "coded". Each one knows its position in the Table and can act accordingly.

INTERNATIONAL LOW SHAFT FURNACE PROJECT

During 1953, the Association has continued to co-operate in the low shaft blast furnace project at Liége. The installation was completed in the spring and a preliminary trial run took place in May. In August, a series of furnace trials was begun, with and without oxygen enrichment of the blast, based on the use of graded small coke and self fluxing ore mixtures.

PUBLICATIONS

A number of books have been published during the year, in addition to a large number of reports, both open and restricted, and the Association's Annual Report to Council. Their titles include *The Fight Against Rust* (the work of the Corrosion Committee of the British Iron and Steel Research Association); *Engineering Maintenance* (Proceedings of the 8th Plant Engineering Conference); *BISRA Survey; Physical Constants of Some Commercial Steels at Elevated Temperatures* (Butterworths' Scientific Publications); *Symposium on the Corrosion of Buried Metals* (Iron and Steel Institute); *Spectrographic Analysis of Low Alloy Steels* (Iron and Steel Institute).

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1948, to 31st December, 1952, a block grant of £75,000 per annum was made provided £200,000

of grant-earning income was received from industry, and an additional grant of £75 for each additional £100 contributed by industry up to a maximum additional grant of £75,000.

For the period 1st January, 1953, to 31st December, 1957, the block grant is £75,000 per annum, provided £400,000 is received from industry.

The income of the Association for the last completed year was £474,128.

THE BRITISH JUTE TRADE RESEARCH ASSOCIATION

Members have continued to make extensive use of the Technical Enquiry Section, and the number of enquiries has reached a figure of nearly 850 per annum, representing an increase of 35 per cent. over the previous year. Whilst the majority of these are received from firms engaged in production, analysis shows that all sections of membership are now utilizing the services of the enquiry section. Several firms have sent personnel to the laboratories for training in methods of quality control and assessment, and the close liaison with the industry has been further strengthened by laboratory investigations in which the quality levels of particular products have been examined and the results analysed.

During the past year twenty-three technical reports on research work in progress in addition to 122 abstracts of published literature, have been communicated to members.

REVIEW OF RESEARCH PROGRESS

Raw Materials

The results of the basic work on the evaluation of the physical and chemical properties of lignified bast fibres are now being utilized in applied research investigations, and the scientific methods which have been developed for assessing the more important fibre properties have enabled work to proceed rapidly in a number of fields: for instance, many samples of bast and leaf fibres grown in different parts of the Commonwealth have been analysed, tested, and assessed. Further, the methods and techniques have enabled progress to be made in experiments on the mechanism of retting and in the evaluation of the chemical extraction of bast fibres from their plants. A study of the physical properties of fibres in relation to the efficiency of processing of the final product will help to determine which modifications in the properties are needed to produce an "improved" fibre. For this purpose knowledge is needed of the relationship of the properties to the fibre structure, not only of jute but of other types of fibre as well. With this object in view a large number of bast and leaf fibres have been examined for tensile strength and elastic properties, and the values of these quantities have been correlated with the dimensions of the ultimate fibres and the spiral arrangement of the cellulose chains as determined by X-ray measurement. It is apparent from this work that the extension behaviour of leaf fibres is very different from that of bast fibres.

Spinning

The function of batching oil in the processing of jute fibre is still not fully understood, but some results have been obtained which clarify one aspect of this problem. In the past it was widely believed that one function of the film of batching oil on jute fibres was to reduce to some extent the rate at which moisture is lost during passage of the fibre through the preparing and spinning processes, but it has been shown that the presence of oil at concentrations normally used in batching has remarkably little influence on the rate of moisture change.

Most of the work on spinning has been concerned with the study of changes in slivers, yarns, etc., resulting from changes made in the operating conditions of the production machinery. The relationship between the weight variability of a sliver and the length examined has been investigated, together with the effects of doubling and drafting on the properties of the final yarn. The results, which are of considerable practical importance, have indicated additional lines of research mainly concerned with the weight per unit length of slivers at the different stages of preparation.

In addition, the measurement of tension in the yarn before it enters the flyer cap during spinning is being studied. It has been found possible to calculate from theoretical considerations the tension to be expected from the values of weight and dimensions of the bobbin and the frictional drag, and good agreement has been found between the theoretical figures and those obtained in the practical trials. It is anticipated that eventually certain conditions for optimum spinning efficiency may be established.

Weaving

Investigations of various factors which may have a possible bearing on warp breaks in weaving and hence on loom efficiency have continued, under conditions designed to minimize effects of the human factor and of differences between looms. Two important aspects, namely the moisture in the beam and changes in atmospheric humidity, have been re-investigated in a further series of trials in which complete records have been obtained of the occurrence and nature of warp breaks and the amount of waste accumulated under the looms, so that it is now possible to determine the improvement in weaving efficiency which is to be obtained by maintaining specified conditions of both relative humidity and beam moisture.

Interesting results have also been obtained from examination of the effects of constructional changes on the physical properties of a loom state 11 porter hessian. Most of the work in this connection has been concerned with the relationship of the warp and weft breaking loads of the cloth, expressed as strength per thread in the cloth, to the single thread tests on the yarns before weaving. The investigation is being extended to assess the changes, if any, which occur on subsequent finishing, such as calendering, chesting and mangling.

Finishing

Further work on the rotproofing of jute has included a comparison of results obtained by laboratory test methods with those occurring in actual field use, and it is expected that the work of the Biological Section will be accelerated by the development of a new testing technique in which a large number of cloth samples can be subjected to controlled microbiological attack at the same time.

The long term series of experiments on the methods of fireproofing jute cloth has been continued, and the first part of this work on the use of water-soluble compounds has been completed; in all 110 such compounds have been studied and several substances hitherto uninvestigated in connection with fireproofing have been found to be effective. The ultimate usefulness of the most successful treatments is now being assessed in experiments mainly designed to determine the effects of the treatments on the physical properties of the treated cloths on prolonged storage. A study has also been made of the mechanism of combustion of jute with particular reference to the relationship between temperature and exposure time in the case of samples of jute fibre suspended in air streams maintained at constant temperatures. This particular investigation is yielding valuable information on the general subject of the fireproofing of textile materials.

BASIC CHEMICAL RESEARCH

Research on the chemical structure of jute fibre has been concentrated mainly on the hemicellulose fraction, which contains chemical linkages and groups susceptible to modification. The kinetics of the reactions involved in the hydrolysis of jute hemicellulose by dilute sodium hydroxide solutions have been studied in detail. It has been found that whereas the increase in the free carboxyl groups followed the course expected for the homogeneous hydrolysis of an ester, the rate of acetyl hydrolysis could not be interpreted satisfactorily on the basis of a simple equation. The differences in the kinetic behaviour of the acetyl and carboxyl groups on hydrolysis suggest that the groups may be differently located in the fibre.

The isolation of relatively pure hemicellulose from jute fibre is facilitated by a preliminary removal of lignin. The preferred reagent for delignification is acidified sodium chlorite solution, the action being arrested, however, to yield a holocellulose still containing 2 per cent. lignin, since complete delignification is accompanied by loss of carbohydrate material. The solubility of jute holocellulose in sodium hydroxide solution is a maximum for 7–8 per cent. concentration at 20°C.; at lower temperatures maximum solubility coincides with concentrations lower than that required at 20°C. The residue obtained from treatment with the optimum concentration of sodium hydroxide solution is pure α-cellulose, uncontaminated with hemicellulose. The structure of the hemicellulose present in the alkaline extract is being investigated, supplemented by studies on the graded hydrolysis of jute fibre with acids.

The investigation of the effects on jute of radiation in the ultra-violet and visible spectrum has been continued. The identification of the coloured products formed is being attempted by chromatographic techniques, and the extents to which the oxidative and chain-cleavage reactions affect the fibre properties are being determined. The impregnation of jute yarns with copper and manganese salts has not shown the advantages reported in the literature, but limited protection against photochemical degradation has been achieved by the incorporation of anti-oxidants. The shielding of jute fibre from direct radiation, for instance by bitumenizing or pigmentation, has been found to be effective, but such treatments are of limited practical application.

The contribution of yarn and cloth structure to the retention of strength during irradiation is at present being examined, and some significant preliminary results have been obtained.

INSTRUMENTATION

During the year the engineering department has produced several new instruments and special testing equipment for use in the research problems under investigation, for example:—

(*a*) An electronic apparatus for the rapid estimation of moisture in jute packages by a non-destructive method utilizing the fact that the dielectric constant of jute increases with increasing moisture content.

(*b*) A simple electrical device for measuring the changes in the cover factor of a cloth arising from finishing treatments.

(*c*) A yarn testing machine designed to measure the frequency and location of breaks in a yarn when running under a predetermined tension.

(*d*) A testing machine operating on new principles, for the determination of the breaking load and extension of single fibres.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st July, 1951, to 30th June, 1956, a block grant of £9,000 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 £9,000.

The income of the Association for the last completed year was £37,071.

THE LACE RESEARCH ASSOCIATION

This has, in many respects, been a year of consolidation for the Association and it is now working on a scale commensurate with its income. There have been a few increases in the staff intended to improve the balance of the team. The facilities of the laboratories are being continually improved by the purchase of new equipment. In particular, the Chemistry Department is now functioning on a satisfactory scale and this has increased the scope of chemical problems which can be undertaken and in some instances increased the effectiveness of other departments. Much of the research effort has necessarily been devoted to lubrication, but the expansion which has taken place has enabled more work to be carried out on the other research projects without adverse effect on lubrication. This expansion has also made possible an improved service to members, by way of liaison visits, information and the solution of day-to-day problems. This has helped to establish closer contact between the trade and its Research Association.

MANUFACTURE OF MACHINE PARTS

The manufacture of certain parts of the lace machine either from alternative materials or by non-conventional methods has received attention.

Limited trials have been made with catch bars, Jacquard cylinders and bearings of Plain Net machines made with plastic materials. The advantages to be gained by this substitution of plastics for metal depend upon the particular application, but they cover such factors as cost, wear and lubrication.

A more important investigation is into alternative methods of manufacture of bobbins and carriages. These parts are costly and replacements can usually be obtained only after a long period of waiting. A provisional patent has been taken out covering their manufacture by a different method, which it is hoped will quicken the supply, improve the quality and cheapen the final product. This investigation has reached the stage where trial sets of parts must be produced to determine their quality and the practicability of the method being developed by the machine builders.

LUBRICATION

In previous years the greatest degree of success has been achieved in the Leavers section, particularly with those firms anxious to produce white and pastel coloured nylon dress laces. A number of plain net firms whose principal interest is in the manufacture of elastic and nylon nets have now adopted the new lubricant, and the most recent success has been the successful elimination of graphite from a lace furnishing plant.

Further improvements in the lubricant are looked for, and experiments to this end are being continued in the laboratory. It is probable that the increasing use of synthetic yarns in all sections of the trade coupled with continued improvements in the lubricant will lead to an expansion of its application.

JACQUARD STRINGS

The Jacquard String developed by the Association is continuing to give satisfactory results, and a number of firms have retied their machines during the year. It was not anticipated that lace manufacturers would, in general, cut down a satisfactory linen harness to replace it by the new string, but that they would wait until the linen strings were due for replacement. The initial queue for supplies of the string has now been exhausted, and in addition to supplying the firms in the lace trade, the string is now available to other sections of the textile industry.

NEW TYPES OF YARN

The lace trade has always endeavoured to make full use of any textile fibre which is found suitable for lace-making. When nylon was introduced, the Association was not able to undertake any of the necessary trials and members of the trade were forced to experiment for themselves. The position in regard to plant and equipment has now improved and supplies of "Terylene" yarn have already been obtained for trial. When a satisfactory stage is reached with this development work, members will be advised of the advantages to be gained by the use of "Terylene" and the best methods of processing. Other synthetic yarns, whose properties offer promise of useful application, will be tried when supplies are available.

In addition to providing information concerning the newer yarns, there is a field for extending and improving the use made by the industry of well-established fibres. An example of the way in which modified processing of cotton yarn may lead to improvement can be quoted. Manufacturers of cotton guipure laces were having trouble with white goods turning brown. This problem was submitted for investigation and found to be due to the difficult of satisfactorily bleaching the cotton, without adversely affecting the acetate vanishing cloth. As a result of the adoption of recommendations made by the Association, this problem has now been satisfactorily overcome.

SERVICE TO MEMBERS AND LIAISON

The response of the trade to the Association's modified policy of undertaking day-to-day problems has been one of the most notable features of the year's work. Associated with this, there have been more visits of the staff to members' factories and of members to the laboratories. These have enabled members to form a better appreciation of the type of work in progress and the methods by which problems are investigated.

The types of day-to-day problems submitted have been most varied. They have ranged from yarn tests to problems of fabric manufacture and methods of dyeing and dressing. One complaint received, concerning the fading of fast dyed curtains, was due to the presence of optical white dyestuffs in domestic washing compounds.

In addition to the direct help given to the members concerned they form a valuable indication of the types of trouble encountered in practice. In a few cases work of a very much more general character has been undertaken as a direct result of the findings in a particular problem.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1949, to 31st December, 1953, a block grant of £7,000 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.

The income of the Association for the last completed year was £19,150.

BRITISH LAUNDERERS' RESEARCH ASSOCIATION

Although steady progress was maintained in fundamental investigations the keynote of the Association's work during the current year has been the application of research results to practice; in this aspect of the work, members of the research staff took an active part and conducted or controlled a number of experiments on the large scale, either in the Experimental Laundry or in the laundries of members.

For the past 20 years liaison between the Association and the industry has been maintained by the visits of the technical officers which are made to each member's laundry in turn. This serves the purpose of providing the member with an opportunity of discussing his own problems and receiving advice in the light of the latest developments. It also helps the Association to obtain a comprehensive view of the problems facing the industry and of the measure of success with which the problems are met. Many of the individual difficulties can be solved on the spot but problems which are more general frequently call for further investigation and are included in the programme of work of the Association.

The daily work of the Analytical and Textile sections and of the Information Department also gives very valuable pointers to what is required. The wisdom of having widened the basis of membership in 1936 so as to admit textile manufacturers and distributors, soap and detergent manufacturers and laundry engineers has been amply demonstrated, particularly in recent years.

TEXTILE DEVELOPMENTS

The increasing use of new fibres, new mixtures and new finishes in textile fabrics has made it difficult for the launderer to decide, by rapid inspection, how particular articles should be washed and finished. The presence of new fibres may not be apparent even to an experienced sorter. The Association has advocated for some years the introduction of a scheme of informative labelling to give guidance on methods of washing and finishing, and is represented on the Committee now considering the matter.

The Association has over a long period co-operated with textile manufacturers in regard to the launderability of their products and has exchanged information with the other textile Research Associations. It also works closely with such bodies as the Textile Institute, the Society of Dyers and Colourists and the British Standards Institution on questions of shrinkage, colour fastness and marking inks. Its investigations on shrinkage, in particular, have contributed to the standardization of methods of test and have assisted in making producers " shrinkage-conscious ".

Other work in the textile laboratory has included studies of resin-treated fabrics of the crease-resistant, glazed or embossed types. These finishes vary in their fastness but they do not, in general, give rise to difficulty in the washing of coloured articles. Trouble sometimes occurs with white articles which have to be bleached. Some of the resins retain chlorine even after thorough rinsing and the articles become yellow either immediately or during subsequent ironing. The yellowing is often associated with extreme weakness.

WOOL WASHING

Further work on the removal of mineral oil from wool fibres by soap solutions of varying pH has been carried out, the residual oil content of the wool being estimated by extraction with a solvent. It was found that the

contact angle of the oil on the wool, measured in the oil, was at a maximum at a pH value of about 9·5. This indicated that the oil was not firmly adherent to the wool but was in a condition to be easily removed. Washing trials confirmed that maximum removal of oil was obtained under these conditions. At about pH 10 the contact angle and the washing efficiency fell to very low values, due to the fact that in soap solutions of high pH value, very little free fatty acid is formed by hydrolysis. The presence of fatty acid or other polar substance was already known to assist the removal of mineral oil and it is, in fact, common practice to add polar substances to mineral oil used in wool processing in order to facilitate its removal. When polar compounds such as olive oil were used as the soiling matter it was found that increasing the pH value in the range pH 9 to pH 10·7 resulted in a more rapid removal of the oil.

The efficiency of removal of oily soiling matter from wool by a solution containing mixed detergents was usually found to be intermediate between the efficiencies of solutions of the respective single detergents. Laboratory washing tests on soiled cotton fibres (using the BLRA chopped fibre technique) gave similar results except in one instance where a mixture of soap and a non-ionic synthetic detergent was not as effective as a solution of either component alone.

KINETICS OF DETERGENT ACTION

Kinetic studies of detergency have led to certain conclusions about the conditions required if the time of a washing process is to be curtailed. A practical survey of rinsing times has also been made and the mathematical considerations of the rinsing process have been studied. As a result, it has been possible to formulate a shortened washing process which has successfully undergone preliminary trials on the large scale and which some members are now using in their own laundries.

Further work on redeposition of soiling matter has been carried out in order to compare the effects of sodium carbonate and sodium metasilicate in soap processes when the concentrations were lower than usual. Towards the end of a wash the concentration of soap is low due to the fact that considerable quantities of soap are taken up by the dirt and the load. During rinses, the concentrations of both soap and alkali are low. It was found that under all the conditions studied less redeposition occurred with sodium metasilicate than with sodium carbonate.

EFFICIENCY AND ECONOMY IN LAUNDRIES

Targets for consumption of fuel, power, materials and water in relation to the amount of work handled were set some considerable time ago by the Association and information has been available from many members showing how the actual consumptions compared with these targets. Until recently, however, there has been no reliable information about the consumption of the industry as a whole. The Final Report on the Census of Production for 1948 has now provided figures from which it has been possible to deduce the overall averages and it has become clear that in the industry as a whole much greater economy is possible.

The targets are set for good normal practice under works conditions and are based upon the work and experience of the Association: they do not depend on exceptional measures of economy ; many members of the Association have been able to improve substantially on the target figures, though the industry as a whole. The Final Report on the Census of Production for value of membership of the Association, for if every launderer were a member and applied the Association's recommendations large sums of money could be saved.

Fuel is one of the items showing unfavourable figures ; fuel economy has been a subject of great interest to the Association for many years and a communication entitled *Fuel Economy in Laundries* has been published which summarizes the position. References to articles which have been circulated to members in *BLRA Bulletins* and *Reports* are listed.

A comprehensive survey of data on productivity and production targets in the laundry has been made jointly with the trade organization and a report entitled *Laundry Productivity* has been issued.

SERVICES TO MEMBERS

The number of samples for analysis, and of fabrics or articles sent in by members for examination, increased greatly after the war but has now reached a fairly steady level of about 3,000 per annum. The number of test pieces of fabric sent to members wishing to check their washing processes has increased appreciably but many more could be used with profit.

Reference has already been made to the visits paid by technical officers to members' laundries. In many instances it was possible to suggest changes which led to greater economy or ease of working. Productivity can often be increased or labour saved by a re-organization of the whole laundry or even of one department. A simple re-arrangement of racking and packing methods has enabled the staff of a department to be halved in several instances.

Fuel consumption also received considerable attention because hidden waste of heat can occur so readily through the use of too much hot water, too high temperatures, leaving the steam turned on when drying machines are idle and similar causes which do not become immediately obvious. In one relatively small laundry, improved use of the finishing plant enabled a supplementary boiler to be shut down with a consequent saving of three tons of fuel per week.

Many problems still arise in the washhouse but some of them are outside the control of the launderer. A leaflet intended for insertion in laundry parcels was prepared, pointing out the dangers of using bleach carelessly and improperly in the home, and about 130,000 copies were supplied to members.

TRAINING COURSES

Other activities of the Association include training courses for potential laundry managers and manageresses and for wash-house men. Part of the time on these courses is spent in the Experimental Laundry working under commercial conditions. It is of interest to record that in the last six months' course there were five students from the Gold Coast.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st October, 1949, to 30th September, 1954, 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.

The income of the Association for the last completed year was £52,105.

THE BRITISH LEATHER MANUFACTURERS' RESEARCH ASSOCIATION

During the past year progress has been made in applying the results of a number of laboratory investigations on a large scale. This work has been greatly assisted by the advice received from the small Research Sub-Committees set up in recent years to keep the Association informed of the problems of the different sections of the industry which they represent. When the work of the Association leads to possible new processes, these Research Sub-Committees can indicate the most likely types of production to which the new processes are applicable. The Committees can also suggest how new methods should be modified and why they require modification before they can be utilized in existing plant or be inserted into a normal series of processes. The following is a brief account of some of the work of the Association which will influence current production.

PRESERVATION OF HIDES AND SKINS

Hides and skins are a by-product of the meat industry, and the more carefully they are removed from the slaughtered beast, and the more rapidly they are cleaned and preserved, the better the leather obtained. Tanners have therefore always been interested in encouraging good flaying and in improving methods of preservation.

Preserved hides and skins are a worldwide commodity. The producer has therefore to be convinced that if he adopts a modification in his methods of preservation none of his customers will be able to attribute faults in their finished leather to the new methods of preservation. The Association is therefore often called upon to make carefully planned experiments with hides and skins which have been preserved by new methods, and to report on the quality of the leather obtained from them.

Use of disinfectants in brines

The large-scale experiment in Uruguay described last year aimed at the prevention of the growth of halophilic bacteria in the brines in which the hides were soaked. In this statistically planned experiment 1,000 hides were treated with brines to which sodium silicofluoride and sodium pentachlorphenate had been added. After twelve months' storage under conditions identical with those to which these hides are normally exposed, they were tanned in two tanneries in Great Britain. The results showed that sodium silicofluoride brought about some improvement, but was not as successful as sodium pentachlorphenate, which at 0·1 and 0·2 per cent. on the weight of the salt in the brine gave hides which were visibly free from halophilic organisms after twelve months. Sodium pentachlorphenate caused some rather unsightly darkening of the blood vessels in the hide, but after tanning the leather produced was sound and of good quality.

Replacement of crystal salt by vacuum and granular salts

Crystal salt produced by the uneconomic open pan evaporation is normally used for preserving hides in this country. The question arose whether it could not be replaced by fine grained vacuum salt or a special granular salt which can now be produced using modern evaporators. A large number of hides, calfskins and wool skins which had been salted in hide markets with these different kinds of salt, stored in tanneries, and then converted into finished tanned products, were compared with similar materials made from similar raw material salted with crystal salt. The conclusion reached is that both vacuum and granular salts are as effective as crystal salt for curing hides and skins, although without some change in the usual method of application they may not always be so easy to apply.

Curing of Sudanese sheepskins

In the autumn of 1952 the Colonial Office held a conference of officials from the Colonies and British tanners to discuss the preservation of Colonial hides and skins. The Association contributed to the discussion, and drew attention in particular to the need for distinguishing between bacterial and heat damage during preservation by sun drying. In conjunction with the Colonial Products Advisory Bureau and a member firm the Association made a comparison between sun-dried and dry salted Sudanese sheepskins, from which it was concluded that in both the hot and cool seasons sun-drying yields fewer skins showing damage in later processing than dry salting. Evidence was obtained that when dry salted the skins contain too much moisture to withstand the high atmospheric temperatures to which they are exposed.

ENZYME DE-WOOLLING AND UNHAIRING

Because of the almost universal use of sodium sulphide pastes or solutions, the depilation processes of the leather industry are among the dirtiest operations in leather-making: depilation by enzymes can be a much cleaner process. Largely, but not entirely, for this reason, enzyme depilation has been studied on a semi-large scale in members' yards. Two enzyme preparations have been used: a mould enzyme from a mould culture supplied by the Bio-chemical Unit, Commonwealth Scientific and Industrial Research Organization, Melbourne, Australia, and a bacterial (*B. subtilis*) enzyme prepared commercially. Little difference was found between the two preparations: both loosened the wool of sheepskins and the hair on dry- and wet-salted hides. Much of the difficulty of using enzymes was traced to the adventitious bacteria introduced from the wool or hair, and only when the growth of these was controlled by the use of antiseptics was it possible to use enzyme preparations effectively.

PRE-TANNING WITH POLYMERIC PHOSPHATES

For many years it has been known that hides would absorb sodium hexametaphosphate which is, however, easily displaced by other tannins. Sodium hexametaphosphate is a polymer containing six $NaPO_2$ units. Recently, with the assistance of an associate member, hides have been tanned with polymeric phosphates containing up to 25 units. When the number of units exceeded 15, it was found that the polymers combined much more firmly with hide substance. The polymeric phosphate tanned hides could be retanned either with chromium or vegetable tannins. The advantages gained are two-fold: polymeric phosphate pre-tannage takes place more rapidly in the looser parts of the hides, so that as a whole they become more uniform: this leads to an increase in cutting value. Secondly, the pre-tannage lowers the affinity of the hide substances for other tannins, so that penetration is assisted. This enables retannage with vegetable tannins to take place in strong liquors, and hence shortens the duration of tannage. Pre-tannage of hides with polymeric phosphates before chrome tanning to produce upper leather is already in bulk production. Pre-tannage of split hides before vegetable tannage to produce upholstery leather promises to make equally rapid progress. Besides increased speed of retannage, the polymeric phosphate sequesters iron impurities and thus improves the colour of the tanned leather and protects it against rotting by acid industrial atmospheres which ionic iron is known to catalyse.

IMPREGNATION OF LEATHER WITH LATEX

As an alternative to the use of polymeric phosphate pre-tannage to tighten the loose flanks of hides and skins, a considerable amount of work in conjunction with the Rubber Producers' Research Association has been done in an attempt to even up hides by impregnating them, after chrome tannage,

with natural rubber latex. The main obstacle that has had to be overcome is to bring chrome leather and latex together under conditions which do not cause the latex to coagulate. These conditions can now be defined. On a semi-large scale as much as 5 per cent. of rubber has been found to penetrate half-way through the leather, and, what is more important, a larger amount of rubber is taken up by the flanks than by the prime parts of the leather.

A more recent modification of the method, using a different type of latex, has given much larger uptakes, particularly in the flanks. What, however, is probably more important is that by this modified method the leather becomes waterproof without losing its ability to transmit water vapour.

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 is made provided £27,000 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 £56,607.

LINEN INDUSTRY RESEARCH ASSOCIATION

The Research Institute of the Linen Industry Research Association, situated at Lambeg, near Belfast, is conveniently near the centre of the Northern Ireland linen industry. Adjoining the original mansion are modern post-war extensions to house the plant and equipment necessary for technological researches.

Over the years, research objectives have changed considerably. At the outset the raw material commanded foremost attention; the commercial varieties of flax then extant were of unsatisfactory quality, and an intensive breeding programme eventually culminated in the isolation of the well-known Liral varieties, of which Liral Prince provided the major part of the flax grown in the British Isles during the second world war.

In later years attention has been focussed on flax technology; and the various processes of flax preparing, wet spinning and dry spinning, weaving, bleaching, dyeing, and finishing, have been studied. In many cases, systematic investigations have served merely to confirm the correctness of current practice, though in so doing they have also inspired confidence in the results of applying the scientific method to technical procedures.

In recent times the emphasis has been on certain aspects of applied research, i.e., on investigations of which the results are likely to prove capable of early application in the industry. In co-operation with members, instruments designed for research purposes have been modified for use in mill and factory, whilst surveys of flax processing and working conditions have revealed where there is scope for improvement. Illustrations of such work in the different departments are given below.

SPINNING

The yarns of all textile fibres show a greater or less degree of irregularity. It is the constant aim of the spinner to keep this irregularity to a minimum; to achieve his aim, he should exercise the utmost care in the selection of his raw material, maintain his machinery in first class condition, and ensure that the settings of the various parts are perfectly adjusted to the raw material being processed. This ideal is never attained in practice. Controls are introduced to reveal irregularities which exceed the permitted tolerances,

so that action can be taken as soon as possible to make readjustments which reduce the irregularity to within the permitted limits. It is accordingly a permanent section of the Association's work to investigate the drafting of flax and rayon staple fibres on flax machinery with the object of improving the regularity of the yarn. New methods have been developed for studying the action of drafting mechanisms and for analysing irregularities in yarns.

In spite of all such precautions, the human factor is responsible for the occasional appearance of gross irregularities known as slubs, or thick places which exceed a pre-determined size. The LINRA photo-slubber is a patented electronic device designed for detecting and removing or counting these slubs during the winding of the yarns at high speed. This apparatus can be used not only for removing such slubs on high-speed winding frames; it can also be used for a special type of irregularity test to determine the frequency of excessively thick or thin places in the whole length of a batch of yarn. Widespread interest has been shown in both these applications.

Lubrication is a necessity for any machinery, but, in the wet spinning of flax, the methods of lubrication in vogue tend to deposit oil stains on the yarn. Lubrication is therefore being studied not only with the object of reducing power consumption and wear on bearings, but also to develop new methods of applying the lubricant in order to reduce to a minimum the amount of oil used and the risk of oil stains.

The success of a mill depends on its rate of production, and investigations on productivity in flax spinning have been continued. In wet spinning, various parts of flyer spinning frames have been modified in design so as to improve both running efficiency and the quality of yarn spun. Alternative spinning mechanisms are also being examined; thus, a study is being made of the possibilities of increasing production by using the ring and pot spinning methods developed for other textile fibres; the properties of flax in wet spinning lead to certain difficulties with these methods, and further work is required before their potentially high production rates can be realized in practice.

The moisture content of flax is closely related to the humidity of the atmosphere, and also radically affects its physical properties: some atmospheric conditions of humidity are therefore probably more favourable for the dry spinning of flax than others, and certain optimum conditions may exist at which yarn breakages are a minimum, and production and productivity a maximum. No information on this subject is available in the literature, and a systematic investigation has now been undertaken to determine the effects of variation in atmospheric humidity, and moisture content of the fibre, on yarn quality and on production as measured by the frequency of dropped ends.

Some loss of production in flax spinning is commonly caused by "lick-up", i.e., the collection of fibres on the rollers; the frames have to be stopped so that the rollers can be cleaned. Intensive investigations have been undertaken to avoid these frame stoppages, and mill trials are now in progress to try out several methods which, in experimental trials, have proved very promising in reducing lick-up.

WEAVING

Before the yarn can be woven, it has to be properly prepared by being wound into suitable forms for use as warp and weft. A new machine, which has been designed at the Institute to wind at high speed from hank on to special spools, has now been developed further, and factory trials are being arranged.

In factory surveys of the winding processes, cone winding machines invariably gave more yarn breakages than spool winding machines, but the fall in production was avoided by reducing the number of spindles attended by a winder. In recent years, high speed warping machines have been introduced to increase production; factory surveys have shown that for maximum output all yarns should be wound at a uniform low tension.

Warp yarns have to be given a coating of size before weaving, and size materials need to be tested for certain physical properties which are relevant to their performance in the loom. For this purpose it has been found very advantageous to make a size film in sheet form, and a satisfactory method has now been devised for doing this.

Work on weaving mechanism has been concentrated on the loom picking motion which drives the shuttle containing the weft across the warp. Interesting results are being obtained from a special investigation of the effect of the torsional stiffness of the picking shaft. A new form of the cam used as a picking shoe which has been designed from first principles, has now had an extensive factory trial; this shoe gives a much improved pick and also results in reduced wear on the mechanism and the shuttle.

BLEACHING, DYEING, AND FINISHING

The work on the bleaching of linen yarn in package form has been developed to the practical stage, and the results are now being applied successfully in members' works.

Investigation of the crease-resistant process for linen dress goods has been continued, and further improvements have been made, leading to still higher quality fabrics.

A number of linen fabrics are normally subjected to hard wearing conditions in service, and it has been found possible by suitable treatments to improve the wearing qualities of these fabrics.

Experiments are continuing with the object of finding simple methods of flame-proofing and water-proofing heavy linen fabrics.

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.

LINOLEUM AND FELT BASE RESEARCH COUNCIL

The Linoleum and Felt Base Research Council was set up in 1949 as a result of, and in line with, the recommendations contained in the Working Party Report on the Linoleum and Felt Base Floor-covering Industry. Grant was offered for the period 1st April, 1949, to 31st March, 1954.

After three years' work the industry decided to discontinue its support for co-operative research on the above basis. In consequence the Council was formally wound up on 23rd April, 1953. No grant has been paid for the last financial year as there was no industrial income. Resources were however available to allow the extra-mural researches to be rounded off. After winding up the balance of funds representing unspent grant was repaid to the Department.

In the work at the Paint Research Station the fractions produced by solvent partition of samples of linseed oil gels formed both by the low temperature "scrim" method and by the higher temperature "smacker" method have been examined.

The fractions studied by a number of novel analytical techniques were:—

(*a*) an insoluble polymer fraction;

(*b*) an ether-soluble polymer fraction;

(*c*) a non-polymer fraction.

The polymeric acid distribution in the alcoholysis products varied markedly from sample to sample and since this in part measures the degree of cross-linking, this property will have an important bearing on the physical properties of the oil gel and of products derived from it, by ester interchange reactions for example.

There were also important differences in the proportion of oxygen bonded polymers between two scrim oils and between the scrim and smacked oils. Two of the scrim oils gave ether-soluble fractions of widely different molecular weight, which will undoubtedly affect their reactivity. The ether-soluble fractions of the smacked oils were more difficult to handle due to their high reactivity but their examination has established the important point that as the ether-soluble fraction is converted to ether-insoluble material on ageing, the characteristics of both fractions show little change except that the proportion of trimeric acid radicals increases. In other words, this conversion involves strictly a polymer growth and polymer cross-linking reaction.

Dr. Dean of the Wigan Mining and Technical College has studied the preparation of the constituent glycerides of linseed oil in the purest form possible. The chromatographic method of separation is most promising and it has been demonstrated that adsorbents may be used in conjunction to separate first of all the oil pigments and then the glycerides.

THE PARSONS AND MARINE ENGINEERING TURBINE RESEARCH AND DEVELOPMENT ASSOCIATION

The Parsons and Marine Engineering Turbine Research and Development Association, or Pametrada, as it is now widely known, is controlled by a Council consisting of the senior directors of its 19 members, under the present chairmanship of Sir Philip B. Johnson, with Committees on such matters as administration and finance, patents and staff pensions. The Council also elects and controls an advisory Research Board, comprised of representative technical executives from the industry, shipping lines and H.M. Government, which has Sub-Committees dealing with Steam Turbines, Gas Turbines, Transmission, Materials and Naval Designs. The importance of these Sub-Committees, composed of senior technical members of the industry, outside experts and Pametrada staff, is that they enable close contact to be maintained with industry, ideas to be marshalled, and happy co-operation to be achieved between the interested parties.

Pametrada Research Station is situated at Wallsend on the River Tyne, where ample transport facilities and cooling water are available. It is organized under the Research Director into two main departments, Design and Research. The duty of the Design Department is to prepare specific design particulars and, when required, basic plans from which members and licensees can build steam turbine machinery and reduction gearing, and

with the co-operation of the industry, ensure steady progress in the design of marine turbine machinery from the aspects of reliability, efficiency and economy in manufacture, incorporating directly the results of research.

One of the duties of the Research Department is to provide data for the Design Department, and it therefore concerns itself with research and development work on steam turbine components, gearing and gas turbines. In this connection it is to be noted that improvements in gas turbine design often help steam turbines, and vice versa. Facilities are available for all such types of research, as well as for carrying out full-scale researches on complete prototype sets of machinery.

The activities of these two departments are supported by Drawing Offices and Experimental Workshops which are being extended. The present facilities include Design and Drawing Offices, Administration Offices, Chemical, Metallurgical, Electronics, Applied Physics and Acoustic Laboratories, and specialist equipment for wind tunnel work, turbine and compressor rigs and combustion research. In the main Test House prototype sets of machinery can be run under controlled conditions on shore. Two units can be handled at a time and shaft horsepowers up to 60,000 at 160 r.p.m. are catered for. The large Aerodynamics, Heat Transfer, and Combustion Building, in which 4,000 horsepower of blower capacity has been installed, is now in full commission. Further extensions to the laboratory and workshop facilities are under construction.

Investigations are frequently made in ships at sea, particularly in connection with noise and vibration. A team is always available to give expert assistance in case of trouble at sea and the Association is represented on all important trial trips where machinery of co-operative design is installed.

DESIGN DEPARTMENT

The Design Department now includes five sections dealing with steam turbine design, gas turbine design, gearing development, engine room layouts, feed systems, auxiliaries and boilers. Very close working collaboration is maintained with members engaged on important shipbuilding contracts. A total of 60 design enquiries have been dealt with during the last twelve months. Most of these were of a preliminary nature for tendering purposes, but a considerable number were fully detailed for machinery to be installed in vessels actually on order by members and licensees. The policy has been steadily to develop impulse type turbine machinery in place of the reaction type, as the arduous conditions of marine service make this the most robust design and the least sensitive to thermal effects when manoeuvring, besides being less affected by clearance losses. The latest type of design on order for oil tanker machinery operates at steam conditions of 600 Lb./sq. in. and 950°F. It comprises a double casing H.P. turbine, overhung H.P. astern turbine, and a double casing L.P. turbine, including an L.P. astern turbine running in a separate inner casing. The shaft is driven through double reduction articulated gearing.

Work on the development of turbine components has continued, the major items being the development of blade roots suitable for applying segmental blading to gashed rotors, improved methods of diaphragm construction, the development of shorter journal bearings with lower losses and improved load-carrying capacity, and improved designs of flanges for turbine cylinders.

The Admiralty-Pametrada Gear Grinding Machine, referred to last year, has not yet reached the production stage, but the contractors, in conjunction with the Association, are proceeding with the final drawings.

Since the Association was set up a total of 93 patents has been filed in the United Kingdom, and of these 43 have now been granted. In a number of cases corresponding patents have also been granted in the U.S.A., Switzerland, Italy, Holland and Sweden.

RESEARCH DEPARTMENT

The Research Department comprises eleven sections, dealing with full-scale research on steam turbines and on gas turbines, component research, combustion and chemical research, metallurgical research, aerodynamics and heat transfer, gearing and bearing research, applied physics, including vibration and metrology, electronics, in connection with the development of special instruments, an instrumentation section and a noise investigation section.

Marine Gas Turbine

Work on the 3,500 H.P. marine gas turbine has been concentrated in the direction of burning residual fuels, and quite considerable success has been achieved. The gear-case and reversing gear which were not used in the early stages have now been installed and the satisfactory performance of the fluid reversing mechanism demonstrated.

This machinery has proved to be one of the Association's most important research tools and has enabled valuable developments and improvements to be made in the design of gas turbines. As a result of this work the Association is now in a position to design a very good marine gas turbine for any requirements likely to arise.

During the year work has continued on the liquid cooled gas turbine which is being sponsored partly by the Admiralty and partly by industry. A single stage experimental version is now in an advanced stage of construction. A liquid cooled turbine, when developed, will be able to sustain very high operating temperatures of the order of 2,200°F., and is expected to yield a higher thermal efficiency than the diesel engine. This is probably the most important long-term research on which the Association is engaged. A reinforced concrete test cell has been constructed for the preliminary running trials.

Running Trials of Admiralty Machinery

Full-scale trials, both functional and performance, have continued, with periodic intervals for development modifications, during the year on a highly rated set of prototype machinery for an anti-submarine frigate. Apart from the trials on the turbines proper, experimental comparisons have been made between several different gear-cases, and many experiments have been carried out in order to obtain the optimum performance from the auxiliary systems and machines. The complete machinery layout is installed, with all auxiliaries, and comprehensive performance data on the main boiler have been obtained. It is expected that trials on this machinery will be completed before the end of the year, when a further Admiralty prototype set of machinery will be installed.

An experimental high pressure high temperature steam turbine designed by the Association has been running during the year. This turbine operates at steam conditions of 1,100 Lb./sq. in. and 1,150°F. Particular attention is being paid to the performance of the special high temperature materials used and the effect of rapid manoeuvring on the thermal stressing and distortion of the austenitic steel casing. To date its performance has been very satisfactory.

Other Researches

Other items of experimental research carried on during the year have been full-scale research on gearing, the measurement of non-condensible gases in

steam, turbine blade vibration, development of and research on an experimental condenser, performance trials on various types of auxiliary machinery for Naval purposes, wind tunnel work on the aerodynamic performance of blading and other elements, the development of control gear for gas turbines, the development of gas turbine combustion chambers, and a very large amount of research on ash fouling and corrosion in connection with the burning of residual fuels in gas turbines. Various fundamental researches have been carried out on gearing elements and in connection with the development of instruments necessary in the case of research.

CONFERENCE ON STEAM TURBINE RESEARCH AND DEVELOPMENT

The Institution of Mechanical Engineers held a successful conference in London on 6th March, 1953, on steam turbine research and development, in which the Association actively participated. Seven papers on the following subjects were presented by the Research Director and members of his staff.

Facilities for Full-Scale Testing of Marine Turbine Machinery, by T. W. F. Brown, D.Sc., S.M.

The Development of a Marine Steam-turbine Design, by H. G. Yates, M.A.

The Measurement of Specific Steam Consumption, by Michael H. Petty, B.A.

Back-to-back Testing of Marine Reduction Gears, by A. Cameron, Ph.D., and A. D. Newman, B.Sc.

Some Reflections on the Thermal Distortion of Turbine Casings, by Basil J. Terrell, M.B.E., B.Sc.(Eng.).

The Determination of Natural Resonances in Mechanical Systems, by Dr. O. P. T. Kantorowicz.

The Application of Research to Marine Turbine Development, by T. W. F. Brown, D.Sc., S.M.

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 £242,045.

THE MOTOR INDUSTRY RESEARCH ASSOCIATION

Considerable dislocation of the Association's research programme has occurred during the past year as a result of the move to the new laboratories at Lindley, near Nuneaton. This move commenced in December, 1952, when most of the laboratories and offices at Brentford, with the exception of the chemical laboratory and information section and library, were moved into a section of the partially completed buildings at Lindley.

The efforts of the staff during the early part of 1953 were mostly concentrated on the installation of machines and research equipment and the provision of services and stores in the new buildings, so that only a very limited amount of research has been possible during this period.

In May, 1953, the remaining departments at Brentford moved to Lindley, which caused a certain amount of dislocation of the information service, as it had to be housed in temporary quarters.

It is hoped that all sections of the new buildings will have been completed and handed over to the Association by the time this Report appears in print, and when this finally occurs rapid expansion in the Association's research work is envisaged. This expansion will, however, be governed to some extent by the recruitment of suitable staff to fill many vacancies caused by the removal to the Midlands.

PROVING GROUND

The major development during the past year at the Proving Ground has been the construction of a high speed circuit nearly three miles in length around the perimeter of the Proving Ground. This circuit has been designed for "safe" speeds of 100 miles per hour, the bankings on the curves being such that at this speed only 1/6th of the centrifugal force has to be counteracted by the friction between tyre and road. The circuit is nearing completion, and should prove of immense value not only to the Association but to manufacturers wishing to investigate the performance and reliability of their vehicles and components when driven at sustained high speeds. Formal opening of the new track will probably take place early in 1954. The other features of the Proving Ground continue to be used increasingly by members, and during the year ended 31st July, 1953, nearly 19,000 hours of vehicle testing on the Ground were recorded.

PROGRESS OF RESEARCH

In spite of the dislocation of the research programme caused by moving the laboratories, progress has been made in a number of items, including the following:—

Measurement of Noise in Vehicles

As indicated in the previous Report the Association has investigated the reduction in noise level in several vehicles produced by introducing rubber body mountings, and rubber bushes in independent front wishbone linkages and rubber cones isolating the coil springs. The presence of rubber body mounts—in place of metal mounts—gave reductions in subjective noise level of 10 to 20 per cent. The replacement of the metal bushes in the wishbone linkage and isolation by rubber cones of the coil spring in the independent front suspensions gave a reduction in noise level of up to 10 per cent. Modification of the suspension and body mounting in the above manner may together, therefore, be expected to give reductions in subjective noise level of 20 to 30 per cent., and possibly more.

The design and construction of a magnetic-tape noise recorder, which is an improvement on the previous instrument and adequate for the Association's requirements, has proceeded throughout the year. This instrument is now almost completed.

Effect of Piston Assembly on Oil Consumption

The very serious lack of reproducibility of results experienced during this investigation has been indicated in previous Reports. It has, therefore, only been possible to arrive at general conclusions.

The work was, in the main, carried out on a single cylinder research engine and oil consumption was found to be insensitive to changes in gap size or side clearance. Any factor, such as geometry of the ring or "dish" of the groove, which affects the attitude of the compression ring face to the cylinder wall, has a large influence on oil consumption, and indicates the importance of the path between the ring face and the cylinder wall in relation to the passage of oil up the piston. Compression rings that bear on the

lower of the face tend to scrape oil downwards and so keep oil consumption low whilst those that bear on the upper edge tend to scrape oil upwards and so greatly increase consumption. Nominally square-faced rings can be quite variable in this respect. Rings produced to have a tapered face and fitted to bear on the lower edge, result in consistently low consumptions. So strong is the control exercised by a taper-faced compression ring that it is possible to run satisfactorily with one such ring fitted alone on the piston, and, when given the aid of oil drain holes, the consumption is the same as when a scraper ring is also fitted. There is a danger of losing the effectiveness of a taper-faced compression ring when it is used in conjunction with square-faced rings.

The main conclusions drawn from the work on the single-cylinder research engine were confirmed with endurance running on two conventional multi-cylinder, motor-car engines at road load and a speed equivalent to 35 m.p.h. In addition this work showed that the advantage in oil control of the taper-faced ring over the square-faced ring was maintained even after deterioration had set in.

Fatigue Strength of Crankshafts

The specimens used for this work were made in an inoculated flake graphite iron and both reversed bending and one-way bending tests were employed, since crankshafts in service may be subjected to a loading intermediate between these conditions.

Preliminary tests on cast bars showed that under reversed loading, shot-peening increased the strength by 15–30 per cent. Under one-way loading, the improvement was 35 per cent., and if the shot-peening was followed by polishing, as would be necessary with production crankshafts, to produce a suitable bearing surface, an improvement of as much as 45–50 per cent. was obtained. Crankshaft specimens, shot-peened and polished, gave an improvement of about 50 per cent. under one-way loading.

Cold rolling the fillets of crankshafts, using steel balls under heavy load, gave even better results, the improvement under reversed stress being about 60 per cent., and the improvement under one-way loading being as much as about 80 per cent. Fillets produced in this way are clearly superior to fillets finished by conventional methods, since, apart from the beneficial cold working effect, they are smooth, truly circular, and of closely controlled radius.

Operating Loads in Crankshafts

The bending stresses in the crankshaft of a typical 2 litre 4 cylinder automobile engine have been measured using wire resistance strain gauges attached to the webs.

The measurements showed that up to at least 4,000 r.p.m. the highest loads occurred at maximum torque rather than maximum speed, and that the most severely loaded web in relation to its strength was that at the front of engine. With normal full throttle running and with a forged steel shaft the bending load range per engine cycle at this web was 3,600 Lb/in at about 40·5 IHP and 2,050 r.p.m. This represents about 31 per cent. of the estimated fatigue strength.

Comparison of loads on a forged and cast shaft of similar design showed that the loads were similar except at the front web where the loads on the cast shaft were lower by about 10 per cent.; the maximum loads on the cast shaft were about 57 per cent. of the estimated fatigue strength of the shaft in the original machined condition and about 35 per cent. of the

strength with the fillets cold rolled. It appears likely however that at high speeds slightly more serious loads occur, since although the loads are smaller in magnitude the strength of the machined shaft drops off rapidly as the loading becomes one-way bending.

Increase of the front bearing clearance from 0·002 to 0·006 in. gave load increases of 10 to 15 per cent. on both shafts, while a decrease to 0·001 in. gave a load decrease of about 25 per cent. on the cast shaft. Measurements of the loads at different webs showed that the crankshaft behaviour approximates to that of a beam on three supports but that the combination of encastré effects at the bearings and uncertainty of the position of the centre of pressure of the bearing precludes any easy calculation of the crankshaft bending moments from the applied loads.

It might be expected that the results obtained would be typical of medium sized engines but the relative increase in importance of the inertia loads at high speeds suggests that with the smaller usually higher speed engines the high speed loads will be more important.

Bending Fatigue Strength of Gear Teeth

The investigation was concerned primarily with the bending fatigue strength of the teeth of gears made from a wide variety of carburizing steels of different characteristics, ranging from high alloy and "economy" British steels to some typical American steels. Tests were also carried out in which the teeth were subjected to repeated impact and slow bend single application loads, with a view to determining the resistance of the gears to occasional high loads. With a number of the steels, various heat treatments were examined.

An observation of great interest from this work is the small variation of the tooth fatigue strengths, although the gears were made in steels ranging from negligible alloy content up to 4½ per cent. nickel-chromium. Most of the specimens gave bending fatigue limits falling within a range of about 25 per cent. of the average strength. Gears in a non-alloy steel, in its best condition, gave results which were equal to those of gears made from a number of the alloy steels, and were only about 15 per cent. weaker than some of the high alloy gears. Strength differences between the various steels appeared to be of no greater significance than possible strength variations resulting from different heat treatments on a particular steel. Tempering was shown to be harmful, since in tests on five steels, four showed reductions of strength of 5–20 per cent. as a result of this treatment.

In the repeated impact and slow bend tests, the high alloy gears were clearly superior to gears made from the other steels, although it is not certain that this superiority is due directly to high alloy content. The fact that the high slow bend strengths were associated with the high repeated impact strengths suggested that either of these methods would be suitable for determining the resistance of the gears to occasional high loads.

The appearance of the fractured teeth from the different types of test has been of considerable interest, and suggest that it might be difficult, with gears made from many carburizing materials, to distinguish between service failures resulting from occasional high loads and those resulting from the fatigue conditions. However, with a few of the materials examined—those showing best results in the static and impact tests—such distinction would be possible, since the high load failures often exhibited a clearly defined region of shear-type failure, which was not seen in the usual fatigue failures.

Bending Fatigue Strength of Carburized Gears; A Comparison of Some Production Methods

The following methods of gear manufacture have been compared: (*a*) Hobbed; (*b*) Protuberance hobbed and shaved; (*c*) Shaped; (*d*) Form wheel ground, including tooth roots; (*e*) Maag ground; (*f*) Roots preformed, and teeth ground on the flanks; (*g*) Shot-peened. Also, with one of the hobbed gears, and one of the gears ground in the roots, the effect of a phosphate treatment was investigated. The tooth roots in the various gears were not all of the same form, although this was approximately so with a number of the processes. Rather was it intended that each of the processes should be representative of good commercial practice.

Gears which were ground in the roots were markedly weaker than unground gears, three form wheel ground gears having strengths of 72, 66 and 48 per cent., respectively, of the strength of unground gears of similar form, and three Maag ground gears having an average strength of 66 per cent. of that of unground gears. The gears with preformed roots, ground only on the tooth flanks, were not greatly affected by the grinding operation. Shot-peening was beneficial, giving an improvement approaching 20 per cent., and it would appear that by using preformed roots and shot-peening together, it would be readily possible to produce ground gears which are on average about twice as strong as gears ground in the roots.

Hobbed gears gave similar strengths to those of shaped gears of similar form. The shaved gears were somewhat weaker than the hobbed and the shaped gears, but their fillet form and size were clearly less favourable than those of the latter gears. The phosphate treatment did not reduce the strength of the hobbed gear and in fact produced an improvement of strength in the gear which had been ground in the roots.

These differences in strength arising from different production methods are generally greater than differences shown previously to exist between gears made from a wide range of carburizing steels.

INFORMATION SECTION

During the year the Information Section concentrated on maintaining the existing services to members which, it was anticipated, would be difficult owing to the move to Lindley.

The full abstracting services were maintained, 480 loose-leaf abstracts and a regular monthly List of additions to the library being issued to members. The library dealt with some 6,000 requests for loans resulting from the issue of abstracts or from enquiries generally, this service being interrupted for about a fortnight during the move from Brentford to Lindley.

The technical and bibliographical enquiry service was also maintained, some 120 enquiries of this description being handled. An attempt was made, where it seemed appropriate, to draw on the experiences of other members in answering some of these enquiries; and a good response was obtained when this was done.

Eight translations were completed in this period, five from German sources and three from French.

Additions to the library catalogue numbered 920 items. These cover material which has been classified from periodical sources, pamphlets and text-books, and is available for answering enquiries.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st July, 1950, to 30th June, 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 July, 1953, to 30th June, 1955, the block grant is £30,000 per annum, provided £60,000 is received from industry, and the additional grant £100 for each additional £100 contributed by industry up to a maximum of £30,000.

The income of the Association for the last completed year was £98,625.

BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION

The researches described below have been selected as illustrating industry's varying requirements. A number of them have arisen from some problem common to a number of companies which the Association has been asked to solve for the general good. In some cases a remedy has been provided and the research results are already being applied in industry with immediate benefit to production, either by improving quality or reducing waste. Other examples are moving towards this goal. One of the researches (on titanium) is of the long-range type, to provide information and experience on a material which is of great future promise. Yet another (on analysis) has the purpose of facilitating industrial testing methods: to the lay eye these methods may seem humdrum, but in fact they are one of the keystones of modern scientific industry.

SAVING METAL AND LABOUR IN THE FOUNDRY

When molten metal is poured into a mould, solidification generally starts adjacent to the mould face and progresses inwards towards the centre of the casting. Unfortunately, in most cases, the solid metal occupies less volume than the same weight of liquid metal by several per cent., with the result that when all the metal has solidified there is still a void left in the centre of the casting. The usual way of overcoming this and making the casting sound right through is to provide "feeders" or "risers" which are of such size that they remain liquid until the bulk of the casting has solidified, so that the freezing shrinkage of the metal in the casting may be made good by the supply of more metal from the feeders. Often these feeders may weigh as much as the casting itself and the cost of melting and handling this excess metal, and eventually cutting it away from the finished casting, is substantial and furthermore these unproductive operations waste manpower and fuel.

Substantial economies would therefore accrue if the efficiency of the feeders could be improved, so that smaller feeders could be used with a given casting. One way of improving the efficiency of feeders is to delay their solidification by surrounding them with sleeves of insulating or exothermic material, and the Association has made an experimental study of the advantages to be gained by using these techniques. It has been found that whenever large feeders are normally necessary, large reductions in size can be made by the use of these sleeves, the weight of the feeders being then a much smaller proportion of the weight of the casting. These methods have been successful both in the laboratory and on the works scale. A particularly cheap and useful form of insulating sleeve is one made from porous plaster, and two firms of foundry suppliers have undertaken the provision of sleeves in this material. This use of insulated feeders was described in a paper discussed at the Brassfoundry Productivity Conference held at Harrogate in June, 1952.

PREVENTION OF CRACKING OF HOT BRASS STAMPINGS

A wide range of products, including some plumbing fittings, are made from leaded 60/40 brass by the process of hot stamping, i.e., forging in dies in the hot state. The material withstands a remarkable amount of deformation, but occasionally it has been known to crack during the stamping operation, and at the request of the trade the Association's investigators have been seeking the cause. The cracking frequently coincides with the occurrence of large grains in the brass, and after a study of factors controlling grain growth it has been possible to define conditions of composition, extrusion temperature and reheating temperature in which large grains will not grow. By applying these conditions, cracking of the stampings can largely be obviated, although there are a few cases arising from other causes which are still under examination.

IMPROVED ELECTRODEPOSITED COATINGS ON ALUMINIUM

Electrodeposited coatings are applied to aluminium articles on a considerable scale for decorative and other purposes, but the plating techniques still present certain problems, which the Association has been studying. Already certain difficulties in the production of an adherent zinc undercoat by immersion in sodium zincate (a standard process) have been cleared up, and latterly attention has been concentrated on the examination of an industrial process of plating in which the zinc undercoat is applied electrolytically. This has certain advantages. In the first place, the danger of corrosion after application of the plated coating is said to be less than in the zincate method : and second, bimetallic assemblies are readily plated, a matter of great practical importance. However, the conventional electrolytic process is complicated, involving some thirteen stages, and it has certain drawbacks. The major aim of the Association's investigation has therefore been to improve and simplify it. The last step in the process has hitherto been stoving the work at 22°C. for 20 minutes, and by a variation of one of the earlier steps it has been found possible in the laboratory to dispense completely with this operation. Apart from the economy which would be achieved by the industrial application of this work, this innovation opens the possibility of plating on heat-treatable aluminium alloys, whose properties might be impaired by the conventional stoving operation. The results of this investigation, on which work is continuing, have been published and discussed before the Institute of Metal Finishing.

TITANIUM AND ITS ALLOYS

Under the general sponsorship of the Ministry of Supply, research on the properties of titanium has been in progress in several British laboratories, including those of the Association, whose part has been to make a rapid survey of the mechanical properties of a number of alloys, to be followed by a more detailed study of promising alloy types. The fabrication of titanium requires more complicated methods than those used for the base metals (thus melting must be carried out *in vacuo* or under argon) and the experience acquired by the Association in melting and in alloy production should be of value to the industry when the metal achieves wide use, as it inevitably will. The working (e.g., forging and rolling) behaviour of a number of alloys, and their mechanical properties at normal and elevated temperatures, have been investigated. Preliminary experiments on the resistance towards sea-water corrosion of the metal and its alloys indicate outstanding performance.

MECHANIZED ANALYTICAL CONTROL OF PRODUCTION

About two years ago the Association obtained through E.C.A. funds a Quantometer, an American direct reading spectograph, which enables metals

and alloys to be analysed much more speedily. Thus by the use of a Quantometer in an aluminium works, a quantitative determination of 10 to 13 elements in an aluminium alloy can be provided in 2 to 3 minutes of receipt of the sample, thus greatly facilitating production: furnace time is minimized, and rejects are reduced by closer limits and more frequent checks. The Association's instrument has been specially designed for the analysis of copper and copper-base alloys, and its suitability for application in the copper industry is being assessed. Experience with the Quantometer indicates that apart from the speed of operation which it provides, it shows promise of pushing spectrographic analysis into regions not hitherto amenable to it. It is already clear that the accurate quantitative analysis of trace impurities in copper can readily be done for a large number of impurities by use of the Quantometer. By contrast, in certain classes of alloys at any rate, it has been possible to determine up to 40 per cent of an element with an accuracy hitherto impossible by conventional methods.

LIAISON AND INFORMATION SERVICES

These services, separate though operating in close co-operation, have the function of assisting members to apply scientific knowledge arising from the Association's researches, from the literature, or elsewhere, to the improvement of industrial practice. In general, the Liaison Department deals with problems requiring practical "know-how", whereas the Information Department provides data from recorded knowledge. The services of both are in heavy demand. In 1952, the liaison staff made 256 visits to members: 79 in the London area, 87 in the Birmingham and Wolverhampton district, 21 in Scotland and 69 to firms situated in the rest of the country. During the same period 1,200 visitors mainly from member companies were received in the laboratories, apart from hundreds who attended during the Open days. Nearly 1,000 major technical enquiries (i.e., for advice on questions arising from production or development problems) were received in the Liaison Department. The *B.N.F. Review*, published monthly by the joint efforts of Liaison and Information, contains statements on current research results designed to enable members to keep in touch with the Association's work: it is confidential to the membership. The *B.N.F.M.R.A. Bulletin* (covering the world's published metallurgical literature) contained 2,883 notes in 1952, the notes being carefully selected in order to keep the *Bulletin* down to reasonable size. The numbers of loans sent by post by the Library is approaching 10,000 annually (and incidentally in 1952 the Library lent literature to 13 other Research Associations and borrowed from 11).

REPORTS AND PUBLICATIONS

In 1952, the Association issued 60 reports on its researches to members, the total number of copies of reports issued being 7,694. The scientific staff wrote 24 papers for publication in various journals. The Association has published two pamphlets (obtainable on request) describing its activities: *B.N.F. Service to Industry*, and *Technical Problems*. Full details of the current research programme and the stages reached in the various investigations are set out briefly in the Association's Annual Report, which is freely available.

MEMBERSHIP

In the twelve months from September, 1952, to August, 1953, the membership increased by 33 companies to 599, the highest ever.

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 is made provided £52,000 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 January, 1954, to 31st December, 1956, the block grant will be £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 £128,436.

THE RESEARCH ASSOCIATION OF BRITISH PAINT, COLOUR AND VARNISH MANUFACTURERS

The fundamental work in progress is concerned mainly with the chemical and physical changes occurring during the preparation or processing of various raw materials and the manufacture of varnishes and paints, or during their subsequent application, drying and ageing.

DRYING OILS, RESINS, VARNISHES, ETC.

For some time now the aim has been to identify the reactions occurring in the various types of drying oils during heat-bodying, oxidation and film formation, or during gel formation as in linoleum manufacture. The influences of various pigments (as in paints) on these reactions is now being examined, and the sequence of reactions is being followed into the later stages of film oxidation leading to ultimate breakdown.

Information about the chemistry of the heat-bodying of oils, as in the production of stand oils, has been obtained by studying the mechanism of the thermal polymerization of the esters of unsaturated fatty acids. Recently, methyl linoleate has been examined in this way, the mechanism of catalysis of its polymerization by anthraquinone has been established, and the activation energies involved determined. The possibility of finding superior catalysts for use in the industrial production of stand oils is receiving attention.

The technical quality of the oil resulting from the extraction of about 17 tons of conophor nuts (reported last year) is now being examined both at the Research Station and by the co-operating paint and varnish manufacturers. The results so far obtained indicate that the oil bodies more quickly than linseed oil and that paints made from it dry rather more rapidly than corresponding linseed oil products ; weathering tests are being continued.

The technical evaluation of other drying oils (including tung oil from *Aleurites montana* grown in Nyasaland, " isomerized " linseed oil and various treated fish oils) has been continued.

The work on the relationship between chemical structure and performance of films prepared from drying oils or natural resin varnishes has been extended to include alkyd-type media. As part of this research, a range of alkyd media of different characteristics (e.g. different acid values, hydroxyl values and degrees of polymerization) has been made from the same raw materials and the clear and pigmented films are being examined for durability and water absorption.

Infra-red and ultra-violet spectroscopy have continued to give valuable data for the oils and resins programme. Specific methods have been developed for the analysis of co-polymerized, autoxidized and thermally polymerized fatty esters and related compounds, and the spectra of various natural and synthetic resins have been recorded for reference purposes.

The chemical changes occurring during the drying of oil and varnish films have been observed spectroscopically, measurements being made directly on individual films at intervals during the drying process.

Drying oil film studies have also included the determination of the amount of material extractable with various solvents after various periods of drying and ageing, and examination of the volatile products of the drying (oxidation and polymerization) reactions. Oil films have also been examined by fractionation and chemical analysis methods similar to those which have proved valuable in the linoleum research programme where the main concern is with oil gels in mass. The production of these gels is a primary stage in the manufacture of linoleum, preceding combination with resins in the formation of linoleum cements—a subject which has also received some attention.

Measurements have been made of the rate of oxygen uptake during the drying of oils, etc., this work having been facilitated by the construction of an automatic recording apparatus. Particular attention is being paid to the examination of paints after various periods of storage, by which information may be obtained about the effects of pigments on the drying reaction. Another part of this programme concerns the adsorption of metallic driers by pigments, though this is not wholly the cause of loss of drying power: the adsorption of other components of the medium may also be involved.

Relatively recently, various vinyl-type monomers, as used in the production of synthetic resins, have become of considerable importance to the paint industry. For example, styrene has been incorporated in, and co-polymerized with, certain drying oils and used as a modifying agent in alkyd-type media. A detailed study of styrene solidus drying oil reactions and of combinations of drying oils with other vinyl monomers including the acrylates has been made.

Aqueous suspensions of synthetic resins, e.g. polyvinyl acetate, now form the basis of extensively used emulsion paints and various techniques, including electron microscopy, are being used to determine the structure of the films deposited from such emulsions, both pigmented and unpigmented.

Another range of newer materials based on vinyl-type synthetic resins are the so-called wash ("etch") primers which, in a very thin coat, form a strongly adherent bond with the metal to which they are applied and carry an anti-corrosive pigment. The nature of the reactions between these primers and the metal surface, in which their content of phosphoric acid is involved, has been examined by radioactive tracer methods and in this and a variety of other ways (including electron diffraction examination) the parts played by the various components are being examined.

PIGMENTS, PAINTS, ETC.

The influence of crystal structure and habit, particle size distribution, etc., of pigments on colour and general performance continues to receive attention, but pigments differ markedly in chemical type and there is little common ground for study as in the case of the drying oils which are all triglycerides and have a similar chemistry. Pigments, therefore, have to be dealt with one group at a time and the general structure/performance studies may conveniently be associated with work on specific technological properties or weaknesses. Thus studies of the tendency of certain chromate pigments to darken on exposure to light have been associated with work on the

influence of precipitation conditions during the preparation of such pigments, including the order of addition of the reactants, the influence of acidity or alkalinity, and the manner in which the water-wet products are aged before filtration and drying.

Radioactive tracers (^{51}Cr, ^{212}Pb) have been used in isotopic adsorption and interchange work in lead chromate suspensions in order to obtain information about the character of the pigment surface and whether it may be lead or chromate rich.

Electron microscopy, X-ray crystallography and spectrography are all providing useful information in this group of investigations. Thus they have given some understanding of the role of lead sulphate when introduced into lead chromate to provide a pigment of a lemon colour instead of golden yellow.

In a previous report, reference was made to an apparatus devised for the examination of certain organic pigments in which rosin derivatives are included to enhance the colour. Such pigments sometimes show a tendency to heat up unduly during the drying of the wet cake during production and the new method of examination helps to detect that tendency. This has led to a wider examination of rosins now available from many parts of the world for their content of various acids, which may also be important in the utilization of rosin derivatives in varnishes and paint media.

The measurement of colour and the recording of colour values are of importance in the maintenance of colour standards and colour matching problems generally, but also have great value in the more fundamental studies of the relationship between colour and the physical and chemical structure of the pigments which provide it. Colour measurements, with spectral distributions, etc., have been made on a variety of experimental materials during the year, including the various lead chromates listed above. There has been further utilization of calculation methods (based on relatively simple optical measurements on the individual pigments) for the prediction of the colour of paints made from various pigment mixtures.

The capabilitities of instruments for detecting differences between closely matching colours have been closely studied combined with a limited survey of the closeness of colour matching by a number of colour matchers in the industry.

Wetting and dispersion are essential parts of the paint making operation and the use of radioactive techniques in the study of pigment surfaces and the sedimentation of pigments in liquid suspensions, etc., is now beginning to be applied to the problems of incorporating pigments in media by the roller mill process of paint making. The first step has been to study how a fluid (in this case a radioactively-labelled oil) behaves when passing between the rolls of a two-roll mill running at different speeds.

PAINT FILMS—PERFORMANCE

The optical and mechanical properties of paint films and the influence of different pigments and media thereon, continues to receive attention both for direct technical reasons and to provide information about the internal structure of films. On the mechanical properties side, the method of measuring elasticity by passing sound waves through films has been added to the more orthodox stretching, bending and other methods based on the effects of mechanical distortion. On the optical side, further attention has been given to the measurement of gloss, various types of semi-gloss or near matteness, and the electron miscroscope has been used to determine the physical nature of the disturbances of film surfaces associated with loss of gloss by " hazing ", " veiling ", " blooming ", etc.

The reflectance properties of films throughout the spectrum (including the infra-red and ultra-violet ends) have been examined for a number of purposes. The ultra-violet reflectance of pigments and paints has a particularly interesting connection with paint breakdown and certain special applications such as the painting of arc welding booths. Other aspects of optical properties which have received attention include staining, spotting, general yellowing and other discolourations of paint films due to various causes including industrial atmospheric impurities.

Changes occurring in paint films during ageing and weathering are being followed by surface replica techniques using the electron microscope, by the measurement of water sensitivity (absorption, permeability, etc.), dimensional changes, loss of weight, changes in mechanical properties, and by radioactive tracer methods.

The investigation of the effect of trace impurities in the water supply to the spray units in accelerated weathering equipment has been continued in collaboration with other interested organizations. Attention has been focussed mainly on the effect on paint performance of trace metals and of small variations in acidity or alkalinity.

ANALYSIS, ETC.

Many of the researches outlined above require at some stage reliable analytical data on the primary materials used and on fractions, derivatives, etc.; in addition the analytical department is concerned to develop methods for use in the industry. Recently there has been an extension of methods for the analysis of lead chromate and chrome pigments (including the molybdated scarlet chromes), methods have been further developed for the accurate determination of trace metals in the water used in accelerated weathering tests, and a new simplified scheme for the analysis of white pigments has been extended to include yellows and some blues. General developments have included a more extensive application of ion-exchange resins in pigment analysis, the direct determination of oxygen in organic compounds, and improvements in the methods for the rapid wet destruction of organic matter, e.g. as a preliminary in the determination of drier metals in varnishes and paint media.

In much of the work on polymerization and oxidation, analytical data on carbon, hydrogen and oxygen contents, acid values, hydroxyl values, iodine values, etc., need to be supplemented by determinations of chemical groupings by infra-red and ultra-violet spectroscopy and by molecular weight determinations. To the facilities for measuring the weight-average molecular weight by light scattering, previously reported, an improved ebulliometer has been now added giving number-average molecular weights up to about 30,000.

LIAISON, PUBLICATIONS, ETC.

During the year, contacts with the industry have been maintained through liaison visiting by the staff and numerous visits of members to the Research Station. Some 600 technical enquiries have been dealt with and there has been an extended use of the Library and Abstract Review services. The Director and members of the staff have served on numerous technical committees, given lectures in various parts of the country, and have participated in technical conferences at home and abroad.

The Association exhibited at the Chemical Society's Conversazione on March 26th, 1953 and, as in previous years, participated in the Technical Trades Exhibition organized by the London Section, Oil and Colour Chemists' Association (March, 1953).

Publications during the year have included 9 *Technical Papers*, 7 *Research Memoranda*, 1 *Bulletin* and 12 *Monthly Memoranda*, which have been issued to members. Two new series have been introduced; namely, summary reports of the items discussed by the research committees and *Technical Commentaries* on papers circulated to members. These *Technical Commentaries* are more than collections of summaries or abstracts for they give, where appropriate, indications of the practical significance of the work reported; they are prepared not by the staff, but by those members of the industry who serve as Chairmen of the Subject Panels.

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 £63,510.

THE BRITISH PAPER AND BOARD INDUSTRY RESEARCH ASSOCIATION

The paper and board making industry consists of some 200 mills in widely separated areas of England and Scotland, varying in size from large concerns producing newsprint, packaging board and similar materials in bulk to quite small yet important units producing specialist lines. The industry is noteworthy for the wide range of qualities produced.

This wide distribution of size and interest has largely governed the Association's functions as a central research organization for the industry. Its research activities cover a broad field of interest ranging from scientific research *per se* to matters of immediate concern to the production units.

FUNDAMENTAL RESEARCH

The application of mechanical power to a dilute suspension of fibres in water causes changes in the physical and chemical characteristics of the fibre which enable sheets to be formed on paper and board machines: the Association devotes a proportion of its effort towards elucidating the fundamental scientific facts underlying such changes.

Several new techniques have been developed in the study of fibre structure by the use of optical and electron microscopy, and preliminary studies have been made into the value of reflection electron microscopy, a technique recently developed for the study of metal surfaces. It has already been possible to examine visually changes previously unobserved, and from these photographs it can be deduced that the primary, secondary and tertiary walls of the fibre behave in very markedly different ways when beaten. This is pioneer work which has attracted the attention of other workers at home and abroad interested in the structure and behaviour of natural fibres used in industrial production.

Similar advances have resulted from studies of the chemical nature of the sugars and hemicelluloses making up the fibre. Chromatographic techniques have been modified and applied to these relatively unexplored fields. The detailed results will be published in due course in a scientific journal.

MOULD PROOFING

The development of mould growth in cardboard soap cartons frequently leads to economic loss. A system of mould proofing for soap cartons has been devised which appears to give sufficient protection to reduce such losses to a bare minimum. The process has been investigated on the production scale and shows considerable promise from both technical and economic standpoints.

In studying the mechanism of mould growth and propagation it has been found that certain moulds are parasitic to one another and the rate of growth in the presence of two such moulds is many times that of either separately. Other moulds previously thought to be non-cellulose degrading in character have proved to have the power to consume large quantities of cellulose in a relatively short period. The subjection of fungal growths to gradually increasing doses of mercury-containing fungicides has been observed to result in their developing immunity to doses previously found lethal and studies are in hand to overcome this.

Attention is also being directed to the possibilities of mould proofing materials used for food and other edible products.

EFFLUENT

The disposal of mill effluent has been under investigation for several years and the programme includes the following aspects of the problem.

Biological Oxygen Demand

It has been shown that percolating filters and the activated sludge process used in sewage works practice can be adapted to the treatment of certain paper mill effluents. The work has now reached the stage where pilot scale units have been installed at a paper mill, in order to assess the economic aspects of these processes. The area occupied by such non-productive processes needs to be kept to a minimum, and studies are in hand to determine the maximum throughput of a plant of given size and also to investigate the practical limits of purification, bearing in mind the economics of the matter.

Recovery of Solids

Allied to the work on biological oxygen demand is the question of reducing the amounts of solids in mill effluents. It has been shown that many proprietary forms of "saveall" can be applied to certain mill effluents and it is even possible in some cases to improve the overall fibre efficiency in the mill by the use of such devices. The Association is now in a position to advise mills on the best practice to adopt.

Pulp Washing

Some mills in the United Kingdom produce paper pulp from imported esparto grass, straw and other similar materials. The pulping process involves the use of chemicals, and mills have a recovery system, but the efficiency of washing of the digested pulp has a direct bearing on the recovery efficiency and consequently upon the amount of waste liquors for discharge from the mill. Following a long series of investigations at a paper mill to determine the factors governing washing efficiency, it has been found that by careful attention to digester filling, control of wash water volumes and modification of the system of draining wash liquors, decided improvements in strength of recovered wash liquors can be effected, resulting in improved liquor recovery and at the same time reducing the discharge volumes. Work has now commenced on systems of washing external to the digester for pulp products in order to compare the economics of the purchase of additional plant with the best practice using the digesters as washing vessels.

REMOVAL OF WATER FROM PULP SUSPENSIONS

Investigations have been carried out on a full scale newsprint machine to determine the factors affecting the efficiency of water removal from pulp suspensions on the paper machine moving wire. The results indicate that such factors as temperature, alum concentration and pH have very marked influences on the behaviour of stock on the wire. It has also been possible to study the effects of recirculation of backwater containing fines from the machine on machine operation. From a statistical study of the large amount of data collected, a formula has been deduced which, at least to a degree, permits prediction of the results to be expected when operating a fast running paper machine under a given set of conditions. This work will undoubtedly lead to developments in paper machine design and have a definite practical and economic value.

GENERAL

In addition to the investigations summarized above the Association has been able to assist members on day to day problems, such as elucidating the cause of unsatisfactory behaviour of paper and board when made up into packages or printed. The Association has also studied several members' individual effluent problems, and provided technical information and cost data on plant required to render mill effluent acceptable to river boards and other local authorities.

The Association has a Library and Information Service available to members and translations of articles in foreign languages can be provided on request. Also a summary of world literature on paper making and allied subjects is provided to all members. These library abstracts are purchased from the American Institute of Paper Chemistry and are considered to be the best publications in this field in the world.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st September, 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 grant of £12,000.

The income of the Association for the last completed year was £57,827.

THE PRINTING, PACKAGING AND ALLIED TRADES RESEARCH ASSOCIATION

One of the most pressing problems facing a Research Association is to spread technical information throughout the industries served. This question has received the most earnest consideration of the Printing, Packaging and Allied Trades Research Association: exhibitions and conferences held in Lancashire, Yorkshire, the Midlands, Wales and the West Country were attended by nearly 3,000 people, and over 1,000 have visited Patra's laboratories at Leatherhead.

This has had the two-fold result of getting industry acquainted with the Association's work and also encouraging new members. More exhibitions and conferences are planned during the coming year for London, Scotland and East Anglia, so that when the programme is completed practically every major printing centre in the country will have been covered.

It is also the aim of the Association to get research results applied in industry and during the year members of the staff made periodic visits to

firms to discuss new developments and technical queries. Linked with this problem is the question of encouraging members to make use of the services available, and in this direction considerable progress has been made. Over 2,000 technical enquiries are dealt with each year—and the figures are still growing; on the figures for the last six months almost 50 per cent. of the membership has made a service contact with the Association. The use made by members of the Library facilities has again shown a marked increase, the number of loans to members having increased by 1,153 to a total of 4,342 in the year, and the number of abstracts published month by month in *Printing Abstracts* and *Packaging Abstracts* having risen from 1,900 to 2,968.

Divided into two divisions—Printing and Packaging—the Association operates under three broad headings: Research, Enquiries and Information. The work of these divisions and some of the technical developments arising from it are described below.

PRINTING DIVISION

In the Printing Division investigations have been carried out on some 28 items covering the three major printing processes (letterpress, lithography and photogravure), process engraving, stereotyping, bookbinding, as well as on the printer's raw materials—ink, paper and board. New items have been added to the programme, including improvements in deep-etched lithographic plates, the emulsification of lithographic inks, speedier and more efficient methods of washing-up machines and improved methods of controlling the colour of the print as it is being produced.

Letterpress Printing

Work has centred during the year on the problems involved in minimizing make-ready (the adjustment of the pressure applied to various parts of the printing plate). In this connection studies have continued on the question of the make-ready techniques which are applied to metal or rigid plastic printing characters and to printing plates made of rubber and flexible plastics. To this end the officer in charge of letterpress research visited the United States to attend the Make-Ready Conference held in Chicago in December under the auspices of the Research and Engineering Council of the Graphic Arts Industry, Inc. A report on his visit was published early in 1953.

Lithography

The greater part of the present programme of research on lithography is devoted to obtaining trouble-free running of the lithographic machine with no undesirable side effects such as poor ink-drying. Improved deep-etch lacquers have been developed along with Patracol 90, a solvent which overcomes certain defects in plate-making. New plastic squeeze bottles for use with the Patra Wash-Up Solvents have also been developed, and many sets of these bottles have been sold to the trade through recognized supply houses. Arising from research work on desensitization, a useful and more accurate way of choosing likely metals for bi-metal lithographic plates has been obtained, and work is continuing on the development of a practical process from the laboratory product.

Photo-Mechanical Processes

New magenta contact screens for photo-engraving and photo-lithography have been obtained from the U.S.A. and an investigation has been made into the quality of tone reproduction obtainable with them. Attention is now being given to the possibility of producing a new type of contact screen capable of giving screen negatives of correct gradation. If it can be achieved, this will remove the biggest single cause of poor tone reproduction and incorrect colour rendering in lithography.

Bookbinding

Research has been carried on into the question of warping of bookcovers—a problem of especial importance in the export of books. Treatment of bookbinding boards by resin impregnation has given encouraging results and the commercial possibilities of this are being pursued.

Inks

Progress has been made on the question of ink-misting, mentioned briefly in the previous report. Apparatus has been designed for the production of ink-mist under controlled conditions, so that the possibilities of producing inks of improved performance can be investigated.

Control of Colour Intensity

One of the most important developments in this field has been the commencement of studies into the application of electronics to printing processes. The present line of investigation is to develop methods of scanning and controlling electronically the colour of the print as it is being produced. Linked with this work, a survey is being undertaken to ascertain what applications there are for electro-mechanical control in the printing industry.

PACKAGING DIVISION

Research is in hand on fifteen items concerned with the strength of packages and the protection they give to the contents against mechanical damage, moisture, odour, and mould and insect attack. Three new items have been added to the programme—a study of the cutting and creasing of carton board, adhesives and the effect of processing on the properties of transparent wrapping materials.

Strength of Containers

This research embraces such items as a study of the hazards to which containers are subjected in transit and storage (infrequent shocks, such as drops and shunting shocks, vibration and compression due to stacking); reproducing transport hazards under controlled conditions; and determining the basic principles in the design of efficient containers. The Patra Journey Shock Recorder, mentioned in the previous report, is used to assess the number and intensity of the shocks. Members have collaborated in sending these recorders on typical journeys. As an example an investigation was made to gain information on the number of drops experienced by packages on a journey between Manchester and London. The outward journey between London and Manchester was in full container loads while the return journey was by mixed goods. The results of the tests showed a marked difference in the handling under these two conditions, the hazards in full container loads being appreciably less than in the case of mixed goods. It was also shown that the hazards varied considerably from case to case, pointing to the fact that "journey tests" must be statistically planned if reliable results are to be obtained.

Recorders have been purchased by a number of firms and Government departments including the Admiralty, the United States War Department and the Swedish State Railways.

Quartz Crystal Accelerometer

In order to design an efficient container it is necessary first to study the strength and protective qualities of containers in relation to the materials from which they are made. For this work an accelerometer, using the piezo electric properties of quartz crystals, is mounted at some point in the package so that an accurate record can be obtained of the shocks experienced by

goods when packaged in experimental containers and subjected to transport hazards under controlled conditions. The prototype equipment, including amplifiers, a cathode ray oscilloscope and a centrifuge for calibration purposes, has been developed.

Cutting and Creasing of Carton Board

The aim of this new line of research is to improve the strength of a container at the crease through a better understanding of the mechanism of creasing in relation to the properties of the board and the method of creasing.

Transparent Wrapping Materials

This new research project is concerned with an investigation into the properties of moisture-proof cellulose film before and after printing, as it has been found that the processing—in particular printing—of cellulose film may have the effect of modifying its efficiency as a moisture vapour barrier.

Adhesives

The immediate object of this work is to devise methods of forecasting the performance of adhesives in application, particularly on high-speed machinery. To help this work a " tackmeter " has been designed and constructed at Patra House to study the nature of " tack " in adhesives.

Odour Protection

Odour contamination is a problem of considerable concern to some manufacturers—particularly those producing foodstuffs. Work has been concerned with the developing of appropriate techniques for measuring and comparing odour, with the object of assessing the possibility of odour contamination from the materials used in making the package. A method has been evolved whereby an observer is " fatigued " to the odour of one of the components of the package, and following further " fatigue " tests, the component giving rise to the odour can be determined.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st April, 1951, to 31st March, 1953, a block grant of £12,000 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, 1953, to 31st March, 1956, the block grant is £16,000 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 £16,000.

The income of the Association for the last completed year was £74,632.

PRODUCTION ENGINEERING RESEARCH ASSOCIATION OF GREAT BRITAIN

The Association continues to receive increasing support from the industry, membership having increased by 54 firms in the past year. The response to the appeal for funds for the erection of a new research building, which is expected to cost at least £200,000, has been very encouraging and construction is expected to begin before the end of 1953.

During the year six open days have been held to enable executives from industry to see the research work being carried out, an exhibition of the information services, and demonstrations of recent developments, such as

electric spark machining, electrolytic polishing, and a method of applying cutting fluid under high pressure. Attendance from both members and others was about 1,000.

The Association's resources for extending the field of research have been considerably improved by the receipt of further scientific equipment and machine tools from the United States of America under the Mutual Security Agency Technical Assistance Scheme. The equipment includes a contour surface grinder, a recordmatic titrator, a grinding wheel grading comparator and a cold heading machine.

METAL FORMING INVESTIGATIONS

An investigation to determine bend allowances for a wide range of materials has been completed. Formulae and nomograms have been derived to facilitate the accurate determination of blank sizes for formed components, and a report on the work has been issued under the title *Bend Allowances for Sheet Materials.—Part II.*

Research is continuing into factors affecting the efficiency of blanking and piercing operations. Progress has been made in the study of conditions required to produce a highly polished and burr-free finish on the sheared edge when blanking aluminium and copper. Results of the investigation to date have been successfully applied in industry, enabling the manufacture of accurately finished components in a single blanking operation, thereby eliminating additional machining and finishing operations. Work is continuing on the blanking of brass and mild steel.

The efficiency of different types of deep drawing lubricants has been investigated and a study is being made of the effects of punch and die radius on the efficiency of the drawing operation. Results are expected to provide information on the most suitable lubricant and shape of the punch and die which will give the maximum permissible draw with different materials thus enabling a deep drawn component to be produced in fewer operations.

A research on thread rolling for the determination of suitable blank diameters for rolling unified screw threads in a wide range of ferrous and non-ferrous materials is nearing completion. Results will eliminate trial and error methods at present in use by industry for determination of blank sizes.

Further progress was made with an investigation to determine the relationship between percentage reduction and load required to impact extrude aluminium, zinc, duralumin, copper and steel. The work is expected to yield valuable information on the extrusion of the harder materials, and encourage the wider use by industry of the process.

A study is continuing on methods of dry cleaning hot rolled ferrous rod prior to wire drawing in order to eliminate pickling operations, and thus reduce handling costs.

METAL CUTTING INVESTIGATIONS

An investigation into the effects of rake angle and flute area on tap life and performance is nearing completion. This work has also included an examination of various metallurgical factors affecting tap performance. A report entitled *Tapping—Part I* has already been issued giving recommendations on core hole size and hole depth when tapping various ferrous and non-ferrous metals. Application of the recommendations in industry should result in considerable economies due to the reduction of tap wear and breakage.

Researches into the effects of tool surface finish on tool life when rough turning, and workpiece surface finish when finish turning have been completed. The results of this research are expected to assist in the rationalization of tool grinding techniques.

The effects of relief and point angles on drill life are also being investigated in a series of tests on a range of ferrous and non-ferrous materials.

Tests have been commenced to study the effects of reamer shape on hole accuracy and surface finish. It has been necessary to design special equipment to measure the standard and special reamers used in these tests.

Tests have been completed on the effect of shape, traverse rate and infeed of the dressing diamond on grinding performance during cylindrical grinding. There is a lack of specific information regarding grinding wheel dressing and the results of this work will assist in providing information which may be used directly in selecting conditions for rough and finish grinding.

Further progress has been made in the investigation to determine the effect on grinding performance of wheel grade, infeed and traverse rate.

The investigation to determine the effect of applying cutting fluid centrifugally through the pores of the wheel as compared with the conventional external method of application is nearing completion. Tests have been completed on cylindrical grinding and are being extended to cover surface grinding. This work will provide information as to the most effective method of applying cutting fluids in rough and finish surface and cylindrical grinding operations.

Further corrosion and machining tests are being carried out on experimental aqueous cutting fluids containing various additives and corrosion inhibitors.

Programmes have recently been initiated to investigate the application of carbide drills, tool grinding methods (including the use of electric spark machining and abrasive belts) and the use of liquid carbon dioxide as a coolant for machining operations.

SURFACE FINISH

An investigation is now being carried out to determine whether the plastic replica method of surface finish evaluation is practicable for workshop purposes. The development of a suitable simple test of this nature will assist in the control of component surface finish in production.

MACHINE TOOL INVESTIGATIONS

A report *Notes on the Design and Use of Radial Rolling Machines* has been issued. A research into horizontal milling machines, covering investigations of accuracy and alignment, power and efficiency, rough and finish machining, deflection and vibration, has been completed, and the report *Milling Machine Performance Tests* issued. A similar research into cylindrical grinding machines is nearing completion. The information obtained from these researches is of value in indicating where improvements in design should be made and in determining the most effective operating conditions for the machine.

Further tests on the accuracy and performance of angular contact ball bearings are in progress. It is hoped that this investigation will provide a clear guide to the essential requirements of bearings for machine tool spindles.

A special friction testing machine for investigations into machine tool slideways has been completed, and tests are now in progress in connection with an investigation into the relative merits of different surface finishes,

materials and lubricants for machine tool slideways. An interim report entitled *Developments in the Study of Metal and Plastic Slides* has already been issued. It is expected that the investigation will provide valuable information on the factors governing slip-stick, friction and wear in machine tools.

MISCELLANEOUS INVESTIGATIONS

A number of investigations into machine tool vibration problems have been carried out at the request of various members. These investigations, which are carried out either at PERA or in the works of the firm concerned, have in many cases resulted in satisfactory solutions to the problems. Special vibration testing equipment obtained under the M.S.A. scheme, has greatly facilitated the execution of work of this nature.

Other short term investigations have been carried out to assist members in selecting suitable cutting conditions and tool shapes for machining various materials and components.

An operational research into de-burring is now in progress. The work, which is concerned with the application of different de-burring methods to a wide variety of engineering components, should provide valuable guidance to industry in selecting the most efficient de-burring method for particular components.

EDUCATIONAL ACTIVITIES

A new series of refresher courses was held during the past year to stimulate application of the results of the researches into metal forming techniques, e.g. blanking and piercing, deep drawing, and impact extrusion. These courses again showed that demonstrations of improved techniques can secure the attention of industrial personnel and lead to the immediate application of improved methods in factories where the circulation of the formal research reports describing these techniques had not achieved this result. In a large electrical company one operation was completely eliminated by the introduction of a blanking technique demonstrated at PERA.

Special courses of instruction for individual personnel from industry, such as toolroom foremen, have been arranged on various subjects, including tool grinding and machine tool maintenance.

The six-month courses in production techniques organized for young engineers from member-firms continue to be well attended.

MEMBER-LIAISON

As a result of 300 liaison visits to members a considerable increase in the use of PERA services has been noticed and several hundred enquiries of a varied nature were put to PERA engineers during these visits. Nearly all these enquiries related to problems whose solution would lead to increases in productivity either by the reduction of the time taken to perform a given operation or by the reduction in costs arising from increased tool life, the provision of special fixtures, etc.

TECHNICAL ENQUIRY SERVICE

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 factory, continue to find that the most efficient way to locate information on new developments and special techniques is to contact PERA. Over 1,200 requests for information and advice were received during the past twelve months.

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.

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 is made provided £50,000 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.

For the period 1st January, 1954, to 31st December, 1956, the block grant will be £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. Also, provided industry raises a minimum of £100,000, there will be a special grant of £100,000 towards the cost of the new research building mentioned in the opening paragraph.

The income of the Association for the last completed year was £105,100.

BRITISH RAYON RESEARCH ASSOCIATION

The Association is still housed in temporary premises at Barton, near Manchester, though it is in process of moving to its permanent home at Heald Green, Wythenshawe. The limited space available at Barton has seriously restricted development, particularly on the technological side.

The arrangements, mentioned in the previous report, for integrating the work of the Association with that of other organizations engaged in complementary fields of research have proved fruitful and are being continued. There is close co-operation with the universities as well as with the other textile Research Associations, and on the technological side with the rayon and synthetic fibre producers, with the processers of textile materials and with the textile machinery manufacturers.

The members of the British Rayon and Synthetic Fibres Federation already possess very extensive research, technical control and technical service laboratories. The function of the Association, therefore, is to serve as a link between them and the university research schools, to investigate the more fundamental aspects of the problems confronting the industry and to work out such methods of technological control and test as are more cheaply and efficiently carried out on a co-operative basis than by the individual member.

This the Association is already doing, with the result that it is steadily establishing itself as an essential and permanent part of the industry.

PHYSICAL STRUCTURE AND PROPERTIES OF FIBRES

Previous work has shown that the classical laws of friction do not obtain with fibres. The new form of these laws is being investigated theoretically with a view to their interpretation in terms of purely elastic deformation of surface asperities. Coupled with this is an experimental investigation of the transverse rheological properties of fibres. Frictional measurements are now being extended to blends of fibres.

Work is in progress to elucidate the manner in which the molecules are arranged in the highly ordered ("crystalline") and the less ordered ("amorphous") regions of fibre-forming materials using experimental techniques which include X-ray and electron diffraction, infra-red spectroscopy and optical methods such as the use of multiple beam interferometery and the measurement of dichroism.

It has been confirmed that the crystalline regions of cellulose do not possess a unique unit cell, four modifications having been definitely established. An important problem now under examination is the manner in which the glucose residues of the cellulose chains are arranged within these unit cells. Different fibres contain these crystalline regions in varying degrees: their assessment is being carried out by both chemical (e.g. heterogeneous acid hydrolysis) and physical (e.g. X-ray and infra-red spectroscopic) methods. The density of molecular packing in the non-crystalline regions is also of significance in determining the chemical reactivity and mechanical properties of the fibre: techniques are being developed for its study.

Several aspects of the interaction of water with cellulose are being studied from both experimental and theoretical points of view. For instance, an investigation of the effect of tension on the swelling of cellulose has been completed. It has been shown that the equilibrium water absorption of viscose rayon increases on the application of a tensile stress and decreases as the stress is removed. The effect is in the direction required by thermodynamic theory and is of the expected magnitude, but since the application of stress changes the fine structure of the fibre, no true equilibrium is possible, and the effect is not completely reversible.

CHEMICAL STRUCTURE AND PROPERTIES OF FIBRES

Tendering of cellulosic textile fabrics exposed to strong light causes serious loss and the effect is accelerated by certain classes of dyestuffs, particularly certain yellow anthraquinonoid vat dyes which are otherwise suitable for dyeing furnishing fabrics. Owing to the complexity of the cellulose molecule, work has been started on the apparently analogous photo-oxidation of simple alcohols and ethers sensitized by anthraquinone sulphonates. The complete chemical mechanism in the case of the primary and secondary alcohols has been elucidated; its applicability to the more difficult cases of water-soluble carbohydrates and cellulose itself is now being investigated.

A major consequence of such photochemical oxidation of cellulose is the introduction of carbonyl groups into the pyranose rings, which when exposed to even mildly alkaline conditions (as in washing) readily give rise to chain scission. The mechanism by which this degradation reaction occurs has been elucidated by reference to the behaviour under similar conditions of simple β-alkoxy ketones. This work is also of significance to an understanding of (*a*) the alkaline ageing process carried out during viscose manufacture, and (*b*) the degradation of certain other types of polysaccharide under the influence of alkali.

A point of general interest in considering the degradation of cellulosic materials lies in the possibility that there is incorporated in the long chain molecules a limited number of chemical groups or structures which, through their abnormal sensitivity to attack, effectively predetermine the course of degradation. Recent work in the Association's laboratories has demonstrated the absence of abnormally acid-sensitive linkages of the types proposed by earlier workers, at least in the case of cotton. It has been shown, however, that there is present a small fraction of bonds which, although not acid-sensitive themselves, can be rendered labile by alkaline treatment, probably by an oxidative reaction.

The dyeing of regenerated cellulose and cellulose acetate rayons is being studied from two points of view. In the first, thermodynamic methods are being used to investigate the nature of the bonds between dye and fibre. In the second, information on the structure of the rayons themselves is being sought through their dyeing behaviour as revealed in measurements of diffusion rates and equilibrium uptakes.

TECHNOLOGICAL RESEARCH

An extended programme of technological research has been approved and consultations have taken place with members covering all branches of the textile industry. Orders have been placed for the equipment required, including spinning machinery, and when this has been installed the technological sheds at Wythenshawe as well as the existing premises at Barton will be fully occupied.

The main emphasis in the new programme is to be on the production and processing of blended yarns, although this will of necessity involve much work on unblended materials, particularly the newer fibres. Investigations will be carried out into all aspects of the blending of the raw materials. Methods of quality control and assessment will be developed for each stage of the processing from the blending to the carding and spinning. Other investigations will include: the differential effect of the elements of the card upon the various components of the blend; fibre breakage and nep formation, including the development of quantitative methods of measurement; techniques for improved assessment of the distribution of components of a blend; the limits of variation which can be permitted at one point without producing trouble at a subsequent stage; and finally the theory of drafting and the limitations of high draft systems.

It is intended to process the blended yarns under close control right through to the finished fabric. The dyeing and finishing programme has also been extended to keep in step with the mechanical processing programme. The introduction of blended yarns has rendered useless many fugitive tints previously used. Entirely new ones, therefore, are being developed and arrangements are being made to put them on the market.

FINISHING

Weathering of cellulose acetate fabrics occurs during loom-state storage and is revealed after delustring and dyeing as a lustre defect, which may extend over many yards of cloth. Nothing can be done to the finished fabric to cure this defect that does not lower the value of the cloth considerably. It has been shown that weathering is caused by condensation of moisture on the cloth resulting in the transfer into the acetate fibres of an anionic surface active agent from the lubricant. This agent subsequently produces an excess of delustring of those parts of the fabric into which it has penetrated. In some cases the defect can be cured by removal of this agent before delustring, i.e. by simply soaking the fabric in water.

Investigations have been carried out with the object of throwing light on and minimizing the loss in tensile strength suffered by acetate rayon during delustring treatment. For this purpose the effect of delustring on the fine structure of the rayon (as indicated by X-ray and birefringence measurements) has been studied. An instrument for measuring lustre has been developed.

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. A machine of improved design is being constructed and will shortly be put on trial.

Work is proceeding in co-operation with loom manufacturers on the application of pneumatic shuttle propulsion to very wide looms. The application of pneumatic picking to the weaving of fine denier rayon materials is being investigated and specially designed shuttles are under trial at Barton.

A comprehensive series of tests is now in progress on British, American and Swiss automatic looms with a view to investigating their performance on fine denier rayon yarns.

Trials of both shuttle changing and pirn changing attachments on Lancashire looms have been arranged in members' mills.

A prototype machine has been constructed for detecting and measuring periodicities in the irregularities in yarns. The machine has proved satisfactory in laboratory tests and its usefulness for quality control is to be evaluated by tests under mill conditions.

An optical device for detecting and correcting irregular weft orientation in fabrics during processing has been designed and constructed. It has proved satisfactory for certain types of fabric and work is continuing to extend the range of fabrics for which it can be used.

An electronic timing indicator has been designed which gives an instantaneous display on a cathode ray tube of the various loom motions, including the shuttle flight. The principle will be applied to other types of textile machinery where separate motions have to be synchronized.

A machine has been developed for stripping the residue of yarn from exhausted pirns and bobbins by pneumatic means. The machine is being manufactured and sold under licence by a British firm of textile machinery manufacturers.

LIAISON WITH MEMBERS

An extensive liaison section has been developed to deal with the difficulties arising in members' mills. For instance, at the request of one firm, an investigation was carried out into " repping "—a starting fault which occurs in weaving with certain types of loom after standing overnight. The work was carried out both in the member's mill and in the Association's laboratories and a satisfactory solution was found. Further work is being carried out on starting places in fabric under more varied conditions. Warp stripiness and weft barriness continue to be the most frequent faults submitted for investigation.

In collaboration with the various sections of the British Rayon and Synthetic Fibres Federation, an exhaustive examination of the actual costs of production of various rayon fabrics is being undertaken. In addition observer teams have conducted surveys at mills of the production of spun rayon fabrics on automatic looms and on Lancashire looms fitted with automatic weft replenishing attachments.

The work on oil stains discussed in the previous report has been continued. It has been found that some 15 per cent. of the stains are resistant to any normal scour. Investigation into methods of reducing the incidence of oil stains to a minimum and of removing them is continuing.

The method of test proposed by the Association for determination of shrinkage on washing of woven rayon and synthetic fibre fabrics has been published in the *Journal of the Textile Institute* as Tentative Textile Specification Number 24. The Association is collaborating with the British Standards Institution in an investigation to formulate a suitable washing shrinkage test for warp knit rayon fabrics.

Methods of analysing rayon and synthetic fibres containing filling materials used in the bedding and upholstery industries have been investigated and suitable methods proposed for inclusion in new standards and regulations now being established for these materials.

As foreshadowed last year a small group has been established at the London office of the British Rayon and Synthetic Fibres Federation to act as a link between the Federation and the technical departments of Service Ministries, to maintain liaison with the Federation's Design Section, industrial designers, fashion houses, etc. The group includes a small laboratory to enable minor queries, identification of fibres, etc., to be dealt with on the spot.

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 grant of £40,000.

The income of the Association for the last completed year was £387,056.

THE RESEARCH ASSOCIATION OF BRITISH RUBBER MANUFACTURERS

During the year much time and effort have been devoted to adapting the premises acquired in 1951 as the new headquarters of the Association, to planning the removal from Croydon to the new location at Shawbury, near Shrewsbury, and to the problem of staff housing in that area. The adaptation has now been largely completed, a substantial proportion of the staff and equipment transferred, and good progress made by R.A.B.R.M. Housing Association Limited in erecting houses for staff in Shawbury. It is hoped to have the move completed by the end of 1953 in readiness for the official opening of the new Laboratories during the summer or autumn of 1954.

In spite of these distractions and the inevitable staff losses and changes, a good volume of research work has been maintained, generally along the lines indicated in recent reports.

TEST METHODS AND INSTRUMENTS

The unique properties of rubber as a medium for absorbing shocks and vibrations have made it an indispensable part of all transport equipment—road, rail, sea and air. In vehicle and other suspensions rubber is being used more and more, and under ever more exacting conditions. Hence there is a growing need to understand the behaviour of rubber under "dynamic" stressing, in particular how efficiently it will insulate against shocks and vibrations, and how rubber components must be designed to ensure many years' service under severe conditions. The classical engineering methods developed for metals fail in designing or testing rubber components, for the behaviour of rubber differs fundamentally from that of metals. A lengthy investigation by the Association has now led to a hypothesis regarding the dynamic behaviour of vulcanized rubber that explains the observed trends in many measurements by different methods, and will provide a much sounder basis than has hitherto existed for the testing of rubber compounds and design of components for vehicle suspensions and other engineering uses. Further developments on both fundamental and practical aspects, based on this new knowledge, are being pressed forward.

Testing and measuring the properties of rubber is altogether a complex and specialized subject and therefore appropriate for study by the Association, which has done valuable work especially in securing greater standardization —both nationally and internationally—and reliability of the test methods commonly employed by the manufacturer and the user of rubber products.

Over the years it has done much to stimulate the production in the United Kingdom of reliable test instruments. One such, the "Hardness Meter" which replaces an American instrument, is technically far more satisfactory and less costly; its sales already have saved British purchasers some £15,000 price difference as well as avoiding expenditure of some 60,000 U.S. dollars.

Previous reports have referred to work on the development of a rapid semi-automatic "plasticity" test for process control which has culminated in a member undertaking the manufacture of an instrument that is now proving its worth by service in the factory, and indeed provides the answer to a widespread need expressed by the industry some few years ago. Another test apparatus recently developed on the basis of R.A.B.R.M. researches is the improved "Ozone Cabinet" for assessing the liability of rubber to cracking when exposed out of doors under slight stretch—a frequent and insidious type of failure, the cause of which was first definitely established by the Association.

COMPOSITE RUBBER-TEXTILE ARTICLES

Rubber-proofed fabrics were one of the earliest products of the rubber industry, and still form a major item in its output and one of particular importance to the public in the familiar "mackintosh" garments. For this reason the Association has studied many problems concerned with composite rubber/textile articles and the method it has devised for reducing the tendency of double-texture mackintoshes to wear into holes at exposed spots has been taken up by several manufacturers with a view to more extensive trials. Much of the Association's work has been directed to avoiding troubles due to the poor adhesion of rubber to continuous-filament synthetic textiles like rayon, nylon and "Terylene". Successful practical results have been achieved particularly in garment fabrics such as those used in ladies' fashion rainwear, where it has been found possible, applying the principles devised by the Association, to make a material having on the outside the attractive sheen of continuous-filament textile, whilst the inside has the characteristics necessary for good adhesion of the rubber proofing; the adoption of these principles could undoubtedly avoid many of the complaints about poor service of lightweight rubberized rayon mackintoshes.

Moreover, in certain Service applications such as diving dresses, these new methods have made it possible to take advantage of the high strength and wear resistance of nylon fabrics. In general, the Association's work provides rubber manufacturers with means for utilizing more effectively the valuable properties of new synthetic textiles, and its application to other important products such as tyres and belting is being studied.

Investigations are also in hand on methods of avoiding the premature deterioration that has so often led to complaints about rubberized waterproofs. Fundamental and technological approaches are being pursued, particularly in order to understand and hence avoid the harmful effects of certain trace elements (copper and manganese) liable to occur in the materials used. This work has been welcomed by the proofing manufacturers, several of whom are co-operating in the work.

FIRE AND ELECTRICAL HAZARDS

The investigations described last year on the development of coal conveyor belts free from fire risks have been pressed forward in collaboration with the belting manufacturers and the National Coal Board. It has been found that a belt in which the textile warp is "Terylene" or other fusible fibre, when stalled upon a rotating drum, breaks before it becomes hot enough to inflame, thus avoiding the fire risk that exists with the normal cotton belt.

As an alternative approach it has been found that compounding the rubber used for impregnating and covering the belts with a special chlorine-containing polymer, gives it considerable resistance to flame whilst maintaining strength and other necessary properties. Already experimental belts have been made that come very near to meeting the National Coal Board's stringent test requirements. The significance of this latest development goes further than the immediate problem of colliery belting, for there is a need in many fields for non-flam rubber products, and the type of rubber compound developed by the Association is an important new approach to this problem.

Fire and other hazards frequently arise from the generation of static electrical charges on machinery or equipment insulated from earth by rubber, tyres or other parts. An important development made by the industry in recent years has been rubber that conducts electricity sufficiently to dissipate these charges, and such rubber is being used increasingly for bus tyres, equipment for operating theatres, flooring for explosives factories, etc. However, this development has not been without its difficulties; the electrical resistance of the rubber must be kept within defined limits although this conductive or " anti-static " rubber is a material very susceptible to any variation in manufacturing technique or to rough treatment during use. Since, in addition, the measurement of its electrical resistance presents special difficulties, it will be appreciated why some years of study have been needed to arrive at a reliable test method for determining its electrical properties. The Association has taken a leading part in this work, which has enabled methods to be formulated for the British Standard Specification for this important class of rubber products.

FUNDAMENTAL RESEARCH

A feature of the fundamental investigations has been the extension of extra-mural or co-operative work with Universities and similar Institutions whereby the latest scientific ideas are brought to bear upon current problems and the University workers are given an added interest in the problems of the industry. The research on the fundamental phenomena underlying reinforcement of vulcanized rubber by carbon black (an effect without which rubber manufacture as we know it would be impossible) has reached an important stage of development. Studies of the interaction of carbon black and other powder surfaces with liquids similar in chemical structure to natural rubber have shown that reinforcement cannot be explained in terms of physical (van der Waals) forces between the rubber and powder, but must involve some stronger type of bond such as chemisorption.

RAW MATERIALS

Examination of new raw materials continues to be an important item. Again this work has emphasized the dependence of future developments on the free availability of synthetic rubbers and rubber-like plastics; to name only those concerned with the work in hand, there are the chlorine-containing polymers for making non-flam rubber products, the so-called " high-styrene " polymers which are enabling other countries to develop useful new types of shoe soling, and Neoprene which enables British manufacturers to make footwear cements equal to those made abroad. In advising members about the best materials for particular applications, it is found all too often that the most suitable is not readily available, as it can be obtained only from dollar sources.

ADVISORY AND INFORMATION SERVICES

In its endeavours to provide the best possible advisory and information services to members, the Association has been faced with the problem,

common to all research organizations, of dealing with the rapidly growing mass of published information. A fundamental need is for a system of classifying the information so that all of one sort is automatically put together and can be found when required. One of the outstanding achievements of the Intelligence Division of the Association has been the development of a practicable classification system for the whole science and technology of rubber and rubber-like plastics. Recently the equally important step has been achieved of modifying and extending this system to meet the needs of rubber research organizations in France, Holland, and the rubber-producing countries in the Far East, Malaya, Ceylon, Indochina and Indonesia. This internationally agreed classification has been widely publicized with a view to its being still more widely adopted and has aroused considerable interest. This detailed and painstaking work has perhaps not the glamour of research but it is none the less important, for the greatest need is to use existing knowledge, and to do this there must be efficient means of handling the vast and complex mass of such knowledge.

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 is made provided £25,000 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 £68,018.

THE BRITISH SCIENTIFIC INSTRUMENT RESEARCH ASSOCIATION

The programme of research reflects, in the number and the diverse nature of the investigations undertaken, the many different types of scientific instruments which are in common use today, both in research laboratories and in industry. In the past, the research effort of the Association has been spread rather thinly over a very wide field, and during the current year its research policy has changed in this respect. The programme of research has been drastically pruned in order that greater effort can be given to projects occupying the attention of the Laboratories. It is hoped that the greater speed with which investigations should now be concluded will, over the years, more than compensate for the gaps which must necessarily be left unfilled in any particular year. The good results of this policy are already being felt and some indication of a few of the investigations in which very marked progress has been made is given below.

ANTI-GLARE GLASS FOR INSTRUMENT WINDOWS

It is a common practice for the operations of industrial plant to be controlled from a single room in which all aspects of the operating conditions of the plant are indicated by means of a range of instruments mounted on a large panel. The indications of these instruments have to be read by an operator sitting in front of the panel, and frequently light strongly reflected from certain of the instrument windows renders reading of the instrument almost impossible. An investigation has been carried out in the Laboratories on methods of treating instrument windows so as to reduce the amount of light directly reflected from them whilst still retaining sufficient transparency to enable the indications of the instruments to be read. Satisfactory results have been obtained and windows have been treated which have markedly increased the ease of reading of instruments on such panels.

A similar problem exists in connection with the use of transparent plastic radar screens, where reflections from the outer surface of the screen seriously interfere with easy observation of the fluorescent traces. By applying to the transparent plastic a surface similar to that used in the case of glass windows, a very considerable improvement has been achieved in this field also.

METHODS OF OPTICAL COMPUTING

Whilst in normal circumstances the existing methods of optical computation are substantially adequate, in the design of lenses of the very highest performance there are fields of abstruse calculation which are of so difficult a nature as to require months, if not years, of the computer's time. Nevertheless it is highly desirable that calculations of this type should be made and, under the aegis of the Ministry of Supply, the Association has embarked on an investigation of the aid which can be given in these directions by the use of digital computing machines. The project has now commenced in the Mathematics Department of Manchester University, where an electronic digital computer is available, and during the past year much work has been done in obtaining the basic background data necessary for the effective employment of digital computation. The immediate work to be undertaken covers the design of photographic lenses and the evaluation of the effect of residual lens errors in photography, but if it should prove that the use of digital computers can make an outstanding contribution in the field of optical computation, the results of this work may well have a far-reaching effect on the future pattern of optical design work.

THICKNESS MEASUREMENT OF METAL SHEATHS

Work has been proceeding during the year on thickness gauging of the lead, on a continuous basis, on lead-covered cables. Any device to achieve this must operate during the extrusion process of the lead and give continuous indications of the thickness at several points around the periphery of the cable, and must do so continuously as the cable is being covered. A device which appears to hold much promise has been developed and will soon be undergoing tests under working conditions. The uniform thickness of lead around a lead-covered cable is not only essential from the point of view of the protective properties of the lead, but is equally important in connection with optimum economy in cable making.

RELATIVE HUMIDITY

The work on humidity-sensitive ceramic elements, which has been carried out in the Laboratories for some time past, has advanced markedly during the past year in the development of an element having the physical properties requisite for its practical application in instrument form. In the latest type of element, the electrical resistance has been greatly reduced and the changes of this resistance with variation of relative humidity are sufficient both in magnitude and in stability of performance to provide promise of great practical use. Arrangements have been made for a member to produce these elements and it is hoped they will be incorporated in relative humidity devices in the near future. The work is important in that the measurement of relative humidity is essential in a wide range of industrial processes.

OPTICAL-WORKING CONTROL

A comprehensive research report has been issued during the year, covering the work which the Association has carried out on the conditions governing the efficient use of diamond-bonded tools. The effects of the nature of the lubricant, pressure between work and tool, tool speed, and the ratio of work to tool speed, have all been investigated and, as far as is known, for

the first time factual data on these matters have been made available to members. The work is being continued in connection with the properties of the diamond-bonded tool itself, particularly in relation to the effect of diamond particle size and concentration.

The Association has in its membership makers of polishing powders and, at the request both of the makers and the users of these materials, the Laboratories have been engaged in attempting to devise an instrumental test of the efficiency of polishing powders which would be acceptable to the makers and the users. An apparatus has been developed which has many satisfactory features and is adequate for differentiating between the performance of powders during the early stages of polishing. To carry this differentiation into the region of final polishing presents problems of considerable difficulty, on which further work is to be undertaken.

INFORMATION DEPARTMENT

During the past four years the number of library loans has more than doubled, while technical enquiries from all sources have increased by almost 30 per cent. The increase in technical enquiries from members has been particularly marked during the past year. Another notable feature is the high percentage (65 per cent.) of abstracts in the *Bulletin* of the Association the appearance of which stimulates requests for loans of the original papers. These increases indicate clearly that the services rendered by the department are of very real value.

A new departure during the year has been the issue by the Information Department of a monthly publication, *Sira Technical News*. This new link with the membership contains progress reports on current researches, digests of new research reports, notes on experimental work not fully reported elsewhere, and information about new materials and processes thought likely to be useful to the industry.

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 £58,602.

THE BRITISH SHIPBUILDING RESEARCH ASSOCIATION

The Association has continued to progress satisfactorily during the year. Results of researches have been communicated to members regularly in the form of Research Reports and many have formed the basis of papers read before technical institutions. The policy has been continued of having many of the experimental investigations arising from items on the programme of research carried out extra-murally under contract at Universities, Technical Colleges, Government research laboratories and the works of members. The main laboratory open to the Association is the ship itself whilst under construction, on measured mile acceptance trials and in service: such full scale investigations on both the hull and machinery are largely undertaken by the research staff of the Association.

The small laboratory and workshop at Palmer's Hill, Sunderland, has continued to be used for the development of apparatus and in addition is a base for the more heavy equipment used on ship trials, especially those carried out on the north-east coast.

The Library and Intelligence Section has continued to give valuable assistance to members and the issue of the monthly Journal of abstracts of current technical literature remains one of its most important functions. Many of the enquiries received within the Section prove of general interest to members and may even lead to new researches.

HYDRODYNAMICS

Much of the work in this section entails the use of model experiment tanks, and increasing the Association's share of existing facilities is still a problem. More tank time is to be made available at the Vickers-Armstrong tank at St. Albans where additional equipment has been secured. An item dealing with the resistance of coasters, tugs, trawlers and other specialized craft has progressed during the year and a series of tests has been completed at St. Albans on a number of dredge forms with various types of bucket wells and hopper doors.

An *ad hoc* panel is to be set up to consider the correlation of these model results on dredge forms with full scale trial results. In addition, details are being worked out for a series of propulsion experiments on a tug form covering several speeds between free-running and low speed towing.

Work continues on a number of items in the Ship Division of the National Physical Laboratory, including tests on the effect of form on frictional resistance and the independence or otherwise of skin-frictional and wake-making resistance. Previously tests were carried out in the wind tunnel of the Aerodynamics Division with a ship model of mathematically defined geometric form, and three sizes of flat plates having the same profile as the model. These wind tunnel experiments having been completed the tank tests are being carried out with a similar model: the programme includes measurements of drag, stream flow and pressure distribution.

A survey of information on the effect of propeller hull-tip clearance on propeller efficiency, vibration and erosion has been made by the Association's staff, and as a result it has been decided to undertake experimental work to determine the effect on both vibration and propulsion of the clearance between the propeller and the hull. In the first instance tests are to be carried out on an "articulated stern" model of a trawler. This model has been constructed and preliminary tests have been carried out. A torsionmeter for measuring transient torque is being developed for this work at the Palmer's Hill Laboratory.

SHIPS' STRUCTURES

The new structures testing machine at Glengarnock, Ayrshire, is now in operation. Members, representatives of the technical Press and others interested in the work were invited to visit the establishment, where both the old and new machines were demonstrated. Parties of about sixty each inspected the machines on two consecutive days and the new machine aroused much favourable comment. The technical Press also were interested and published long accounts of the machine and the work. The investigations with the machine are made for the Association by suitably qualified staff of Lloyd's Register of Shipping through modifications to whose Rules the results receive their most immediate and practical expression. A full programme of work with both machines is now in hand.

At the Imperial College, London, work is proceeding to obtain the load and stress distribution in a box girder comparable with a ship's hull. Results

have been obtained from tests on three widths of superstructure and further tests will include an investigation on the effect of length of superstructure and of shear. Theoretical work on stress distribution in a vertical plate representing a superstructure side has also been carried out at the College.

Laboratory tests on launching greases are continuing at the Mechanical Engineering Research Laboratory as are full scale tests by the Association's staff on the performance of such greases. An attempt to measure the temperature of grease during launching has been successful. Measurements of creep of the launching ways prior to the release of the triggers have also been made to supply information for a theoretical study of factors which affect the magnitude of forces acting on launching triggers.

The Association has continued to take an active interest in problems of marine corrosion which are included in the programme of the British Iron and Steel Research Association. A programme of corrosion tests on welds in mild steel has been commenced in conjunction with B.I.S.R.A. staff and specimens have been immersed in sea water at Caernarvon where periodic inspections are being made.

SHIPS' MACHINERY

Work continues steadily in all sections of the machinery portion of the research programme and great interest and co-operation in the work is displayed by the marine engine builders.

A new item has been added to this section of the programme and deals with the descent of funnel gases on to the decks of ships. Experiments in a wind tunnel have been carried out to determine a suitable method for observing the boundary between disturbed and undisturbed flow over models and at the same time observations have been made on a vessel at sea in order to secure correlation with model results.

An item of vital importance is the prevention of crankcase explosions in marine oil engines. The Imperial College, London, have for some time been carrying out investigations for the Association dealing with the ignition characteristics of condensed mists and with burning velocity measurements. A number of samples of crankcase atmospheres have been tested with a view to obtaining further data regarding their nature. Facilities have been secured at the Safety in Mines Research Establishment at Buxton for carrying out large scale explosion tests in a vessel of 200 cu. ft.

At Nottingham University investigations are proceeding to determine the mechanism of failures of diesel engine components exposed to combustion conditions. The problem is to ascertain whether such failures are due to fatigue arising from cyclical fluctuations of temperature or to some form of creep. Two fatigue testing machines have been built and in addition a battery of ten creep testing machines has been constructed. Separate furnaces have been installed to enable the growth of the cast iron to be measured over the period of the creep tests.

The corrosion of tubes in Scotch boilers is another problem which is being actively pursued. The investigations are concerned with improving the corrosion resisting properties of mild steel tubes and the possibilities of a better tube being manufactured in a superior material. Accelerated corrosion tests are being carried out in four special experimental boilers at the Chemical Research Laboratory, Teddington. Various types of tubes have also been installed in the boilers of vessels in service.

The period has seen the completion at Barrow of the two special experimental engines designed for the investigation of the scavenging process in marine diesel engines. The improvement of this process is thought to be of

great importance to the future development of such engines. The programme of experiments with the engines, one of which entails operation on calor gas, has been determined and the work will be carried out by the research staff of a member firm.

VIBRATION

The Association's work on this subject is concerned with both the structural and machinery aspects of the problem and the staff now have almost unique experience of the problems that can arise on board ships and their advice is constantly sought by members. Full scale and model investigations are in hand as well as theoretical approaches. Papers on this work have aroused much interest. Preliminary instrumentation tests have been made on marine engines whilst under construction, and the "Farnboro" indicator, as modified by the Association, has been of use for this work, though the modifications were made with other requirements in mind.

SHIPS' PERFORMANCE

The attendance of members of the Association's staff at ship trials has already been mentioned. As mentioned last year, a heavy programme of loaded trials is in hand to check performance for the purpose of correlation with model tests, the work being carried out in conjunction with the Ship Division of the National Physical Laboratory. Improved prediction of ship performance from model results will be of great value to shipbuilders and shipowners and the need has been enhanced by changes in the nature of ships' hull surfaces which affect resistance. The paper on the *Lucy Ashton* experiments read in March, 1953, before the Institution of Naval Architects dealing with the ship model correlation for the naked hull conditions aroused much discussion.

A prototype apparatus for measuring the speed of vessels on trials by means of radar has been developed. Its object is to measure ships' speed when fog obscures the short mile posts and prevents speed measurement by the normal measured mile method. Satisfactory results have been obtained which confirm the practicability of the method.

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 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 £25,000.

The income of the Association for the last completed year was £243,323.

THE COIL SPRING FEDERATION RESEARCH ORGANIZATION

The discussions which have been in progress during the year regarding the future research activities of the Organization have temporarily deferred the intended expansion of the research programme, pending the outcome of the scheme for establishing a central headquarters. Numbers of problems have, however, been brought to notice, most of which require urgent study, and it is abundantly clear that at the present time an active and wide research programme is an important necessity of the spring industry.

The Organization is gradually accumulating its own special testing equipment which includes machinery built from time to time in the course of researches. In addition to certain apparatus which has been designed at

Nottingham and Sheffield Universities, the second large radial test-rig has now been modified so that tests can be made on a variety of types of springs with varying stress ranges.

Nine research reports have been published in the Journal during the year, and a further report has been completed dealing with a fruitful phase of the research on electroplated springs at Birmingham University.

A report of particular industrial interest has been prepared by the Specifications Sub-Committee on properties of brass spring wires. The experimental work and testing involved have been carried out by the members represented on the Sub-Committee with the object of clarifying the variations which are known to occur in spring making properties of non-ferrous wires, in order to lay down for the first time a suitable basis for specifications and for raising the quality of the materials concerned.

Perhaps the most encouraging feature of the year has been the widening interest taken by firms in the results of the researches, as shown by enquiries and by notification of practical advantages which have been obtained by applying new knowledge in their factories. Nevertheless there is much more which could be done in this direction, and every effort is being made to ensure that all work of practical benefit is utilized. The lecture and open discussion held at the 1952 Conference proved most successful and helpful to the Research Committee and staff as well as to the body of the industrial members.

SPRING STEELS

Following the series of tests on decarburizing scales the more recent work has been devoted to the study of the separate effects which may be involved in decarburization. These are the loss of carbon, the intrusion of the relief constituent in the austenite boundaries, and the formation of fissures coated with oxide. The experiments include the production of decarburization by reducing gases and also the possible restoration of the carbon content of the outer layer by carburizing media. By measuring the effects of these factors in torsional fatigue tests on straight specimens it is hoped to obtain data which will be of basic value as well as of direct usefulness for application to any subsequent industrial experiments.

CORROSION AND PROTECTION OF SPRINGS

Following the determination of the nature of the stresses imposed by thin electro-deposited coatings of nickel and zinc, with and without intermediate coatings of lead, fatigue and corrosion fatigue tests (rotating beam) have been made on standard straight wire specimens plated under similar conditions. In a work's laboratory, fatigue and corrosion fatigue tests were then made on two standard designs of spring, electroplated similarly to the wire specimens. Generally these gave confirmatory results. In contrast to the previous fears that the protection of springs against corrosion implied a distinct risk of deterioration in mechanical properties, the present position would seem to be that springs prepared and plated by methods which avoid hydrogen embrittlement can actually be mechanically improved by a protective zinc coating. Further work on the subject concerns the effects of low temperature heat treatments and electro-deposited coatings of additional metals.

ELASTIC PROPERTIES OF WIRES

In view of the importance of the elastic properties of wires of non-ferrous materials, as well as those of cold drawn and heat-treated steels, the Research Committee has decided to restart the research, which was suspended last year.

TORSION TESTING AND TORSIONAL PROPERTIES OF SPRING MATERIALS

Static torsion studies have shown that decarburization produces a lowering of the overstrain curve, and assist in this respect the harmful influence of scale on the efficiency of the quenching operation. Further work on the effects of low temperature heat treatments on overstrained silico-manganese spring steel has shown that at temperatures as low as 300°C. there are two stress relieving operations taking place, affecting both the textural and body stresses in the material. For the section on prestressing of cold drawn wires, a small torsion testing machine and associated torsionmeter were designed and constructed. Cold drawn wire was found to have similar prestressing characteristics to heat treated spring steel. As regards low temperature heat treatment, it was found that the optimum elastic properties were producible by the addition of a treatment (at 200°C. for 10 minutes) before prestressing. This programme should be of direct assistance to the light spring industry, particularly in the manufacture of highly stressed springs.

SPRING ENDURANCE

Several programmes of tests have been carried out on the large radial test rig. The work as a whole has emphasized the interfering effects of the variable surface quality of black rolled bar and of local defects which can be introduced accidentally in manipulation of springs during manufacture. Further work deals with the determination of the effects of water quenching of heavy springs with different tempering temperature. The new rig, with its facilities for determinations of complete springs under suitable variable stressing conditions, should find increasing use as a research tool for amplifying and applying the results of the more basic laboratory work on small straight specimens.

PROPERTIES OF NON-FERROUS WIRES

The frequent need for non-magnetic and corrosion resistant springs, and the recent developments in new types of alloy, including some specially adapted for high temperature service, involve manufacturing techniques which have not yet been properly studied from the points of view of economy and optimum properties. Further work on this item is planned as soon as facilities become available.

STRANDED SPRINGS

The experimental designs which have been made by various methods and specially tested have added considerably to the knowledge necessary for the accurate design of this type of spring and for the laying down of suitable conditions of manufacture of the basic material. The work is being continued by the Sub-Committee concerned in conjunction with design departments.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st April, 1952 to 31st March, 1957, a block grant of £5,000 per annum is made provided £6,000 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 £5,000.

The income of the Organization for the last completed year was £19,914.

THE COAL TAR RESEARCH ASSOCIATION

The main research effort has been devoted to the further development of projects already in hand. There has been no radical change in research policy, the projects falling into the three main categories—increasing our knowledge of the physical and chemical nature of the industry's raw material; maintaining and increasing the outlets for pitch and creosote, the bulk products of tar distillation; and helping the industry to overcome its day-to-day problems.

CHEMICAL AND PHYSICAL NATURE OF TARS AND PITCHES

During the year seven tars have been completely assayed. The results obtained, together with those obtained in earlier assays, have been studied to determine whether any correlation exists between the chemical composition of a tar and its physical properties. A method of calculating the naphthalene and anthracene contents of a tar from a knowledge of the physical properties of the distillate oils produced from the tar under standard conditions has been devised. The phenol and carbazole content of horizontal retort and coke-oven tars can be similarly calculated but the method is not valid for vertical retort tars.

In the analytical study of the high-boiling tar acids the isolation and identification of the meta and para isomers of isopropyl, n-propyl and n-butyl phenols are noteworthy since hitherto components of tar containing alkyl groups other than methyl have rarely been encountered. It has also been shown that 4–indanol is a major component of these high-boiling tar acids and can be isolated in good yield.

A similar study on the chemical composition of a pitch coking distillate has been in progress. Twenty-two compounds have been isolated and identified in this oil including propionamide, 2:6–dimethyl anthracene, 4:9–dimethyl pyrene, 1–methyl chrysene and 11:12–benzfluoranthene, all of which have not hitherto been reported in coal tar.

Further studies on the electrophoresis and ultracentrifuging of tars and solutions of pitch and pitch fractions and the determination of molecular weights of pitch fractions have tended to confirm the view put forward earlier that tars and pitches contain little, if any, colloidally dispersed material or molecules of high molecular weight, but that the component molecules are strongly associated. Employing the novel technique of osmosis through polyvinyl alcohol membranes of controlled porosity the molecular weights of the fractions of pitch resins have been found to be in the range 300-700 and that of the nitrobenzene soluble portion of the "C_2" fraction to be about 1,100.

UTILIZATION OF PITCH

The only major outstanding problem in the commercial production of carbon ceramics from pitch is the prevention of strain cracks during the firing of large articles. This problem and the commercial assessment of pitch carbon ceramics are being studied in co-operation with a large manufacturer of carbon ceramics.

The production and properties of pitch modified by air-blowing at 325°C. have been further studied during the year and production on a larger scale established. Air-blown pitch is being evaluated in tar paints, roofing felts, road tar, etc., and a considerable amount of interest is being displayed by the industry in this modified pitch. Other methods of modifying the structure of pitch have been studied but without beneficial results. Treatment of

pitch with small amounts of concentrated sulphuric acid, for example, was found to break down its structure and completely destroy its adhesive properties.

In the industrial use of pitch it is normally blended with oils or applied to a solid material at temperatures between 100 and 200°C. On exposure to air at these temperatures pitch increases in viscosity and loses some oils by evaporation. In practice it is important to minimize both the increase in viscosity and the loss of volatile material and the effect of any modification of pitch on its volatility must be assessed. A considerable amount of work has been done during the year on the factors underlying the hardening of pitch on exposure to air at elevated temperatures. It has been shown that with coke-oven pitch the main cause of hardening at temperatures below 175°C. is evaporation but above this temperature oxidation becomes important. In contrast, with vertical retort pitch, oxidation is a major factor at all temperatures. The relation between the rate of viscosity increase and the time of exposure when a pitch or a pitch flux mixture is heated in air can be expressed by $\Delta s = kt^n$ where Δs is the change in softening point in t hours and k and n are constants. The effect of such variables as temperature, amount of fluxing oil, nature of fluxing oil and nature of pitch on these constants has been assessed.

Large amounts of pitch are used in admixture with creosote as a special fuel. The replacement of part of the creosote with cheap petroleum oils could lead to an increase in the consumption of pitch for this purpose. The Association has studied the problem and has determined the limits within which homogeneous blends of different pitches and creosotes and petroleum gas oils or fuel oils can be made up.

Another large outlet for pitch is in the briquetting of coal but certain types of pitch appear to be unsuitable for this purpose. A joint programme of research has been put in hand by the Association and the Central Research Establishment of the National Coal Board to determine the properties of pitch which make it most suitable as a briquette binder.

UTILIZATION OF CREOSOTE

The low temperature non-destructive hydrogenation of tar oils has been further developed in the laboratory and the process extended to the production of tetrahydronaphthalene and *trans*-decahydronaphthalene from both crude and refined naphthalene and to the removal of sulphur from anthracene and phenanthrene. Although it has been shown that the catalytic removal of sulphur becomes progressively more difficult as the boiling range of the feed stock increases, it has also been shown that in the hydrogenation stage the permissible sulphur level above which poisoning of the catalyst takes place is increased so that the process can be applied to anthracene and heavy oils and even to pitch distillates.

It had been hoped that the semi-scale plant to produce hydrogenated tar oils in larger quantities for evaluation would have been in operation before the end of the year. The desulphurization stage was completed and in operation during the year but difficulty in obtaining a gas holder and hydrogen compressor has delayed the completion of the hydrogenation stage. The desulphurization plant has been used to study the catalytic refining of benzoles and naphthas. With benzoles the results have varied with the nature of the crude: some samples were found to be adequately refined at low pressures and high throughputs while others, especially those containing pyrrole, depressed the activity of the catalyst and required elevated pressure for satisfactory results. Catalytic refining has the advantage over the present

process of acid refining in that no losses occur. It has, however, the disadvantage, especially in the treatment of naphthas, that some hydrogenation of the aromatic hydrocarbons accompanies desulphurization, leading to products of low specific gravity.

In order to obtain the necessary data for the design of a semi-technical plant for the fluidized catalytic oxidation of tar oils it has been necessary to study the production of an active oxidation catalyst in suitably finely divided form and to make a study of the conditions necessary for effective fluidization. Both of these problems have been solved. An oxidation catalyst in the form of microspheres has been developed which does not suffer attrition when fluidized and which gives a 10 per cent. increase in the yield of phthalic anhydride from naphthalene oil compared to the catalyst used in earlier static bed experiments. Methods have also been developed for calculating both the minimum and maximum gas velocities for the operation of a "boiling bed" reactor from the dimensions and bulk density of the catalyst. It has, therefore, been possible to finalize the design of the semi-technical plant; all the parts have been made and the plant is now in course of erection.

Further study of the production of thermoplastic resins from tar oils showed that the reduction in cost of the raw material was offset by a lower yield and higher solvent losses, so that these resins could not be produced more cheaply than the lighter coloured products from pure hydrocarbons such as naphthalene. Several methods of cheapening the production of tar oil-formaldehyde resins were found but a more promising development is the simultaneous production of these resins and pure hydrocarbons. It has been found that the rates at which aromatic hydrocarbons react with formaldehyde differ widely and that by reacting a tar fraction with sufficient formaldehyde to condense with the more reactive compounds, the less reactive components can be separated from the resin in a state of high purity. Thus pure phenanthrene and fluorene can be obtained from coke oven anthracene oil, fluoranthene and chrysene can be separated from pyrene and from a lower boiling oil pure diphenylene oxide can be obtained in good yield. This process is now being studied on the large scale using the equipment in the "unit process" laboratory which was set up during the year for the production of evaluation quantities of tar chemicals and their derivatives.

SERVICE PROBLEMS

Corrosion

The work carried out during the year on the corrosion of mild steel tar distilling equipment by hot tar and tar oils has greatly clarified the confusion which has hitherto existed on this topic. It has been shown that the corrosive agents in the lower boiling oils are not the phenols but traces of inorganic salts. In the oils boiling from 200-250°C. both tar acids and inorganic salts contribute to the observed attack on mild steel but, in the oils boiling above 250°C., the main corrosive agents are the phenols. Addition of alkali to the tar inhibits the attack by the inorganic salts but does not prevent or minimize attack by phenolic compounds and therefore is of very limited value. The attack on mild steel increases greatly with the temperature: little attack occurs below 275°C. but on increasing the temperature from 300 to 425°C. the corrosion is increased five-fold. This emphasizes the necessity of restricting still temperatures and the advantage of conducting the later stages of the distillation in corrosion resistant equipment. The only metals which are substantially unattacked by hot tar oils are stainless steel

and aluminium. Certain aluminium paints protect mild steel but only for a limited period; it is hoped that mild steel sprayed with aluminium will prove more satisfactory.

Formations of Deposits in Tar Stills

The cause of carbon deposition in the heater tubes of tar pipe stills is the cracking of the tar which occurs at points where the tube wall temperature exceeds 400°C. In certain plants changes have been made in the method of operation in conformity with the Association's findings and have resulted in greatly extended periods of operation without coking of the coils. The cause of solid deposits in tar dehydration coils has also been studied and the results indicate that such deposits arise from solid impurities suspended in the incoming tar which precipitate at the point at which the last trace of water is removed.

Determination of Chemical Engineering Data on Tar

There is a serious lack of data on tars and tar oils which handicaps the industry in designing new plant and in assessing the efficiency of existing equipment. The Association intends to determine such data on samples submitted by members. To this end apparatus has been constructed and calibrated for determining vapour pressures and specific heats; units for measuring flash vaporization curves and thermal conductivities of liquids have been built and are being calibrated, while apparatus is under construction for the determination of the thermal conductivity, specific heats and viscosities of vapours.

General

During the year 147 analyses of various types were carried out at the request of members. A method of determining the amount of 4-chlorophenoxy-acetic acid in mixed chlorinated phenoxy-acetic acids was worked out at the request of one member and a method for the determination of traces of iron in effluent standardized for another member.

LIBRARY AND INTELLIGENCE SERVICES

Two further issues of the *Review of Coal Tar Technology* have been published. In spite of an increase in the price of this publication its circulation has continued to rise. Section A of *The Coal Tar Data Book* which deals with the properties of the more common constituents of coal tar, has been published and issued to members.

Twenty-four reports were issued during the year. Twelve were research reports dealing with the Association's work and eight were translations from the French, German or Russian. Four papers were published by the Association's staff in the scientific Press and three further papers have been submitted for publication. Four provisional and one final patent specifications were filed by the Association during the year.

Members are making considerably increased use of the Intelligence Section and over 150 queries have been received and dealt with during the year.

CONFERENCE

The third annual Tar Conference held in Leeds on 4th and 5th November, 1952, attracted a record attendance of 122. The programme included two technical sessions at which seven papers on various aspects of the production and utilization of pitch were read and discussed, and two days in which the laboratories were open for inspection.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st April, 1948, to 31st March, 1953, a block grant of £12,000 per annum was made provided £24,000 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.

For the period 1st April, 1953, to 31st March, 1958, the block grant is £12,000 per annum, provided £45,000 is received from industry, and the additional grant £50 for each additional £100 contributed by industry up to a maximum of £12,000.

The income of the Association for the last completed year was £68,486.

BRITISH WELDING RESEARCH ASSOCIATION

The research activities of the Association continue to expand, and in a previous report some idea was given of the extra facilities afforded by the new fatigue testing laboratory at Abington, opened last year. The laboratory houses most of the fatigue work, and is now in active use.

Early in 1953 the Association published a handbook on the welding of corrosion and heat-resisting steels, which has been widely reviewed and commended. Also during the year a number of patents have been taken out, based on developments which have been made during the course of the investigations, and an agreement has been entered into with the National Research Development Corporation whereby inventions will be developed and exploited without expense to the members, while at the same time ensuring that the Association will share in any royalties in excess of the cost of development.

Conversion of a section of the metallurgical laboratories is now largely complete, and provides facilities for micro-gas analysis and for routine chemical analysis. The equipment for gas analysis is designed particularly for the measurement of total hydrogen content, and a start is now being made to obtain basic information useful for researches on the welding of mild and alloy steels, and also for investigations now being carried out on light metals.

New equipment obtained during the year includes a small extrusion press for the light alloy researches, which will be used for the production in wire form of special alloys for welding investigations. A new metallurgical mounting press has been acquired, together with a good deal of auxiliary equipment needed for vacuum work in connection with the gas analysis apparatus. Arrangements are in hand to obtain a function plotter (with dynamometer), an instrument for plotting mechanically the function derived from two independent variables externally translated into electrical impulses. This will considerably accelerate work already in hand on the assessment of weldability of low-alloy steels, and is expected also to expedite some of the other investigations.

Membership of the Association has continued to show a gratifying upward trend during the year, and at the present time there are 260 ordinary members and 27 associate members, compared with 237 and 24 respectively last year. The staff of the Liaison and Development Department, though now reduced in number, continues to give a useful service. Many problems have been

investigated during the year, and in nearly all cases satisfactory solutions have been found. A feature of its activities is the speed with which enquiries are handled.

The Summer School, held at Ashorne Hill from 27th April to 2nd May, 1953, was filled to capacity for the third year in succession, and some of the applicants could not be accommodated. The School departed from the tradition of imparting simple instruction in the art of welding, and the general theme this year was Welding Fabrication and Production. A division was made according to the needs of specialized groups, i.e., the aircraft, ship-building, structural engineering, car and sheet metal, and general engineering industries. The School was a considerable success, and provisional arrangements have been made for a similar function next year.

SPECIAL RESEARCHES

Brittle Fracture

Following the occurrence of catastrophic failures due to brittle fracture in structures previously thought to be immune from this trouble, the Association initiated an investigation of the mechanics of brittle fracture under the direct supervision of the Research Board. Two significant contributions have been made, firstly in the recognition of the important part played by strain hardening in initiating fractures from the root of notches, and secondly in the development of a simple method for the accurate measurement of the energy absorbed in creating unit surface area of crack by recording the temperature wave released. The work has led to the concept of a minimum size or length of crack for the propagation of fracture to take place at a given general elastic stress level, which should be useful in the determination of weld fault size tolerances. The work has been published,* and was also discussed at the West of Scotland Iron and Steel Institute Symposium on Brittle Fracture.

Nitrogen-Arc Welding of Copper

A short investigation in the Association's metallurgical laboratories has established the feasibility of using nitrogen as a neutral shrouding gas for the welding of copper and its alloys. Graphite electrodes were used in place of tungsten electrodes, as the latter tended to be attacked to some extent by the nitrogen at high temperatures. A report has been issued to members, together with brief résumés of the work carried out at the works of two firms on the same subject.

FERROUS METALS

Constitution of Weld Metal

Further trials have now been made with the double-fillet test in several laboratories outside the Association. It has been found possible to distinguish between two electrodes, differing only in the sulphur content of the deposited metal, values, however, lying within the normal range. In spite of the proved value of the test as a research tool, the committee has reluctantly abandoned the idea of its wider application as a workshop test, because of the special precautions required. The new furnace which is to be used for tensile tests in hydrogen and other atmospheres at high temperatures has been completed. With the rapid advance of the facilities for routine and special gas analyses, it is now possible to plan a broad constitutional approach to the problem of hot cracking, covering chemical composition, gas content and non-metallic inclusions.

* WELLS, A. A. Mechanics of Notch Brittle Fracture. *Welding Research*, April 1953, p. 34.

A programme of work at the Northampton Polytechnic on the identification of inclusions in weld metal has involved the development of a new micro-X-ray method. A number of the more recent types of electrode are being examined, also the effect of arc length on the type of inclusions present.

Higher Strength Weldable Structural Steels

A report has been issued to members on the subject of two selected steels chosen from the experimental series of Mn-Ni-Cr-Mo steel examined in the form of two-ton casts. Investigations made for the Ministry of Supply have shown that in steels of similar composition vanadium can be substituted for molybdenum, retaining good weldability and mechanical properties. About half as much vanadium as molybdenum is required. Moreover, it has been shown that a good value of the 0·02 per cent proof stress is obtained using vanadium steels in the normalized condition. This is only possible after tempering with the molybdenum steels.

It has been found that hydrogen depresses the temperature of the austenite/martensite transformation in low alloy steels. In addition, using a thermal treatment simulating the conditions in the hardened zone, hydrogen has a deleterious effect on the mechanical properties, particularly the static tensile strength. This may account for the harmful effect of hydrogen in relation to hardened zone cracking.

Oxygen Cutting

It has been shown that the combustion rate of steel in oxygen is affected both by impurity in the oxygen and by the percentage of carbon in the steel, the latter having an effect five times as great. With a limiting carbon content of about 1½ per cent combustion stops altogether.

LIGHT ALLOYS

Fusion Welding of Light Alloys

Some attention has been given to the metal-arc welding of aluminium-5 per cent magnesium plate with the collaboration of the electrode manufacturers. At the present time, however, priority is being given to the development of an improved electrode for the welding of H.10 alloy. A controlled arc welding head has been constructed, and is now available for tests in connection with the self-adjusting arc and controlled arc welding of magnesium alloys.

A joint investigation is being undertaken with the Electrical Research Association to examine the fundamentals of the self-adjusting arc process. Good progress has been made in the investigation of the relationship between the various fundamental factors, and this will be used to examine the more complex factors, such as weld penetration. A detailed programme has been drawn up to investigate the cause of porosity and its control, and for this purpose determination of hydrogen by vacuum fusion, using the apparatus described earlier, will be required.

Welding of Heat-Treatable Light Alloys

The fusion welding of heat-treatable aluminium alloys is receiving considerable attention and preliminary work has shown that the amount of cracking experienced under conditions of restraint, using both the argon-arc and self-adjusting arc processes, is appreciably less than that expected from the published literature. After heat treatment weld efficiencies of not less than 90 per cent were obtained.

ENGINEERING

Load-Carrying Capacity of Frame Structures

Good progress has been made in the application of the new plastic design methods associated with the name of Professor J. F. Baker of Cambridge to the study of problems such as the instability of continuous stanchions, the lateral instability of beams, the behaviour and design of rigid welded joints, and the plastic behaviour of unsymmetrical sections.

A pair of full-scale pitched roof Portal frames with fixed bases was tested to destruction at Abington in the summer of 1952, and a full report on this test has now been prepared.

Behaviour of Welded Structures under Dynamic Loading

The principal item of research in the fatigue work is a long term investigation of the fatigue strength of butt and fillet welded joints in mild steel. Eventually this work will be directed towards a study of the correlation of fatigue results with the radiographic appearance of the welds, and for this purpose will embody tests on defective welds.

Push-pull fatigue tests on high-tensile steel structural members were completed during the year, the tests being designed to examine two series of specimens differing in the extent of micro-cracking in the heat-affected zone adjacent to the welds, to elucidate the effect of this cracking on the fatigue strength. The results have shown that the presence of micro-cracking significantly reduces the fatigue limit though tests are still in progress using various forms of specimen to examine the effect more fully.

Work at the Manchester College of Technology has shown that the endurance limit can be reduced by flame cutting, though this effect is not large.

Testing of Welded Pipes and Pressure Vessels

The investigation of short-radius pipe bends under static forms of loading has now been completed, and is summarized in two papers presented by the Institution of Mechanical Engineers on 12th December, 1952. Tests on seamless welding tees subjected to internal pressure and to two forms of external loading have been completed, and a report is in preparation for issue to members of the Association. Two unreinforced welded branch connections have also been tested. One of these had a ratio between the branch and the barrel diameters of 5:6, and the other a ratio of 1:1. The strains on both inside and outside surfaces have been measured under four conditions of loading, namely internal pressure, axial loads on the branch pipe, moments on the branch pipe in the plane of the specimen, and torsion moments on the branch pipe. A test on an equal branch welded connection with a conventional plate type reinforcement has been planned, in order to obtain information about the modification of the stress systems caused by the addition of a reinforcement of this kind. Two series of fatigue tests on 6-inch diameter mild steel pipes have been completed. The first series was carried out under alternating bending, and the second under pulsating pressure. In each case the following specimens were tested: plain pipes in commercially finished condition; pipes with metal-arc welded butt joints, and pipes with oxy-acetylene welded butt joints. The welded joints, made without backing rings, were carefully produced to show good radiographic quality so that the fatigue results could be taken as a control basis for the investigation of poorer quality welds. The possibility is being considered of locally machining the bore of the pipe specimens to produce a smooth inside surface at the weld, and carry out fatigue tests on such specimens if

this operation can be successfully applied to the 9 ft. long pipes required for the alternating bending type of loading. In addition, metal-arc welded pipes with backing rings will be investigated.

A series of tests on metal-arc butt joints with lack of penetration has also been planned in order to make a start on the main programme of testing defective welds. Throughout this programme, radiographic records of the welds will be kept for the purpose of comparing fatigue and radiographic results.

PROJECTION, SPOT AND STUD WELDING

A short series of tests has been made on resistance welding of bolts with the projections on the underside of the bolt-head. Satisfactory results have been obtained. A further series of tests has been carried out on double projection welding of low-carbon mild steel sheet. An important aspect of the work lies in the preparation of a code of practice for projection welding of mild steel, which will shortly be available to members. A prototype instrument has been completed as a workshop recording unit to measure simultaneously loading, current and time in spot welding. A revised interim code of practice has been completed for the spot welding of low-carbon steel. An investigation into the effect of steel quality on spot welding has now been completed with additional experiments to determine the effect of a final skin-pass reduction after annealing. Methods for the measurement of the temperature cycle during a spot weld are still being investigated, and a theory relating energy and weld time to size of weld, which was developed for this investigation, has been successfully used to predict welding conditions for a number of tests in projection welding.

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 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 £20,000.

The income of the Association for the last completed year was £93,362.

RESEARCH COUNCIL OF THE BRITISH WHITING FEDERATION

The first five-year period of the Research Council of the British Whiting Federation ended in December, 1952. The membership has so far been limited to the whiting industry, and the scope of research to the manufacture, properties and uses of whiting. The organization has operated successfully on this basis. It has, however, been recognized that some broadening of the membership and field of research would be advantageous. Negotiations have been pursued during the past year with the chalk-lime and the sand-lime industries with this aim in view. Chalk is a raw material for all of these three industries and their research interests are closely related.

PROGRESS OF INVESTIGATIONS

An investigation of the chalk deposits from which the raw material is drawn for whiting manufacture has involved determination of the variations

in chemical composition, porosity and hardness (compressive strength) of the various beds in each quarry, and the relation of these figures to the geological zoning and the locality. Promising results are being obtained in the investigation in progress at University College, London, which is being made, with the co-operation of the Research Council, into the possibility of narrow zoning of the chalk by the foraminifera content.

Some improvements have been made in the methods of determining the minor constituents of chalk and whiting; the exact amounts of minor or trace impurities such as iron, copper and manganese, may be of appreciable significance in relation to some uses of whiting. Work has proceeded on standardizing and simplifying routine test methods for works control. These include (*a*) the use of a vacuum flask instead of a thermostatic water bath in particle size distribution determinations by sedimentation, and (*b*) the use of a volumetric method for determining calcium carbonate and magnesium carbonate content. Individual members have been advised on the application of testing for control purposes. The possibility of mechanizing the tedious operation of sieve testing, and of automatically recording the results, is being investigated.

Two types of modified whiting developed in the laboratories have been made on a production scale at the works of members. The potential uses of these products are being studied. One, having an oleophilic coating, should be advantageous for use in paint and rubber. Investigations of its use in these materials are being made by the Research Associations concerned in co-operation with the Research Council's laboratories. The second product, having enhanced properties of dispersion in aqueous mixes, has been shown to have possible uses in building mortars, plastering mixes, etc.

Interesting results have been obtained in the study of the rheological properties of linseed oil putty. An apparatus has been devised for measuring the extensibility and strength of putties, which have previously only been assessed by the craftsman by stretching a lump of putty in the hands. The effects of temperature, oil content and time and vigour of mixing in laboratory mixers upon these and other properties have been determined, and further studies of the effect of the quality of the whiting and of the effects of additives are being made. The methods of test used are applicable for works investigations to compare efficiencies of different types of mixing plant, and for controlling quality of putty.

A considerable proportion of effort is being devoted to a study of the efficiency of work processes. In particular the drying processes in whiting manufacture are being studied to compare relative costs and efficiencies. The operating conditions of drying plants in members' works are being investigated and measurements made of the variables affecting thermal efficiency. It has been possible to suggest measures for making substantial economies in those plants which have so far been studied. Experimental results with a type of hydraulic classifying plant not previously applied to whiting have been promising, and a pilot plant has been designed as a mobile unit to be used in members' works.

PUBLICATIONS AND SERVICES TO MEMBERS

Papers on *Hydraulic Classification* and *Drying Processes* have described the theoretical background to the operational research work on these subjects.

The results of work of the laboratories and other information has continued to be made available to members by means of *Technical Papers, Technical Notes, Circulars, Translations,* and the quarterly *Bulletin,* as well as by personal discussion, correspondence and meetings.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st January, 1948, to 31st December, 1952, a block grant of £4,000 per annum was made provided £7,500 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 £4,000.

For the period 1st January, 1953, to 31st December, 1955, the same terms apply.

The income of the Research Council for the last completed year was £12,929.

WOOL INDUSTRIES RESEARCH ASSOCIATION

The official opening of new laboratory and other blocks for processing research at Torridon was performed by The Right Honourable Viscount Swinton, P.C., G.B.E., C.H., M.C., then Chancellor of the Duchy of Lancaster and Minister of Materials, on Friday, 17th October, 1952. Mr. I. C. Hill, Chairman of the Council, introduced Lord Swinton to 500 members and guests who attended the ceremony, and Mr. A. R. Baines, C.B.E., F.T.I., past Chairman of the Association and now Chairman of the Wool Textile Research Council, moved a vote of thanks. Exhibitions of work in progress and of research results were shown in the new buildings and in the worsted spinning shed. The laboratories were again open to members and guests on Saturday and the following Monday; the total number of visitors was around 2,000. The Opening Ceremony and the exhibitions in the laboratories did much to bring the work of the Association to the notice of members.

During the year the industry made a rapid recovery from the recession of 1951-52, and the number of operatives employed is reaching a record post-war total. As the income from the statutory levy for research depends on the number of operatives in the industry, it should increase from this circumstance alone; in addition the amount of the levy per operative was increased during the year. The income likely to be available to the Association should, therefore be a satisfactory one. There have always been some misgivings that the use of a statutory levy to finance Research Associations might result in members taking less interest in the activities of the Association. The reverse has been the case so far as wool is concerned: members are obviously consulting the staff more often about processing problems, and a direct indication of their concern for the well-being of the Association, has been the record number of nominations for election to vacancies on the Council.

THE NOBEL PRIZE

The award of the Nobel Prize in Chemistry for 1952 to Drs. A. J. P. Martin and R. L. M. Synge, is a very great honour for the Association. They have been awarded this prize for the discovery and development of partition chromatography, work which they carried through as members of the staff of the Association. It was whilst attempting to analyse the amino-acids in wool hydrolysates that they discovered this most powerful and sensitive method of analysis: the original discovery was published in 1941. Dr. Synge

left the Association in 1943 and Dr. Martin, with other colleagues, developed the filter paper partition chromatogram which is now universally used for chemical analysis. This work was published in 1944. Methods which they developed when at Torridon have proved most powerful in medical science and they are both now working in this field, Dr. Martin at the National Institute for Medical Research, Mill Hill, London, and Dr. Synge at the Rowett Research Institute, Aberdeen.

PROCESS RESEARCH

The Worsted Spinning Sub-Committee has had under consideration for some time the installation of a full scale drawing and spinning plant. Space made available by the new buildings has now made this possible, and a plant which comprises one full sized machine for each process is now in use. The main objective in setting up this plant has been to provide facilities for trying out new devices and to determine where in the series of operations that constitute worsted drawing, the machines can best be used. Work done with the pilot plant hitherto available has always been open to the criticism that processes which work on machines restricted to a few spindles would not necessarily be successful using full sized frames, which are subject to torsional vibration and other troubles. A number of new devices are becoming available which will be examined with this plant, such as high draft spinning, autolevelling units and high speed gill boxes.

The Worsted Spinning Sub-Committee has also been concerned about the correct way of using yarn levelness testers which are now commercially available. There are many ways of expressing yarn levelness but there is still much uncertainty as to which numerical measure expresses best the appearance of the yarns in a fabric. Thus, a small irregularity that repeats according to the width of the cloth may be much more serious than a larger one which arises in random fashion and gives rise to no resonance effect in the cloth. The experience of the industry in using these testers is being pooled by means of a committee drawn from experienced testers and users of yarns. The members of the committee report their experiences to the Association and bring forward examples of yarn where cloth appearance does not agree with measurements given by the mechanical tester. The Association examines these cases and from the assembled information should be able to determine the best method of expressing yarn irregularity in the form of a number.

The behaviour of fibres during drafting in the worsted process has long been a subject of conjecture. The whole success of drafting depends on proper control of the fibres so that each fibre is accelerated from the speed of the back rollers to that of the front rollers, in its proper turn. How far this condition is fulfilled has not hitherto been established although many deductions have been made from measurements of drafting force and changes in the regularity of a sliver before and after drafting, together with the use of appropriate theories of drafting. Recently the Association has been able to use radio-active isotopes to follow exactly when and how fibres are accelerated in this critical zone. Fibres impregnated with radio-active phosphorus have been found to behave in slivers in exactly the same way as non-treated fibres, but being labelled, their position, even in the thickest slivers, can be observed. Using this method it has been possible to trace

out just where and when labelled fibres are accelerated in the drafting zone. The results indicate that whether or not the fibre moves at the speed of the back or the front rollers, is very much a question of chance, and is not determined entirely by the frictional forces that have been considered in present theories of drafting. Thus, a fibre may be accelerated from the back to the front roller speed and subsequently revert to the back roller speed before finally being picked up by the front roller nip. This use of radio-active isotopes is, therefore, giving considerable new insight into a process which forms the basis of many textile operations.

Much of the laboratory work that has been done on the use of scouring agents is now being applied to large scale processing with the plant available in the new buildings. This plant is designed to take full pieces of fabric, and to overcome the cost involved in use of such expensive material, members have supplied grey pieces which are scoured in the Association's plant and subsequently returned for finishing and sale in the ordinary way. This has enabled much work to be done in finding out how improved scouring processes can be used in full scale processing. Most of the fabrics that have been tackled so far have been successfully scoured by methods that were indicated in the laboratory as being the correct ones, and in every case so far examined considerable saving of scouring materials has proved possible. This full scale processing will enable the Association to put forward scouring procedures with much more confidence than has hitherto been possible.

Another development during the year has been the formation in Kidderminster of a technical committee for the carpet industry. The Association, working with this committee, has developed methods for measuring the abrasion of carpets and is now using these methods in a programme designed to determine the best wools and other fibres for resistance to abrasion and other desirable features in carpets.

FUNDAMENTAL RESEARCH

Research on the friction between fibres has been further extended and the theory relating the amount of the frictional force to the elastic properties of the fibres together with their shear strength, has been shown to predict a directional frictional force for wool fibres. The theory has thus been linked up to the felting of wool.

The theory of static electricity which was mentioned briefly in last year's report has shown that anti-static materials need not be spread on the fibres to avoid electrification. They need only be present in minute amounts in the nip where the fibres leave the rollers. This conclusion has been checked by use of sintered metal rollers impregnated with anti-static materials. These have proved most effective in avoiding static and the fibres coming from the rollers carry away negligible amounts of the material; in fact, the impregnated rollers merely provide the small amount of conducting material necessary between the fibres and the rollers at the point where the fibre leaves the rollers and where the biggest accumulation of charge arises.

The Association, in co-operation with the International Wool Secretariat and the Agricultural Research Council, has maintained a small flock of sheep at Cambridge for some years. These have been used to study the inheritance characteristics of fleece, and by following a systematic breeding

policy the flock has now been divided into two strains, one with hairy and the other with smooth-coated fleece. This work is being extended to investigate the effect of nutrition on fleece characters and for this purpose some of the Cambridge flock is being transferred to the Rowett Research Institute, Aberdeen, where appropriate facilities are available.

LIAISON WITH INDUSTRY

Liaison with the industry has been maintained by visits of liaison officers together with a continuance of the discussion meetings which were mentioned in previous years. In addition the Association has brought out a new publication entitled *The W.I.R.A. News Letter* which gives the results of research and indicates how these results may be applied in the factory. The *News Letter* is written to appeal to foremen and overlookers and members are encouraged to pass this publication to these personnel. They may have extra copies to make this possible and as many as 100 copies of each number are used in the larger factories. The *News Letter* has been generally welcomed as an excellent method of showing how research can be applied in the day to day operation of a mill.

During the year there has again been much call on the Association for help in establishing quality control laboratories in members' factories. This is a development that shows how far the results of the Association's work are now being put to good use in improving both quality of product and the productivity of the industry.

TERMS OF GRANT AND INCOME

Under the terms of grant for the period 1st October, 1951, to 30th September, 1953, a block grant of £30,000 per annum was made provided £80,000 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 October, 1953, to 30th September, 1956, the block grant will be £40,000 per annum, provided £100,000 is received from industry, and the additional grant £100 for each additional £100 contributed by industry up to a maximum of £30,000.

The income of the Association for the last completed year was £165,606.

OTHER GRANT-AIDED ORGANIZATIONS

In addition to the Research Associations, grant has been given during the year to three other organizations carrying out work of special importance to industry. Brief accounts of their work are given below.

ASLIB

The past year has been one of rapid development and reflects a growing awareness of the value of information services. The systematic campaign for new members mentioned last year has continued to meet with success and during the period the membership has risen to 1,550, representing a 50 per cent. increase since 1949, when the move to larger premises and subsequent re-organization took place. In line with this increase calls on the services of the Aslib Information Department have risen from 2,700 to

over 12,000 a year, with a corresponding increase in the use made of the Document Reproduction Service. In addition Aslib has begun to furnish the services of consultants in special library and information processes.

As part of a Commonwealth-wide scheme in which Aslib, under contract to the Department, acts as the United Kingdom Centre, a location index has been set up of unpublished translations of foreign scientific and technical papers available throughout the Commonwealth. A new panel of specialist subject indexers, similar to the existing panel of specialist translators, has also been formed.

In 1952, a start was made on the task of publicizing information services within industry by means of a conference held jointly with the Federation of British Industries. New branches were formed—one in Scotland in 1949 and one in the Midlands in 1951—to extend Aslib's influence in those areas; some 170 members now belong to the Northern Branch, 105 to the Midlands Branch and 55 to the Scottish Branch. A new development has been the formation of specialist information groups as a basis for co-operation within certain industries and fields. Groups now exist for aeronautics, chemicals, economics, engineering, food and agriculture, fuel and power, and textiles. A new training course for information officers at the intermediate level has also been introduced into the annual programme, and work has begun on a number of new manuals, directories and other aids to information work, including a new edition of the Aslib *Directory to Sources of Specialized Information* which was first published in 1928. A noteworthy project undertaken in 1953 was the publication on microfilm of the Patent Office's *Class Allotment Index*, 1939–1953, the only subject index available for British patents for that period at the time.

The year completed Aslib's second five-year grant-period, the amount of grant in 1953 being £6,000, compared with £2,500 in 1949. Aslib's gross income doubled from £11,000 in 1949 to £22,000 in 1953.

COMMONWEALTH MYCOLOGICAL INSTITUTE

The work of the section of the Institute concerned with the collection of fungi consists largely in obtaining specimens of new cultures which appear likely to be of potential interest to industrial users. Cultures are required mostly for testing various kinds of equipment for mould resistance, chiefly electrical apparatus but also plastics, textiles, wallboards, paint, leather, printers' inks, etc. Other uses by industry are in the production of chemicals by biological synthesis for preparation of enzymes and for biological assay of chemicals. A collection is being built up of fungi used for special purposes such as the production of amylose, alternaric acid, aspergillin, baking yeast, citric acid, etc., and for manganese and molybdenum assays.

A *Catalogue of the Culture Collection* has been published during the year and there is little doubt that its appearance will stimulate interest in the collection and will lead to an increase in the number of cultures issued. At present, about 800 cultures are issued annually.

A number of culture techniques have been developed by the Institute in the past five years, including a simple but effective method of controlling mites by using kerosene, which enabled the outbreak of a *Cephalosporium* species to be controlled. This method has now been adopted in a number

of laboratories with equal success. The Institute was the first to adopt the use of screw-top bottles for culturing fungi, and a compact culture hood has also been devised for making transfers of fungi with readily dispersible spares.

Grant for the maintenance and expansion of the collection of industrial fungi will, for the next five-year period starting 1st April, 1953, continue at the rate of £1,000 a year until the appointment of an additional mycologist and thereafter will be at the rate of £2,000 a year.

MANCHESTER JOINT RESEARCH COUNCIL

The survey, on the use of science by industry, which was referred to last year, has now been completed by the Manchester Joint Research Council for publication early in 1954.

The grant from the Department towards the cost of the survey is likely to be about £3,000.

APPENDIX I

Throughout this Appendix [1] *against a member's name shows that he retired and* [2] *that he was appointed during the year* 1952–53.

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Air Ministry	Air Vice-Marshal C. B. R. Pelly, C.B., C.B.E., M.C.
Colonial Office	[1]C. G. Eastwood, Esq., C.M.G. [2]W. B. L. Monson, Esq., C.M.G.
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Ministry of Food	Norman C. Wright, Esq., D.Sc., F.R.I.C.
Ministry of Fuel and Power ...	Sir Harold Roxbee Cox, Ph.D., M.I.Mech.E., F.R.Ae.S.
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* Membership of the Committees of the Research Boards is given in the Annual Reports of the Boards.

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* Died 25th December, 1952.

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* Died 29th March, 1953.

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APPENDIX II

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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	Bucknall's 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 Laboratory ...	Thorntonhall, near Glasgow	Busby 1171
CHEMICAL RESEARCH LABORATORY	Coleshill Road, Teddington, Middlesex	Molesey 1380
FIRE RESEARCH STATION ...	Boreham Wood, Elstree, Herts ...	Elstree 1341 or Elstree 1797
London Office	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 3441/2
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 Laboratory ...	Thorntonhall, near Glasgow	Busby 1171
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Scotland	"Southpark", 19, Grange Terrace, Edinburgh, 9.	Edinburgh 45203/4
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Lancashire District ...	102, High Street, Manchester, 13 ...	Rusholme 6760
Northern Ireland	20, College Gardens, Belfast, N. Ireland	Belfast 28041

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MECHANICAL ENGINEERING RESEARCH LABORATORY	East Kilbride, Glasgow	East Kilbride 20222
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PEST INFESTATION RESEARCH LABORATORY	London Road, Slough, Bucks... ...	Slough 21295
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Road Research Laboratory	Harmondsworth, West Drayton, Middlesex.	Colnbrook 116
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Scottish Laboratory ...	Thorntonhall, near Glasgow	Busby 1171
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Minworth Laboratory ...	Drainage Board Works, Kingsbury Road, Minworth, near Birmingham.	Ashfield 1200
Tilbury Laboratory ...	Tidal Basin, Tilbury Docks, Essex ...	Tilbury 3439

APPENDIX III

LIST OF RESEARCH ASSOCIATIONS AND OTHER GRANT-AIDED ORGANIZATIONS

[*The numbers in brackets against certain entries in column* (1) *refer to explanatory notes printed on page* 259.]

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, M.B.E. 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)
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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 81116. *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. 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., 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:* Netteswell Road, Harlow, Essex. Tel. No.: Harlow 2366–7.	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	H. N. G. Allen, Esq., M.A.(Cantab), A.M.I.C.E., A.M.I.Mech.E., A.M.I.N.A., M.I.Mar.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 25134. (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. 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.	W. F. Keay, Esq. H. Corteen, Esq., M.Sc., F.Inst.P., F.T.I.
Lace Research Association	*Laboratories and Office:* Glaisdale Drive, Bilborough, Nottingham. Tel. No.: Nottingham 75976.	J. G. McMeeking, 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 7848.	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 64061.	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 Office:* Great West Road, Brentford, Middlesex. Tel. No.: Ealing 4741-2. *Proving Ground:* Lindley, near Nuneaton, Warwickshire. Tel. No.: Nuneaton 2221.	J. R. Rix, 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 1063 and 2202.	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.	W. Whiteley, Esq., J.P. 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.	A. E. Watts, Esq. G. L. Riddell, Esq., Ph.D., 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) 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.	J. Ramsay Gebbie, Esq., C.B.E. 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 Organization.	*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.
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.: 51047–9.	I. C. Hill, Esq. 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.	*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.
Manchester Joint Research Council ...	*Office:* Ship Canal House, King Street, Manchester, 2.	*Chairman:* Sir E. Raymond Streat, C.B.E.

APPENDIX IV

(A) MAINTENANCE ALLOWANCES TO STUDENTS-IN-TRAINING, SENIOR RESEARCH AWARDS, AND GRANTS FOR DEVELOPMENT OF SPECIAL INVESTIGATIONS

Explanatory Note: Maintenance allowances to Students-in-Training and Senior Research Awards are normally made for two years, with a possible extension to three years. Grants for the development of Special Investigations may be made for one, two or three years according to the circumstances.

The cost of these grants during the year 1952–53 is shown in Appendix V.

TABLE 1

PARTICULARS OF APPLICATIONS RECEIVED IN RESPECT OF THE ACADEMIC YEAR 1952–53 (COMPARED WITH SIMILAR DETAILS FOR EARLIER YEARS)

	Students-in-Training			Senior Research Awards			Grants for Special Investigations		
	1950–51	1951–52	1952–53	1950–51	1951–52	1952–53	1950–51	1951–52	1952–53
A.—Applications granted	382	384	413	3	9	7	50	38	41
B.—Applications refused	365	556	420	14	16	18	20	35	36
C.—Applications withdrawn or referred elsewhere	106	105	132	4	8	10	7	2	—

TABLE 2

PARTICULARS OF THE TOTAL NUMBER OF GRANTS HELD IN THE ACADEMIC YEAR 1952–53 AS COMPARED WITH PREVIOUS YEARS

	1950–51			1951–52			1952–53		
	Continued from 1949–50	New in 1950–51	Total	Continued from 1950–51	New in 1951–52	Total	Continued from 1951–52	New in 1952–53	Total
1. Students-in-Training	528	382	910	539	384	923	563	413	976
2. Senior Research Awards	7	3	10	4	9	13	7	7	14
3. Grants for Special Investigations	45	50	95	53	38	91	29	41	70

TABLE 3

DISTRIBUTION OF GRANTS HELD IN VARIOUS BRANCHES OF SCIENCE

	Students-in-Training			Senior Research Awards			Grants for Special Investigations		
	1950–51	1951–52	1952–53	1950–51	1951–52	1952–53	1950–51	1951–52	1952–53
Chemistry	366	390	419	3	5	3	27	26	20
Physics	283	276	283	6	6	8	41	40	32
Mathematics and Astronomy	58	48	50	—	—	—	7	4	4
Biology	68	73	78	1	—	—	6	6	6
Geology and Mineralogy	36	38	41	—	—	—	1	—	—
Metallurgy	33	27	26	—	—	—	—	1	2
Engineering	66	71	79	—	2	3	13	14	6
Totals	910	923	976	10	13	14	95	91	70

(B) AFTER CAREERS OF STUDENTS IN TRAINING WHOSE MAINTENANCE ALLOWANCES ENDED DURING THE SESSION 1951–52

TABLE 4

Public Service	60	Unaided Research	6
Industry	59	Research Assistantships	18
University Posts	49	Overseas Research Posts	35
Scholastic Posts	6	Miscellaneous	34
Scholarships	66	Untraced	28
Senior Research Awards	2		
		Total	363

APPENDIX V

SUMMARY OF THE EXPENDITURE OF THE DEPARTMENT DURING THE YEAR ENDED 31st MARCH 1953

Organization	Gross*	Receipts	Net
	£	£	£
Headquarters, Administration etc. ...	213,493	374	213,119
Overseas Liaison	90,860	22,712	68,148
National Physical Laboratory	860,842	314,225	546,617
Building Research	456,985	36,052	420,933
Chemical Research Laboratory	159,854	46,280	113,574
Fire Research	64,168	37,824	26,344
Food Investigation	222,480	1,949	220,531
Forest Products Research	110,749	4,635	106,114
Fuel Research	255,505	17,813	237,692
Geological Survey and Museum	247,818	43,687	204,131
Hydraulics	59,024	1,348	57,676
Mechanical Engineering	355,716†	9,559	346,157
Pest Infestation	59,663	3,027	56,636
Radio Research	51,260‡	541	50,719
Road Research	312,728	19,763	292,965
Water Pollution	61,553	129	61,424
Research Contracts...	13,089	3,800	9,289
Miscellaneous Programmes	28,382	1,881	26,501
Grants for Research:			
Annual Grants to Research Associations	1,449,635	—	1,449,635
Special Grants to Research Associations	16,804	—	16,804
Grants to Students, etc.	265,965	68	265,897
Grants for Special Researches ...	317,321	166	317,155
American Aid—Provision of Technical Equipment	99,409	15	99,394
TOTALS	5,773,303	565,848§	5,207,455

* Includes the cost of work for "Boards and Committees" at various Stations of the Department.

† Includes the cost of staff continuing to be transferred from N.P.L.

‡ The increase over 1951–52 results from transfer of staff from N.P.L. with effect from 1 October 1952.

§ This may be classified:—

	£
A.—RECEIPTS FROM INDUSTRY:	
National Physical Laboratory	124,042
Other Stations	65,731
B.—RECEIPTS FROM OTHER SOURCES:	
Payment by other Government departments for services rendered ...	311,205
Sales and Miscellaneous Receipts	33,748
Payment by Government of Northern Ireland for survey work	8,410
Contributions from Dominions towards cost of Overseas Liaison ...	22,712
	£565,848

APPENDIX VI

GRANTS FOR SPECIAL RESEARCHES IN PROGRESS DURING THE YEAR ENDED 30th SEPTEMBER, 1953

Investigator	Subject	Grant	Period covered
		£	
	BIRMINGHAM UNIVERSITY		
Dr. G. F. J. Garlick	Physics of luminescence	2,550	3 years from 1st October, 1950
Mr. K. A. Macfadyen	Research on electrical conduction and breakdown in pure dielectric liquids.	800	2 years from 1st October, 1951
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 6⅓ years from 1st April, 1946: extended to 31st July, 1954.
Professor P. B. Moon	Running expenditure on nuclear physics research	196,100	5 years from 1st August, 1952
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. D. D. Eley	Para-ortho conversion and formation of hydrogen deuteride on metal wires and films.	700	3 years from 1st October, 1950
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	Properties of ionic solids	1,950	4 years from 1st February, 1949
Professor C. F. Powell	High altitude balloon flights	3,300	2 years from 1st October, 1952
	CAMBRIDGE UNIVERSITY		
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	High energy equipment and running expenditure on nuclear physics research up to 31st July, 1952.	67,000	Originally 5½ years from 1st April, 1947; extended to 31st July, 1953.
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	5⅙ years from 1st June, 1952.
Dr. W. Cochran	(i) X-ray investigation of the stereochemistry of nucleotide ... (ii) X-ray study of the hydrogen bond	1,100	2 years from 1st October, 1952.

Investigator	Subject	Grant	Period covered
		£	
	CAMBRIDGE UNIVERSITY—(*continued*)		
Professor H. J. Emeleus	Synthesis and reactions of organo-metallic and organo-metalloid compounds containing fluorcarbon radical.	1,250	3 years from 1st October, 1952.
Professor J. Gray	Homing and migrational phenomena in birds	1,800	3 years from 1st October, 1950
Professor Sir John Lennard-Jones ...	Theoretical studies of molecular structure	450	1 year from 1st October, 1952
Dr. A. G. Maddock	The chemical effects of nuclear recoil and other ionising rays ...	125	1 year from 1st January, 1952
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	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 syntheses by the electronic digital computer.	1,225	2 years from 1st October, 1952
Dr. T. W. Wormell	Structure, development and internal motion of precipitating clouds by radar.	1,200	3 years from 1st October, 1950
	DURHAM UNIVERSITY		
Professor F. A. Paneth	Application of radio-active tracer methods to physico-chemical problems.	150	1 year from 1st October, 1952
	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
Dr. E. E. Schneider	Investigations on paramagnetic resonance	500	1 year from 1st October, 1952
	EDINBURGH UNIVERSITY		
Sir Edward Appleton	The study of ionospheric world morphology	500	2 years from 1st October, 1952
	GLASGOW UNIVERSITY		
Professor P. I. Dee	Construction of a 300 MeV electron synchrotron and other high energy equipment for nuclear physics research.	354,700	7⅓ 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 E. 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	Magnetic investigations of molecular structure	1,200	2 years from 1st October, 1951
Professor F. S. Dainton	Radiation chemistry of pure liquids and solutions, with special reference to water.	2,600	3 years from 1st October, 1950
Professor F. S. Dainton	Entropy of high polymers	2,000	3 years from 1st October, 1952
Dr. F. E. Hoare	The magnetic and thermal properties of metals and alloys at low temperatures.	975	2 years from 1st October, 1951
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 collisions	4,500	3 years from 1st October, 1950
Professor L. Rosenhead	Mathematical tables researches	3,000	4¼ years from 1st July, 1950
Professor H. W. B. Skinner	Construction of a 400MeV proton synchro-cyclotron and other high energy equipment for nuclear physics research.	617,500	8⅓ 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 hydrogen and argon.	600	1 year from 1st October, 1952.
Professor H. S. W. Massey	The calculation of molecular fields of tetrahedral molecules and its application to the properties of metallic ammonium.	575	1 year from 1st October, 1952.
Professor H. S. W. Massey	Nuclear and electronic collisions of electrons and positions 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.
Dr. F. W. Chapman	Radio noise and propagation characteristics at frequencies below 100 kc/s.	2,000	4 years from 1st October, 1949.
	IMPERIAL COLLEGE, LONDON		
Professor H. V. A. Briscoe	Chemical studies using inactive isotopes and the mass spectrometer	1,250	4¼ years from 1st October, 1948.
Dr. D. Gabor	Electron reflexion at crystal surfaces. Irregular oscillations in the plasma of gas discharge tubes.	1,800	1½ years from 1st July, 1951.
Professor R. P. Linstead	Mechanism of photosynthesis	1,400	2 years from 1st April, 1951.
Professor A. J. S. Pippard	Study of tapered boxes	6,000	3 years from 1st January, 1950.
Dr. F. D. Richardson	Compilation of physico-chemical and especially thermodynamic data on metallurgical processes.	1,450	3 years from 1st October, 1951

Investigator	Subject	Grant	Period covered
		£	
	IMPERIAL COLLEGE, LONDON—*continued*		
Dr. A. W. Skempton	Stress-strain and shear strength characteristics of soils	2,650	3 years from 1st October, 1950
Professor Willis Jackson	Investigations in the field of internal electronics	6,000	3 years from 1st January, 1950.
Professor Willis Jackson	Programme of electrical engineering research	12,500	5 years from 1st July, 1948
Professor Willis Jackson	Electrical machine and power network analysis	8,000	3 years from 1st January, 1953
	QUEEN MARY COLLEGE, LONDON		
Dr. G. O. Jones	Investigations at low temperatures	5,000	3 years from 1st October, 1952
Dr. W. J. Hickinbottom	Synthesis and reactions of branched chain hydro-carbons ...	500	2 years from 1st August, 1952
	BIRKBECK COLLEGE, LONDON		
Dr. R. E. Siday	High resolution β-ray spectroscopy	8,350	4 years from 1st October, 1949
	BEDFORD COLLEGE, LONDON		
Professor H. Munro Fox	Haemoglobin synthesis in Daphnia	739	3 years from 1st October, 1950
	THE LISTER INSTITUTE OF PREVENTIVE MEDICINE		
Dr. J. Baddiley	The chemistry of coenzyme A	1,150	2 years from 1st October, 1951
	MANCHESTER UNIVERSITY		
Professor A. C. B. Lovell	Radio Astronomy	230,000	4 years from 1st April, 1952
	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 July, 1954.
Lord Cherwell	Running expenditure on nuclear physics research	197,100	5 years from 1st August, 1952
Dr. D. A. Long	Intensities in the Raman effect, bond polarisabilities and bond character; a theoretical and experimental study.	500	3 years from 1st April, 1951
Dr. L. E. Sutton...	Further development of a camera for studying the diffraction of electrons by gases and vapours.	1,034	2 years from 1st October, 1951
Dr. H. W. Thompson	Infra red spectroscopy	5,000	3 years from 1st October, 1950
	SHEFFIELD UNIVERSITY		
Dr. J. G. Boswell	Metabolic systems of the storage tissues of some angiosperms ...	350	1 year from 1st September, 1952
Professor H. Moore	Absorptions of glasses containing various colouring agents ...	2,500	3 years from 1st October, 1950

	ST. ANDREWS UNIVERSITY		
Professor E. Finlay-Freundlich ...	Interferometers with multi-layer dielectric coatings...	1,000	2 years from 1st October, 1951
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
	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 R. M. Davies...	Experiments on shock and detonation waves	1,500	3 years from 1st October, 1950
Professor T. A. Stephenson	Distribution of algae and animals on the British coasts between tidemarks. (1)	1,125	2 years from 1st October, 1952
	(2)	950	1½ years from 1st July, 1951
	(3)	200	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
	UNIVERSITY COLLEGE, SWANSEA		
Mr. J. S. Caswell	(*a*) Experimental determination of the general effect of variation in span/depth ratio. (*b*) Measurement of the deflections and stresses in rolls loaded and supported in the manner of rolling mill practice.	435	4 years from 1st October, 1949
	TECHNICAL COLLEGE, BRADFORD		
Mr. K. L. Butcher	Energy changes accompanying the solution of non-electrolytes ...	175	2 years from 1st October, 1952

APPENDIX VII

(A) LIST OF DEPARTMENTAL PUBLICATIONS ISSUED DURING THE YEAR

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List of Scientific and Technical Periodicals in D.S.I.R. Libraries 1953 (unpriced)
Public Libraries and Industries, by D. J. Urquhart (unpriced pamphlet)

BUILDING RESEARCH

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No. 50. Emulsion Paints
No. 51. Questions and Answers
No. 52. Lightweight Concrete Blocks for Housing.
No. 53. Perforated Clay Bricks,
No. 54. Fire Resistance of Board and Joist Floors for Small Houses and Flats.
No. 55. Drainage for Housing.
No. 56. Questions and Answers.
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(A) PUBLISHED BY H.M. STATIONERY OFFICE

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FOOD INVESTIGATION

(A) PUBLISHED BY H.M. STATIONERY OFFICE

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