ENGINEERING-BASE BUILDING FOR BRITISH EUROPEAN AIRWAYS.

British European Airways have recently commenced to move into their new engineering base at London Airport, probably one of the most advanced buildings of its kind in existence. It is believed to be the largest example of prestressed-concrete constructions yet built in this country, and is certainly the largest building to be illuminated by cold-cathode lighting. A recent aerial photograph of the new building under construction is reproduced in Fig. 1. The planning of the new base started in 1948, and as a result of their experience with the ex-Royal Air Force hangars and widely separated workshops that were placed at their disposal at Northolt Airport, British European Airways decided that the primary requirements for running an efficient and economic maintenance and overhaul service were to provide easy access for moving aircraft into and out of the hangars and for transferring components between the hangars and the workshops. A flexible layout was essential to allow for the introduction of new types of aircraft and equipment and to allow for expansion.

For this reason, B.E.A. decided that hangars and workshops should be under one roof. They proposed a long hangar, deep enough to accommodate only one row of aircraft, with a clear floor space throughout, and access to the apron along the whole of one long side. The large door area thus entailed would probably not be practicable in a colder climate. The opposite side of the hangar was to adjoin the workshops. The actual dimensions of the building were decided by trying to visualise the type and size of aircraft likely to be in

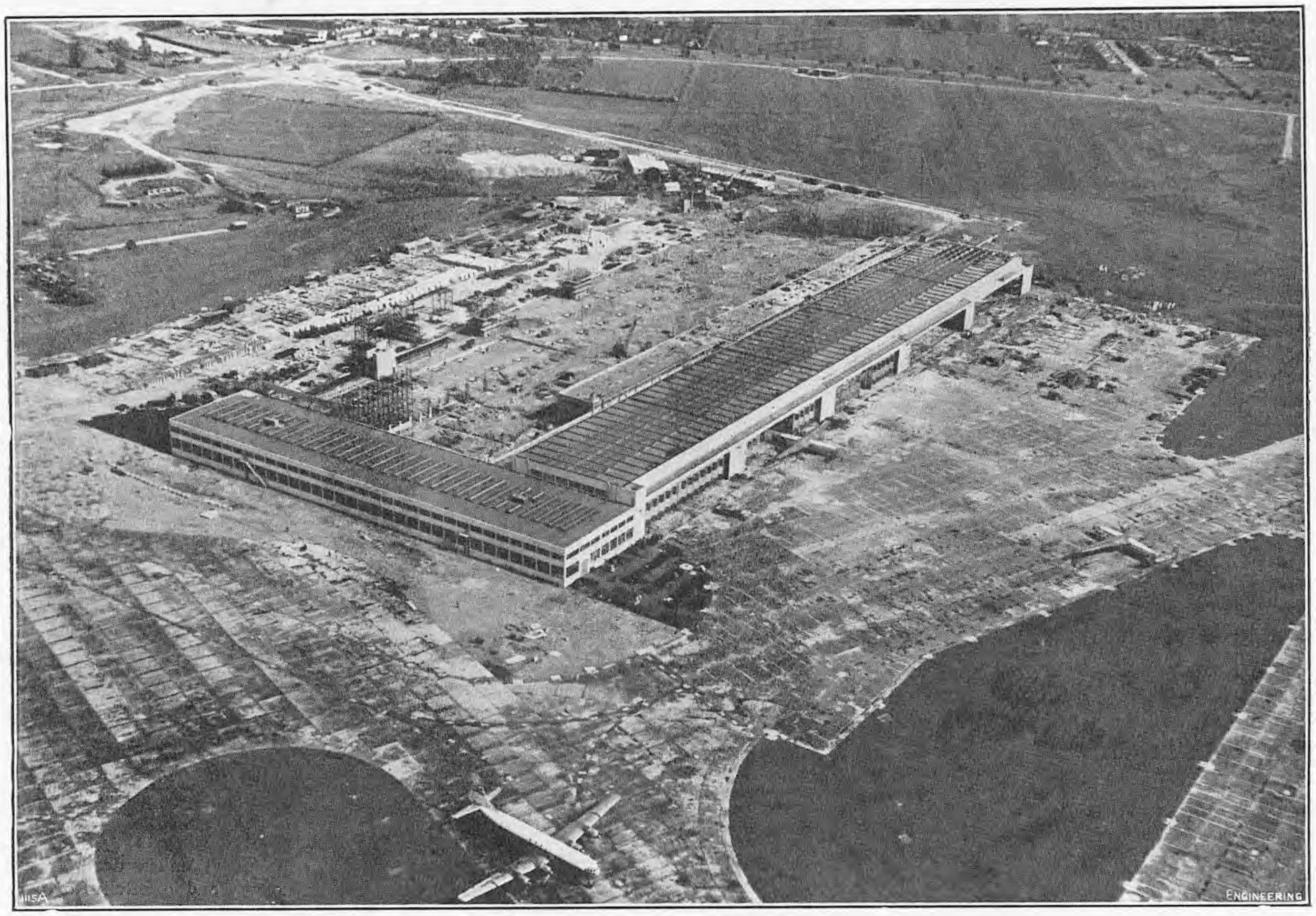
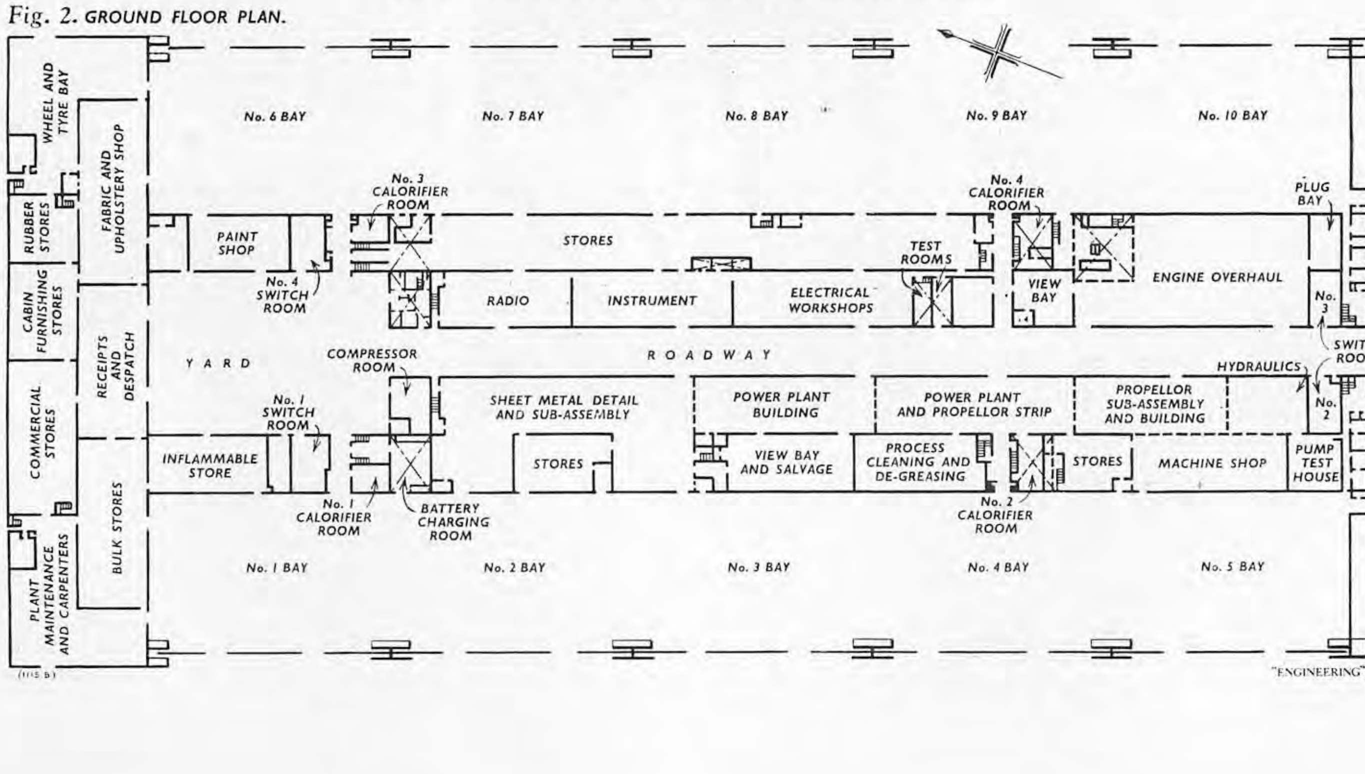


Fig. 1. Aerial View of Building Under Construction.

Fig. 2. GROUND FLOOR PLAN.



ENGINEERING-BASE BUILDING FOR BRITISH EUROPEAN AIRWAYS.

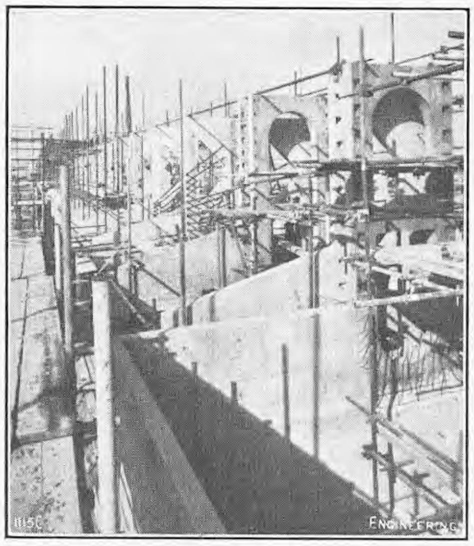


FIG. 3. ERECTION OF MAIN-BEAM PRESTRESSING CABLES.

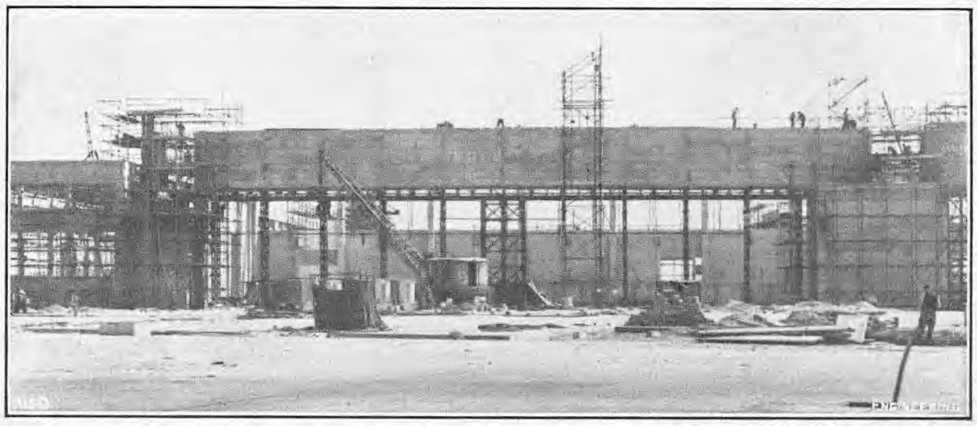


FIG. 4. PRESTRESSED MAIN BEAM FOR HANGAR.

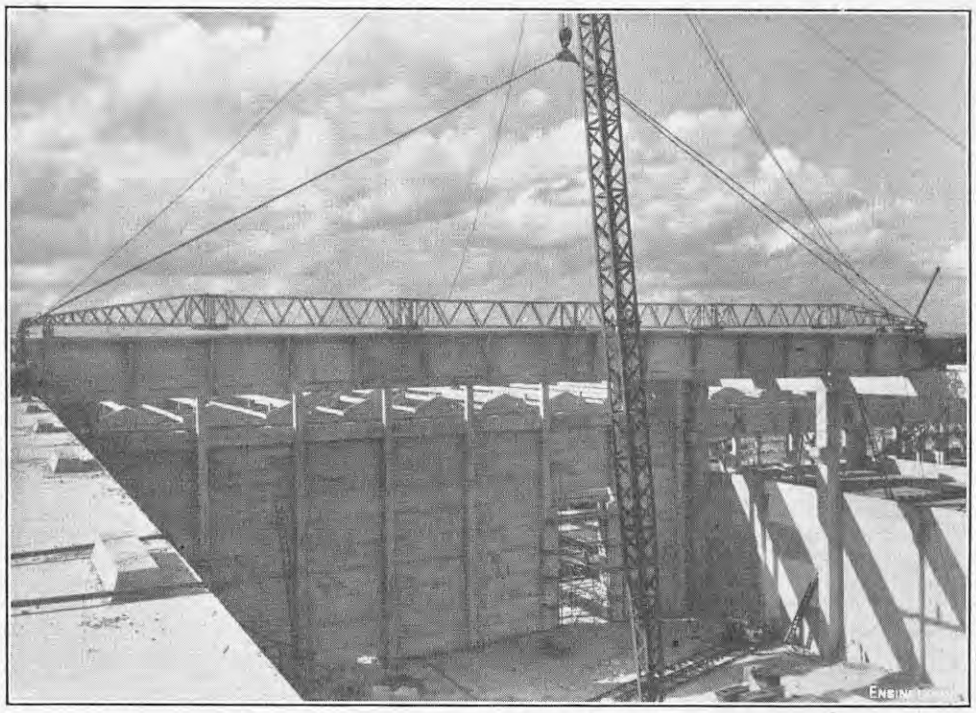


FIG. 5. PLACING PRESTRESSED ROOF BEAM.

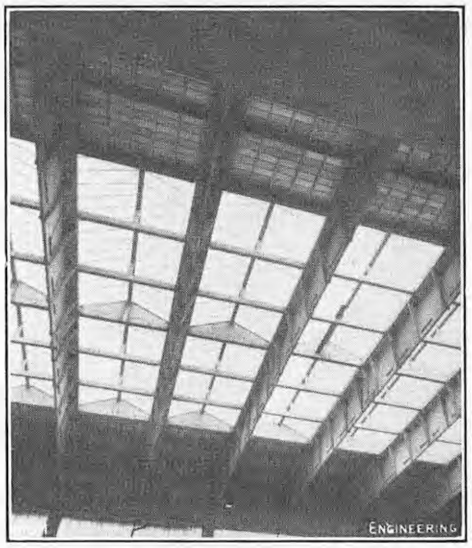


FIG. 6. HANGAR ROOF LIGHTS.

service during the next ten years, and by estimating the annual number of flying hours that would be likely to be achieved, bearing in mind that the efficiency of the air line would improve as experience was accumulated and better plant was acquired. Too large a building was undesirable since it would entail unnecessary capital expenditure and heavy running costs.

Initially, they considered two such hangar blocks, with a separate stores building between them. They soon abandoned the idea of a separate stores building, however, and decided that it should be at the end of the hangars near the main road. This, however, would have entailed cutting a roadway through the stores building for access to the back of the hangars, and so ultimately it was settled that the stores block would have to be at the end remote from the main road. The width of the workshops, originally planned at 40 ft., was increased to 80 ft. as further operating experience was gained. In 1950, tenders were invited from ten selected specialist contractors for the design and construction, in reinforced concrete, of the structural framework of the buildings. Invitations were also given to a number of structural steelwork specialists. The competitors were provided with a basic specification, together with layout plans indicating in outline the general building requirements. The contract was awarded to Messrs. Holland & Hannen and Cubitts, Limited, 1, Queen Anne's Gate, London, S.W.1; their design was based on an economic arrangement of *in situ* and precast reinforced concrete and prestressed concrete.

The main consulting engineers on the whole project are Messrs. Scott and Wilson, 47, Victoria-street, London, S.W.1. They appointed Messrs. J. Roger Preston and Partners, Dilke House, Malet-street, London, W.C.1, as specialist consultants on the engineering services—heating, ventilating, gas supply, water supply and compressed-air supply, and, in conjunction with Messrs. Barlow, Leslie and Partners, 3, Catherine-place, London, S.W.1, on the electrical system. Messrs. A. P. I. Cotterell and Son, 54, Victoria-street, London, S.W.1, are the drainage consultants. The architects are Messrs. Ramsey, Murray and White, 32, Wigmore-street, London, W.1.

LAYOUT OF BASE.

The site on which the British European Airways' maintenance base is laid out is 1,000 ft. square. The plan of the ground floor is shown in Fig. 2, on page 521. It comprises two parallel wings, running approximately from north to south, between which runs a 30-ft. roadway ending in a square courtyard backed by a north block of stores. The buildings of the north block and practically the whole of the west wing are complete and occupied by B.E.A. The east wing is under construction. When complete, major overhauls on the Elizabethan and Discovery-class air liners (more commonly known as the de Havilland Ambassador and Vickers-Armstrongs Viscount), and on Rolls-Royce Dart gas turbines and their propellers, will be carried out in the east wing. Minor inspections are already being carried out in the west hangar, which faces the aerodrome. A large staff canteen, to seat 1,000, will also be provided in a separate building at the south end of the site.

The west and east hangars, 900 ft. long, each comprise a hangar backed by workshops and stores. The hangars are 110 ft. deep, and the entire hangar floor space is clear; they are, however, divided, in effect, into five bays, each accommodating an aircraft. In each hangar bay there are service pits provided with electrical power and compressed-air supplies. Each hangar bay is enclosed by large Esavian sliding-folding doors, which retract into recesses formed in six pylons on the outer boundary of the hangar building, giving a clear door width of 150 ft. and a height of 30 ft. The folding doors are electrically operated, through an endless cable, by two 3-h.p. motors installed in each set of doors. An intermittent warning horn sounds whenever the doors are being opened or closed.

The annexes in the east and west wings, which house the workshops and associated stores, are 80 ft. wide, and have a central row of structural columns down their length, giving two clear areas measuring 900 ft. by 40 ft., which can be sub-

BRITISH EUROPEAN AIRWAYS' ENGINEERING BASE.

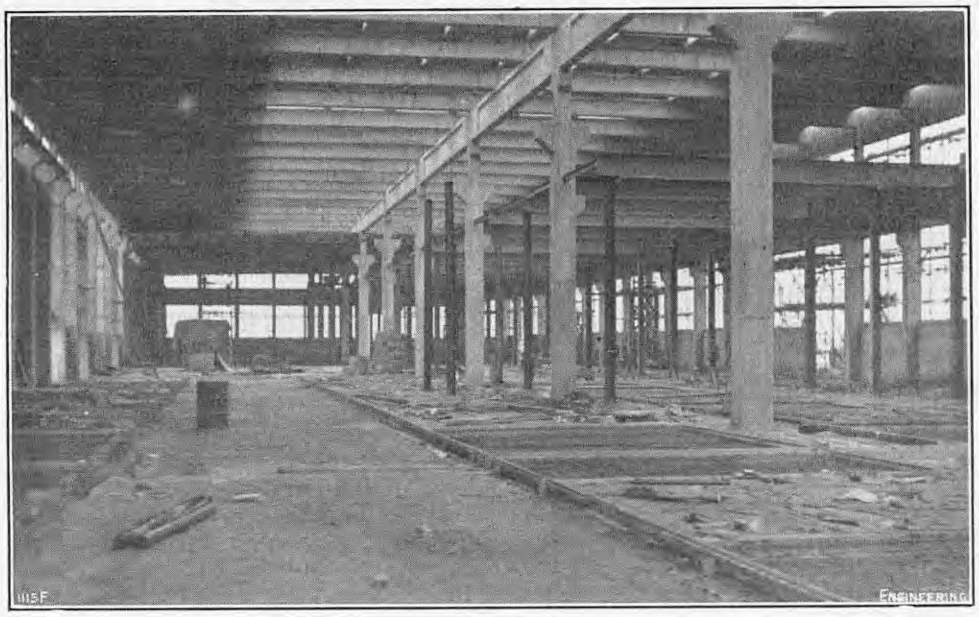


FIG. 7. THE WEST ANNEXE UNDER CONSTRUCTION.

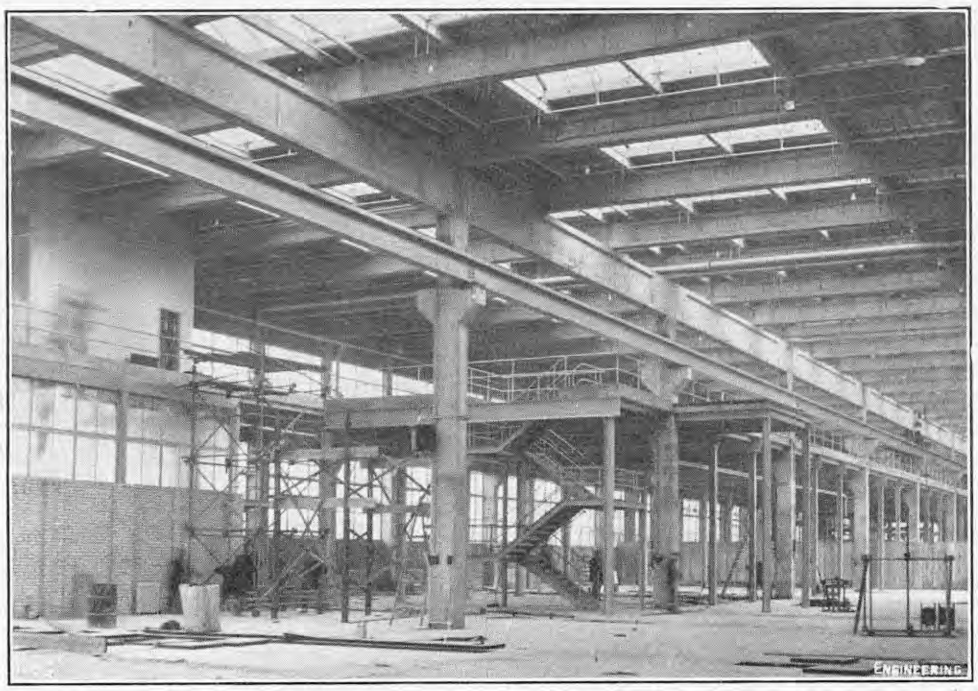


FIG. 8. INTERIOR OF NORTH BLOCK.

divided by removable partitions as desired. There is a storey above the annexes, extending back from the inner boundary over a width of 40 ft., which provides office accommodation. It is intended eventually to transfer the whole of the engineering staff, including the project and development inspection, and purchasing branches of British European Airways to this building.

The north block is 460 ft. long by 100 ft. wide; the ground floor will be devoted mainly to stores, but will also house a plant maintenance shop and certain other shops. A first floor over part of the area provides further office accommodation, and ultimately a radio development laboratory will be established here. The whole building will be provided with a comprehensive system of fire detection and protection—a sprinkler system in the workshops, stores and offices, and a "deluge" system, operating from a 12-in. water main, in the hangars. This equipment, which is not yet in operation, is being installed by Messrs. Mather and Platt, Limited, Park Works, Manchester, 10.

Each hangar will be spanned by a 5-ton two-motor overhead travelling crane, supplied by the Vaughan Crane Company, Limited, West Gorton, Manchester, 12. These cranes are fitted with variable eddy-current slip torque adjustment control (Vestac) in all three motions. The motors themselves provide a constant uni-directional torque, speed control and reversing being carried out by varying the excitation of the slip coupling, the inner member of which comprises an electromagnet and is coupled to the crane gearing, the outer member, of cast steel, being connected to the driving motor. Another 5-ton three-motor overhead travelling crane, with a span of 47 ft., controlled by a pendant push-button, has been supplied for the north block, and two lighter 35-ft. span 5-ton electric block cranes are to be used for handling stores and finished parts in the annexes.

CONSTRUCTION OF BUILDINGS.

The site was prepared by excavating the whole area, including the apron, to an average depth of 4 ft. This excavation was then filled with ballast, obtained locally, and this forms the base for an 8-in. concrete floor slab and apron. Excavations for the column foundations were taken down to the level of Thames ballast, about 8 ft. below ground level, and a mass concrete footing, about 4 ft. deep, was laid. A reinforced-concrete base for the columns, some 2 ft. deep, was placed on the footing.

In general, the pylons and columns are of ordinary reinforced concrete, whereas the main and secondary beams are of prestressed concrete construction, the smaller beams being supplied pre-cast by the Concrete Development Company, Limited, Queen Anne's-court, London, S.W.1, and the larger beams being post-tensioned by the Freysinnet method on site. Dealing first with the hangar structure, which carries the heaviest loads, the main longitudinal beams, shown in Fig. 4, which span between the pylons, are perhaps the most interesting of the structural members. They carry the outer ends of the roof beams, and also a canopy over the doors and one of the tracks for the 5-ton overhead crane gantry. These beams, which are not continuous over the pylons, span 150 ft. and are of hollow box section, 14 ft. deep by 5 ft. 3 in. wide, with 4-in. side walls and top and bottom walls 8 in. and $5\frac{1}{2}$ in. thick, respectively. On their forward faces they carry brackets for the canopy. These main beams, which are prestressed by the Freysinnet method, are constructed *in situ*. In each beam, twelve pre-cast prestressed concrete diaphragms, shown in Fig. 3, are first erected on the scaffolding, brackets for the canopy and the crane track being integral with the diaphragms. The diaphragms are cast with holes which form guides for the prestressing cables, the holes being located on the natural catenaries of the cables. There are 41 twelve-strand prestressing cables in each beam, and they are threaded through the guides, as may be seen in Fig. 3, before the concrete walls of the beam are poured. Steel shuttering is employed, and the concrete is compacted by vibration. The concrete is cured for about 10 to 14 days, and when it has reached the specified strength of 5,000 lb. per square inch, as indicated by test cubes taken at the time the concrete was poured, the cables are tensioned by hydraulic jacks, from each end of the beam, and are then grouted. They are stressed to about 70 tons per square inch, to give a final working stress in the steel wires of 60 tons per square inch (i.e., 60 per cent. of the ultimate stress), after allowing for creep. In tensioning the cables, the beam, which is designed to have a 6-in. camber on the underside, is lifted clear of the scaffolding.

The hangar roof is carried by prestressed transverse beams, also of the Freysinnet type, at 15-ft. centres, spanning between the main beams and the *in situ* longitudinal eaves beams on the opposite side of the hangar, which in turn are supported by normal reinforced-concrete columns at 30-ft. centres. The roof beams are of T-section, 5 ft. 10 in. deep with a 3-ft. wide flange, both web and flange being 4 in. in thickness. They are pre-cast in units by Messrs. Girlings' Ferro Concrete Company, Limited, 30, Jamaica-street, Glasgow, C.1, lightly reinforced for handling only, and embodying holes suitably placed for the prestressing cables, of which there are eight per beam. The units are lined up end-to-end, with a $\frac{3}{4}$ in. gap between them, which is packed with an earth-dry mortar, rammed home. The cables, inserted after jointing, are then stressed from both ends of the beam, and the whole beam, weighing approximately 26 tons, is hoisted up and swung into position, as illustrated in Fig. 5. It should be mentioned that there is a slot formed in each end unit engaging with a corresponding bearing on the main and longitudinal eaves beams. Messrs. Caswell Cranes and Erection, Limited, Grove Works, Hammersmith, London, W.6, erected the pre-cast beams under sub-contract to Messrs. Holland & Hannen and Cubitts, Limited. Fig. 6 shows part of the completed hangar roof.

The hangar door pylons are hollow reinforced-concrete boxes, at 180-ft. centres. On their outer face, they have a T-section extension which forms a recess into which the folding doors retract. The method of erecting the reinforced-concrete columns of the annexes is of some interest, in that they were cast horizontally at ground level, and then hoisted on to their foundations and grouted in. In general, they measure about 15 in. by 12 in. As mentioned earlier, the central row of columns in the annexes, shown in Fig. 7, are at 15-ft. centres, and so are the annexe wall columns. In the north building (Fig. 8) they are spaced at 14-ft. centres. The 40-ft. span transverse roof beams in the annexes have been designed to carry overhead cranes, and six holes are cast in each end of the beam to provide for mounting crane-track bearers. A clear height of 17 ft. 6 in. has been allowed in the workshops to facilitate handling large propellers and airframe components.

The roofs of the hangars and the north block are of pressed aluminium, covered with ½ in. thermal insulation board and felting, all supplied by Messrs. D. Anderson and Sons, Limited, Stretford, Manchester. As may be seen in Fig. 6, the middle third is glazed. Roof lights are provided over the whole of the single-storey part of the annexes.

It has already been mentioned that engine overhaul is to be carried on in the east block, when completed. At the south end of the east block a 40-ft. by 50-ft. engine test-bed chamber, largely of prestressed construction, is to be installed below the engine-overhaul shop, the floor level being some 20 ft. under the ground. The test bed will be isolated from the remainder of the structure, to avoid transmitting noise. Air will enter the chamber through a vertical reinforced-concrete duct, and a similar duct will form an exhaust flue. Over the engine test-bed, a trap door will be provided for lowering overhauled engines into position for test.

(To be continued.)

LITERATURE.

Mathematics: Queen and Servant of Science.

By Professor E. T. Bell. G. Bell and Sons, Limited, York House, Portugal-street, London, W.C.2. [Price 21s. net.]

The interest and value of history are much more than the key they afford to the literature and achievements of the past. In itself history raises and attempts to answer a number of important questions, and one of them is: How did the present state of things evolve out of the past? This study of the past as the parent of the present may arise from the student's interest in the value or instruction he finds in former systems of thought which have passed away and left little behind, or else in the explanation which history alone can provide of the origins of the institutions, beliefs, habits and prejudices of mankind at the present time. When the field of inquiry lies within the province of science, the aim of the student is then to focus his attention on the moving stream of events, the causal and evolutionary aspect of the matter under consideration. In his book, Professor Bell uses material acquired in this way to explain the inner point of view, the *raison d'être*, the secret of fascination for powerful minds, of mathematics, pure and applied, from the geometry of Euclid to the most recent developments of mathematical physics.

The book, with its 20 chapters under headings that invite curiosity, is to be read rather than reviewed. Thus it goes far to secure that the study of mathematics, however tedious and unromantic in its scholastic surroundings, often becomes pleasant and at times exciting. The schoolboy, or even his father, with the book awaiting him in his room, might well walk home with a light step and shut the door behind him with a bang. Has he not the chapter on "The Art of Abstraction" to finish? Or is he not in the middle of Chapter 6, where the topics of transformations, matrices, invariance in nature, and Sylvester's prevision have been arranged under the common heading of "Oaks from Acorns"? One good point leads to another, as in the case of Sylvester's remarkable prediction, which the author again mentions in Chapter 9, in connection with the theory of groups, and the utilisation of this theory by the late Sir Arthur Eddington in his relativity theory of protons and electrons. But the pursuit of mathematics is an occasion for caution, since the "Queen" is of the race of Amazons, armed with an arrow marked "personal equation." In the use of it, she is no respecter of persons, as is very clearly indicated by the statement that Eddington, in deducing his famous "137" from the theory of groups and the principles of both physics and metaphysics, "got 136 (incorrect) first because he overlooked the fact that a group has an identity element." It may be that Fourier, too, felt the sting of this arrow after he had reproached Jacobi for "trifling with pure mathematics," particularly the theory of numbers.

Here all borderlands, marches, and boundaries of the empire of mathematics become attractive, as they may well do when the guide-book contains such chapter headings as "A Metrical Universe," "From Cyzicus to Neptune," and "Storming the Heavens." The practical man may regard mathematicians as a race apart, assembled on the summits of a far-distant and unfamiliar chain of mountains; but there are other places, within easy reach and at least equally fascinating. The delimitations of the sciences might easily keep a Boundary Commission of natural philosophers hard at work for a century. To say, as some lightly do, that pure and applied mathematics are on opposite banks of an unfordable river, is to assert what the author would stoutly deny; for, whenever the reader shows any tendency in this direction, Professor Bell loses no time in doing his best to nip it in the bud. It matters little whether the signpost points to advanced calculuses, waves and vibrations, or choice and chance. Of the race of giants on those far-distant and unfamiliar mountains, the closing chapter has much to say about their deliberations in recent years, and how these deliberations have been greatly influenced by one of their number who took his degree at the University of Brno in engineering.

Diffusion in Solids, Liquids, Gases.

By Professor W. Jost. Academic Press Incorporated, 125, East 23rd-street, New York 10, U.S.A. [Price 12.00 dols.]

This work forms one of a series of monographs on physical chemistry edited by Professor E. Hutchinson, of Stanford University, California, and its chief aim, as stated by the author in his preface, is "to assist in planning, evaluating and understanding diffusion experiments, at the same time giving a survey of the results obtained to date." The fundamental laws of diffusion, connecting the rate of flow of the diffusing substance with the concentration gradient responsible for this flow, are dealt with in the opening chapter. It is pointed out that to cover an average distance of 1 cm. takes a time of the order of some seconds for molecules in gases at standard temperature and pressure, of some days for liquid solutions at room temperatures, and of between a day and 10^{12} years for such solids and temperatures where measurements have been possible; so that, in determining diffusion coefficients, it is advisable to work with distances of a few decimetres for gases, of centimetres or less for liquids, and of between a few centimetres and some 10^{-7} cm. for solids.

The equations governing diffusion in isotropic and anisotropic substances are derived and their solutions discussed. The Brownian movement is considered, together with the effects of convection and the influence of external forces on diffusion. An appendix contains a tabulation of the error function and tables for the evaluation of diffusion measurements due to Stefan and Kawalki. A summary of disorder in crystals and its interpretation is followed by chapters on the theory of diffusion in solids, electrolytic conduction and diffusion in ionic crystals, diffusion in metals and in non-polar crystals, solubility in solids, permeation and diffusion of gases in solids. The increasing availability of radioactive isotopes is likely to throw further light on the mechanism of such processes, and instances of the use of this powerful technique in the measurement of self-diffusion of metals and in ionic crystals are quoted. The next two chapters, on the mobility of ions in solid and molten metals and alloys and on surface reactions of metals, formation of protective layers and related reactions, are not only interesting in themselves, but have important practical implications. Chapter 10 treats of diffusion in gases, and concentrates mainly on experimental methods of determining diffusion coefficients in gases and their dependence on temperature and pressure, though a summary of the relevant kinetic-theory results is included. The following chapter deals with diffusion in liquids, not only in stationary or quasi-stationary states, but also non-stationary diffusion measurements for which ingenious optical methods have been devised. The concluding chapter is devoted to thermal diffusion, which has recently formed the basis of a successful method of isotope separation.

References at the ends of the chapters are very complete, including entries up to 1948, and, in the addendum, to 1950, while a formula index has been provided in addition to author and subject indexes. Pride of place, and space, has been accorded to diffusion phenomena in solids, on which the author is an acknowledged authority, and although "no attempt has been made at completeness in the presentation of either theoretical or experimental material," the wide range of the examples he has selected and treated so comprehensively in this massive monograph cover the essence of the matter to date in a masterly manner.

Physique et Technique du Bruit.

By Dr. A. Moles. Dunod, 92, Rue Bonaparte, Paris, 6e. [Price 960 francs.]

A noise is comprehensively defined on the wrapper of this book as an unwanted sound, which emphasises the fact that psychological as well as physical factors require to be taken into account in dealing with it. Though means have been developed for determining the physical characteristics of any type of sound, the annoyance it occasions to any particular individual is not capable of precise measurement. Modern methods of construction and crowded living conditions have markedly increased the noise problem, and a perceptible fraction of the increased energy now available to industry is expended in generating sound or inducing vibration. In extreme cases, noise may, temporarily or permanently, impair hearing; it almost invariably leads to nervous strain and reduces efficiency. As few of us are able to escape its effects by moving out of its range, all practicable steps should be taken to control its incidence and mitigate its consequences.

It is Dr. Moles' purpose in this book to explain how our knowledge of noise has advanced in recent years and what can most profitably be done to combat it in various situations where it may prove troublesome. The physical distinction between musical sounds and noises is first discussed, and methods are described for determining the two essential characteristics of a noise, namely, its oscillogram, giving its amplitude as a function of time, and its spectrum, giving its amplitude as a function of

DOCKS RECONSTRUCTION AT SUNDERLAND.

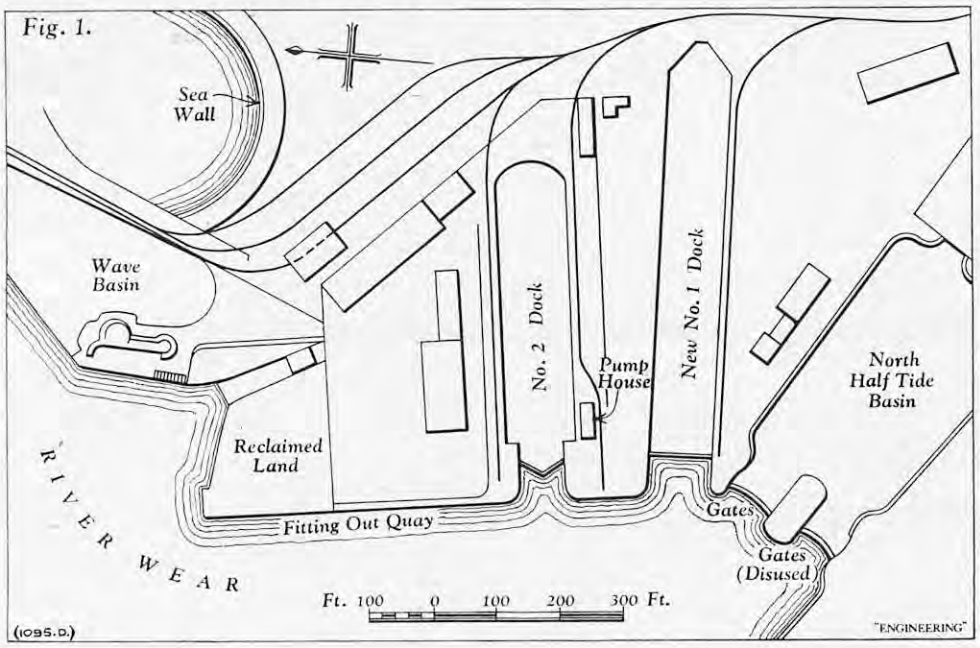


Fig. 1.

frequency. Instruments for registering and analysing noise are treated in some detail, together with brief accounts of the interpretation and harmonic analysis of the resulting records. There would seem to be a misprint in a sentence towards the bottom of page 21, which does not make sense as it stands.

In questions relating to noise the ear must always be the ultimate judge and, in Chapter III, the physiological aspects of noise are considered, including the attempts that have been made to link up objective intensities with subjective sensations, which differ from the former in exhibiting threshold and saturation values. The method of carrying out intelligibility tests is outlined and data on the effects of sub-audible vibrations are given. The remainder of the text is devoted to established methods of designing and treating structures to reduce the transmission of sound and vibration through them. The importance of according proper consideration to acoustics in the design stage is stressed for, as is pointed out, it is usually far more costly and generally far less effective to have to correct acoustic defects after a building has been erected. Illustrations of efficient design or effective treatment are provided by engine silencers, improved plumbing installations, anti-vibration mountings for machinery, sound-proof wall and floor construction, modern flat planning and urban zoning schemes. Suggestions are also made as to minimum conditions that might well serve as a basis for future legal enactments against noise. In equation (2) on page 98 both denominators should be squared.

A number of useful tables are given at the end of the text, together with a brief bibliography and an index. This clear summary, based on an extensive experience of both the scientific and technical aspects of the problem of noise, though primarily reflecting present-day French practice, contains much that is of general interest.

Extensions to Sulphuric-Acid Plant, Billingham.—Civil-engineering work has begun in connection with the extensions to the sulphuric-acid plant of Imperial Chemical Industries, Ltd., at Billingham-on-Tees. The plant is to cost 2,000,000*l*., and the work will be completed in two years. The new installation will increase the output of sulphuric acid at Billingham by 73,500 tons per annum, while another 69,500 tons of by-product, capable of conversion into 73,000 tons of cement, will be produced. The sulphuric-acid plant will need an extra 127,000 tons of anhydrite from the I.C.I. mines at Billingham each year. The main contractors for the extensions are Simon-Carves, Ltd., and Simon Handling Ltd. The foundations for the plant are being prepared by West's Piling Co., Ltd.

RECONSTRUCTION OF T. W. GREENWELL'S DOCKS, SUNDERLAND.

The construction of Messrs. T. W. Greenwell and Company's Dry Dock, Sunderland—generally referred to as the No. 2 Dock—and the other works constructed for the company under the direction of the late Mr. William Simpson, O.B.E., M.I.C.E., were described in Engineering, vol. 121, pages 134, 225 and 312 (1926). In close proximity to the No. 2 Dock was a small, old masonry and timber dry dock —generally known as the No. 1 Dock—owned by the River Wear Commissioners and available for use by any shipowner who required its services. The relative positions of the two docks can be seen in Fig. 1 above. In 1939 the company obtained Parliamentary sanction to take over the No. 1 Dock on a long lease on the understanding—an understanding that they willingly accepted—that the dock should be remodelled and re-equipped with modern installations. In 1943, oil tanks in the vicinity of the dock received several direct hits during enemy air raids and the old timber mitre gates to the dock were severely damaged. In 1947, the late Mr. N. G. Gedye, O.B.E., M.I.C.E., who had been the engineering consultant to the company since Mr. Simpson had retired, drew up the necessary plans for the remodelling of the No. 1 Dock and for other works, and contractors were invited to tender, but the project collapsed due to the excessively high tenders submitted to the proprietors and to restrictions placed on capital development. Following the death of Mr. Gedye, in 1947, Sir William Halcrow and Partners, Alliance House, Caxton-street, London, S.W.1, were appointed engineering consultants to the company. The project was re-examined and a new set of contract documents issued: In March, 1950, the tender of the Demolition and Construction Company, Limited, 3, St. James's-square, London, S.W.1, was accepted for the following works: the reconstruction of the No. 1 Dock (on slightly different alignment from the old dock); lengthening the No. 2 Dock by 50 ft.; extending the fitting-out quay by 210 ft.; and reclaiming the area behind the extension, together with repairs to the existing quay.

Reconstruction of No. 1 Dock.

The principal dimensions of the completed dock, sufficient to receive the new 32,000-ton tankers, are as follows: length, 675 ft.; width between fenders at the entrance, 87 ft. 6 in.; width between the copes, 98 ft.; and the depth over the cill at M.H.W.S.T., 27 ft. 4 in. The plan, longitudinal section and typical cross-sections are shown in Figs. 2 to 5, on page 526. The major work of reconstruction was begun in June, 1950; the three months which had elapsed from the date of the signing of the contract gave the River Wear Commissioners time to find new premises and to transfer property from several buildings within the area of the reconstruction.

The original designs of the consultants called for the head of the dock to be completed by a semi-circular bow wall, of 55 ft. radius in plan, that left 25 ft. clear between the head wall and the boundary. In order that the largest modern tankers might be accommodated and the maximum use made of the available land, the company later instructed the consultants to extend the dock to the limit of the boundary. The dock has therefore been constructed as shown in Figs. 1 and 2, with straight walls and tapering in plan from the full 98 ft. width of the dock to 10 ft. at the head, where a reinforced concrete wall spans between the side walls. A foot-bridge, which can be withdrawn, has been provided to give passage-way round the head of the dock.

In the construction of the remodelled entrance to the No. 1 Dock the contractors were handicapped by the proximity of the gateway to the main Sunderland Docks, which severely curtailed the extent of the protecting cofferdam required to seal off the area of the roundheads and the apron of the new entrance. This can be seen clearly from Fig. 1, herewith. The difficulties were multiplied because shipping could use only the entrance to the half-tide basin that is nearer to the new No. 1 Dock, since the further, disused entrance had been damaged and is permanently closed. So that the demolition of the old walls and the construction of the body of the new dock should not be delayed by the time taken to place and seal the cofferdam at the entrance, the contractors repaired the old timber mitre gates as necessary, strengthened them by concrete buttresses and rendered them sufficiently watertight for the old dock to be de-watered and the work commenced. In the early stages, some sections of the walls were built in trench, the dumpling afterwards excavated and the floor then laid; later, however, when full occupation of the site became available, it was possible to excavate over the whole area of a section of the dock and to construct the walls, following immediately with the laying of the adjacent dock floor. Only where the new works ran close to the property of others was it necessary to sheet-pile the trenches to ground level. At the lower depths, from about 20 ft. to 40 ft. below ground level, the excavation was in the magnesian limestone of the area; although this rock is fissured and water-bearing, the contractors did not encounter any bad seepages, although, of course, continuous pumping was essential.

Typical cross-sections of the new dock are given in Figs. 4 and 5, and the general appearance is shown in the photograph reproduced in Fig. 14, on page 536. The principal feature to be noted is the vertical face of the wall with small jutting cantilever altars, shown in detail in Fig. 6. This form of construction, although familiar on the Continent, has not been adopted previously in Great Britain, but it has the advantage of economy of space over the conventional British practice of stepped walls. Generally speaking, the walls were constructed in lengths of 50 ft., the concrete, a 6 : 1 mix throughout, being placed in lifts of about 4 ft. The concrete floor of the dock was cast in intermittent sections of 500 sq. ft. maximum area and is 5 ft. thick at the centre of the dock, reducing to 4 ft. 6 in. at the toe of the walls; these sections were so arranged that the joints between them were not continuous, but stepped as in brickwork. Difficulties were experienced at site in obtaining suitable sand for the concrete, but finally a mixed aggregate proved to be satisfactory. It was not considered necessary to specify a richer mix for the face of the wall, and granite coping stones were similarly dispensed with, as the concrete itself was thought to possess adequate durability. Details of the joint made between the main sections of the walls is shown in Fig. 7. The water seal was made by bitumen poured into pre-cast moulds located in the ends of each section of the wall; the joints in the cill were made similarly.

To relieve the water pressure beneath the floor and behind the lower portions of the walls, an

RECONSTRUCTION OF T. W. GREENWELL'S DOCKS, SUNDERLAND.

Fig. 2. PLAN.

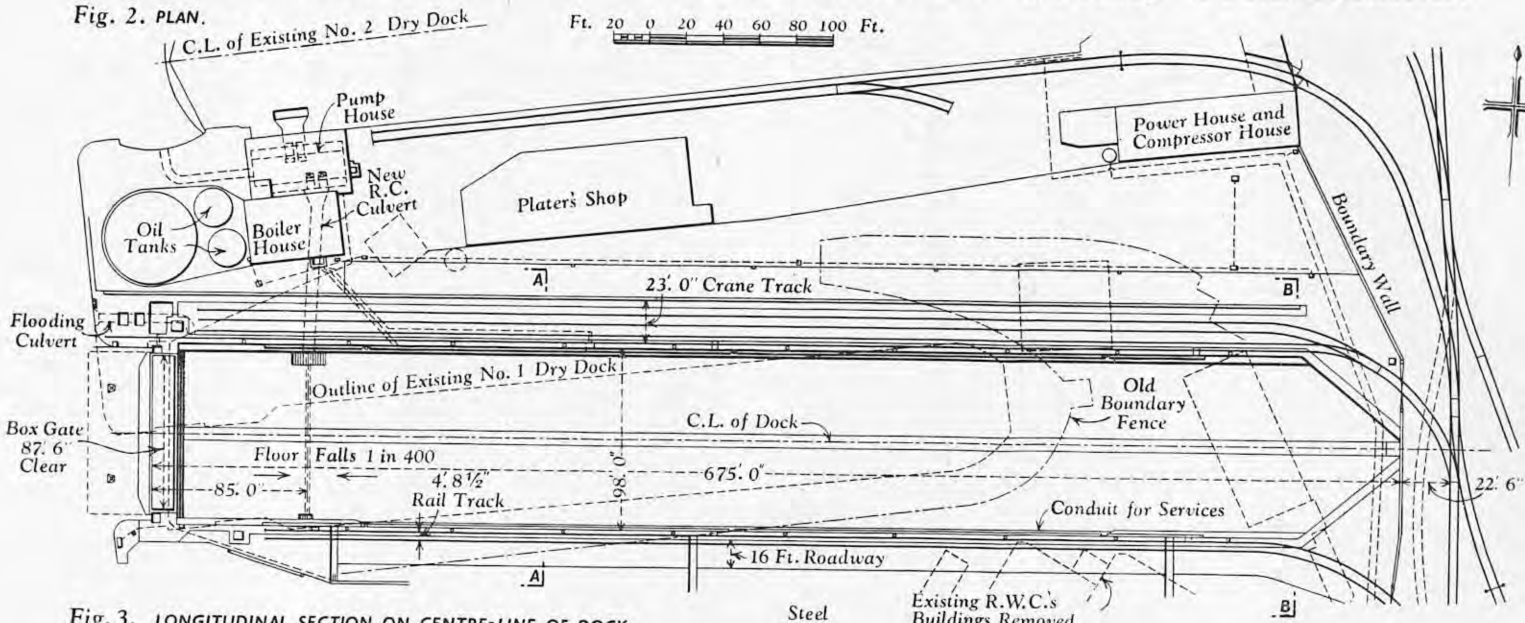


Fig. 3. LONGITUDINAL SECTION ON CENTRE-LINE OF DOCK.

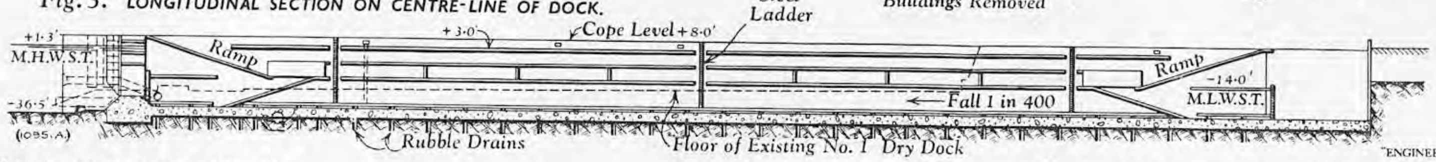


Fig. 4. SECTION A-A. (FIG. 2.)

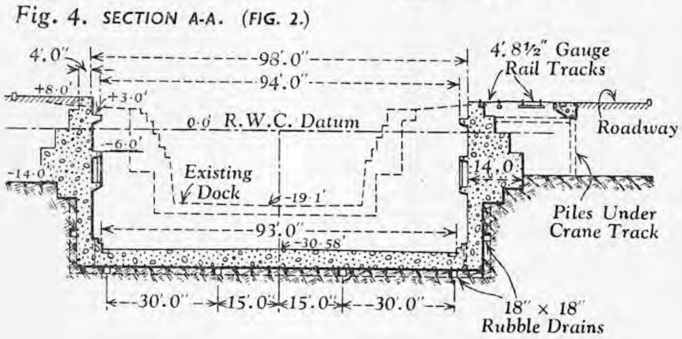


Fig. 5. SECTION B-B. (FIG. 2.)

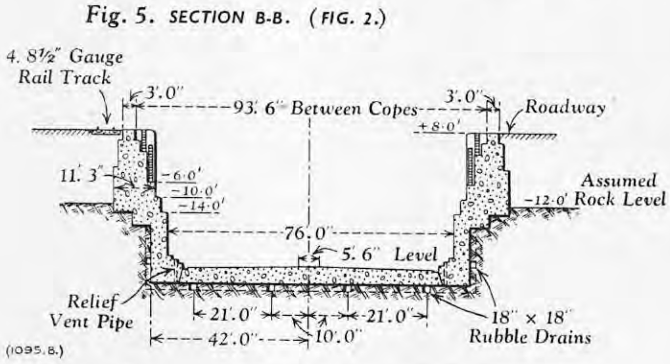


Fig. 6. SECTION THROUGH ALTAR.

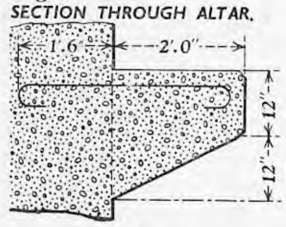


Fig. 7. PLAN OF SEAL IN VERTICAL JOINTS OF DOCKWALL.

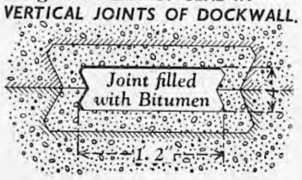


Fig. 8. SECTION THROUGH CULVERT.

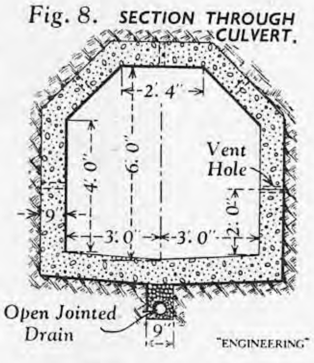
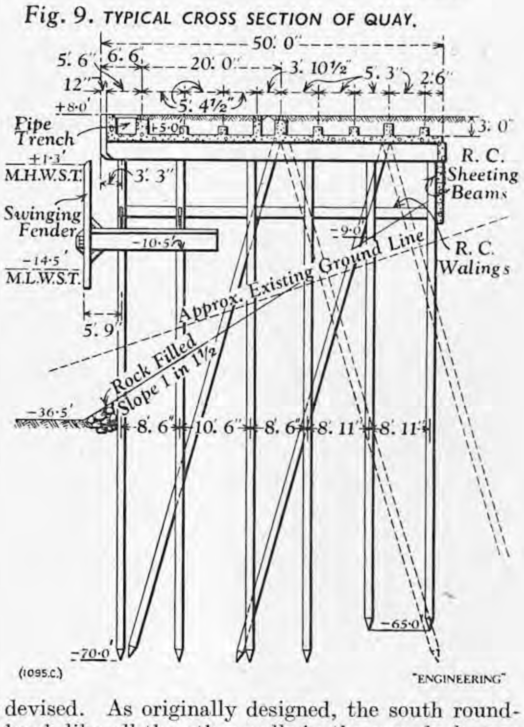


Fig. 9. TYPICAL CROSS SECTION OF QUAY.



interconnected system of rubble drains has been provided that discharges into drainage troughs at each side of the dock floor, through a number of ball-type pressure relief valves. In the earlier No. 2 Dock, it had been thought possible to construct a watertight structure; the floor, however, had not proved adequate to resist the ground water pressure, which had caused it to crack heavily, and it had since been necessary to punch relieving drainage holes through the lower parts of the walls and the floor and to anchor the floor to the rock below by stakes made of old rails.

The dock floor can be reached by vertical ladders of galvanised mild steel fixed to the face of the altars, but the principal means of access is by concrete ramps with a 3 to 1 slope, cantilevered out from the wall. These ramps replace the more usual stairways. Similar ramps were provided at one end of the No. 2 Dock built in 1924-25 and experience has shown their superiority over stairways, it having been found that they are less fatiguing for the men who have to make constant use of them throughout a shift.

The construction of the cofferdam in the tidal basin, so that the new cill and entrance could be built in the dry, raised a number of difficulties. The south roundhead lies close to the gateway to the half-tide basin leading to the Sunderland South Docks, and it was essential that the cofferdam should not encroach upon the shipping lane. The original scheme of the contractor proposed that the south roundhead should be constructed first, behind a small, sheet-pile, limpet dam; the main cofferdam was to be fixed to two junction T-piles left in the face of this completed south roundhead, and on the north side was to be faced up against the quay wall between the graving docks and there sealed with "pug" bolsters. Unfortunately, it proved impossible to drive the piles of the limpet dam sufficiently deep to achieve a "cut-off" and it was therefore not possible to de-water the site of the south roundhead. An alternative method of construction for the south roundhead had to be devised. As originally designed, the south roundhead, like all the other walls in the new dock, was to be of mass concrete with a concrete face from apron level to cope. In the alternative scheme, which was adopted, permanent sheet piles were driven around the face line of the roundhead and the concrete placed behind the piles, which acted as shuttering; a bottom-opening skip was used to place the concrete under water. The tops of these piles were burnt-off at about high-water level, so that the cope of the roundhead could be finished with a concrete face in keeping with the remainder of the new work. Incorporated in the shutter piles were the two T-junction piles to which the closing legs of the inner and outer skins of the main cofferdam were finally fixed.

At the north end of the cofferdam, use was made of a small gap between the caisson foundation of the return wall from the roundhead of the original No. 1 Dock and the block concrete foundation of the quay wall that had been constructed in 1925 at the same time as the No. 2 Dock. A single line of sheet piles was driven down through this gap, and joined to the main cofferdam at the river end, so adding to the protection of the north roundhead. Larssen No. 4B piles, each 54 ft. long, were used

DOCKS RECONSTRUCTION AT SUNDERLAND.

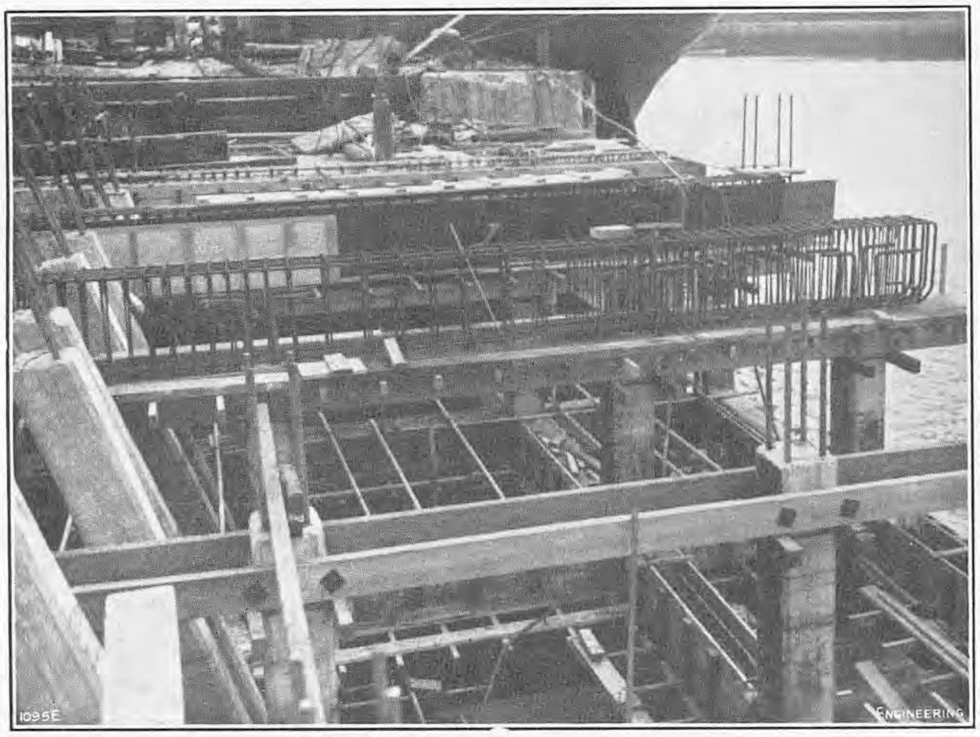


FIG. 10. EXTENSION OF FITTING-OUT QUAY.

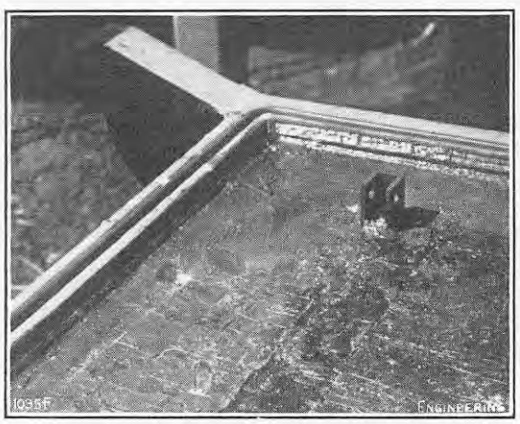


FIG. 11. RUBBER SEAL OF DOCK GATE.

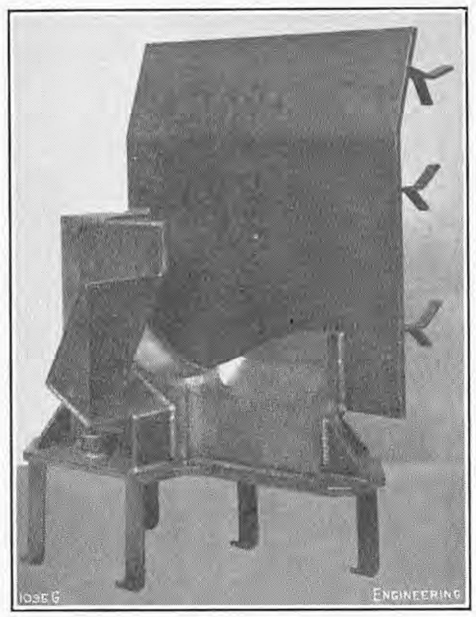


FIG. 12. BEARING SHOE FOR DOCK GATE.

throughout for the construction of the cofferdam, which was strengthened by two sets of channel walings, one at the top of the piles, the other just above the low-tide level. Mild steel tie-rods through the 36-ft. width tied the two skins of the cofferdam, preventing it from bursting by the packing-down of the rock filling. The dam had an overall length of just over 100 ft. and is shown in the illustration in Fig. 13, on page 536. A Scotch derrick, sited inside the entrance of the dock, was used for handling the piles and carrying the McKiernan-Terry piling hammers used in driving them.

When the cofferdam had been finally built and sealed, it became possible to take down the old mitre gates, demolish the remaining masonry of the old dock, excavate for the cill, form the new entrance, including the flooding culvert, and complete the construction of the dock walls and floor.

The pumping system of the old No. 1 Dock had been severely damaged by the bombing, and the provision of new equipment was essential. When the No. 2 Dock was constructed in 1924, a new modern pump-house had been installed, equipped with two electrically-driven twin-impeller 36-in. Drysdale centrifugal pumps each capable of drawing an average of 30,000 gallons per minute when running at a speed of 490 r.p.m. It was, therefore, most satisfactory and economical in future operation, to link the new No. 1 Dock with this existing pumping station. For this purpose a new culvert was driven for 80 ft. in heading from the No. 1 Dock to the well of the pump house; the line of the conduit is shown on the plan in Fig. 2, and a cross-section through the conduit in Fig. 8. The linking of the two docks to the single pump house meant that provision had to be made for shutting off the culverts between either of the docks and the pump well; for this purpose greenheart penstocks working between polished granite faces, and operated hydraulically, have been built into the culverts. Similarly, a hydraulically-operated timber penstock has been fitted in the flooding culvert to the new No. 1 Dock. In each case the original intention had been to fit pipe sluice valves, but valves of the required size were not obtainable within a reasonable time period. Adequate pumping facilities for the hydraulic control of the sluices was already available in the pumping house, but a new 10-in. vertical centrifugal pump had to be installed to deal with leakage water into the No. 1 Dock.

In keeping with the provision of services made for the No. 2 Dock, extensive ducting has been laid in the top of, and behind, the new walls of the No. 1 Dock. These ducts have been used for laying oil, water, compressed-air and steam pipes, and for power and lighting cables. Throughout the period of reconstruction, Messrs. Greenwell's 40-ton crane, which had been built in 1944 in anticipation of the new work, was in position at the river end of the north wall of the new No. 1 Dock and at all times was made available to the contractors. The crane runs on twin rails, at 23-ft. centres; the inner pair of rails is mounted on the top of the new wall and the outer pair of rails is built over a reinforced-concrete ground beam, supported by concrete piles of 16-in. square section, 20 ft. long, driven down to the limestone, and held to correct gauge by reinforced-concrete ties. Adjacent to, and integral with, the ground beam is the conduit carrying the conductor wires of the electrical supply to the crane. The top of the conduit is covered by two mild-steel plates with a longitudinal slot, 4 in. wide, between them for the collector-bar of the crane; to prevent dirt and water getting into the conduit the slot is closed by continuous flap plates which are automatically raised and lowered by a plough as the crane travels back and forth. A short length of similar track has also been built behind the new south wall ready for the installation of another crane of the same kind.

Both the entrance and the gate of the new No. 1 Dock incorporate novel features, particularly in reference to the method adopted for developing the seal. The gate itself is of the "Box" type and is the largest ever to be built to this pattern. The "Box" gate—originally designed and patented by the late Mr. Edward Box and Sir William Arrol and Company, Limited—is in the form of a mediæval drawbridge, turning about a horizontal hinge in the heel of the gate and being raised by wire ropes fixed to the extremities of the leaf. The choice of this type of gate for the work at Sunderland, in preference to a floating caisson, was dictated largely by the restricted space that left no room available for an embrasure into which the gate could be hauled when the dock entrance was opened. So limited is the site, that when the gate is lowered the end of it lies beyond the boundary line of the company's property and it reaches out into the main shipping lane leading into the South Sunderland Dock; this cannot affect shipping generally, since, due to the restricted space, no other vessel can be in that area when a ship is entering or leaving the company's dry dock. The new gate was designed and built by Vickers-Armstrongs Limited, at their yards at Walker-on-Tyne, to the specification of the consultants, and was towed by the sea route to Sunderland. It has overall dimensions of 92 ft. 6 in. by 35 ft. by 6 ft. 6 in. wide, and is fabricated from mild-steel plates welded to form a double-skin structure, with cross-decks and baulkheads of similar material.

The majority of the earlier gates of this type have been built with a timber heel quadrant supported for the whole width of the gate in a cast-iron saddle set in the cill of the entrance; the contact between the wet timber and the cast iron provided the seal at the bottom of the gate. The seal at the sides of the gate was usually obtained by fixing timber meeting faces to the gate, the timber faces then bedding on to finely-axed granite. At Sunderland, however, only side bearings have been provided at the heel of the gate; one of the bearings is shown in Fig. 12 prior to being placed into position.

The seal is obtained by the contact made between a mild-steel billet, with a rubber insert, on the gate, and a stainless-steel strip set into the concrete faces of the quoins and the cill. The rubber insert, which carries virtually no load but merely deforms to fill its seating in the mild-steel billet, is made of relatively soft rubber specially selected for its resistance to salt water. The mild-steel billet with its rubber insert is illustrated in Fig. 11, which shows the heel of the gate. Initial observations have shown the working of this seal to be very satisfactory; indeed, it is claimed that the gate is "drop-tight." In the first instance this form of seal and bearing was developed purely on economic grounds for, despite the apparent high cost of the stainless steel, a less expensive gate was constructed than would have been the case had the standard form of gate been adopted. In addition, the high cost of the finely-axed granite was saved and the employment of skilled masons, who were scarce, was avoided.

In another similar gate, where the seal has been achieved by a mild-steel beading facing up to stainless steel, pitting has been observed that can only be attributed to electrochemical corrosion due to the slight difference in potential between the two steels, the action being hastened by the sea-water. At Sunderland, an attempt has been made to counteract such corrosion by providing a cathodic inhibitor in the form of a zinc strip on the face of the gate adjacent to the mild-steel beading. The zinc strip will, of course, require periodic replacement. General protection of the gate has been obtained by painting; grease paints have been used on the inside surfaces of the gate and bituminous paint on the outside.

The gate is raised and lowered by a single 65-h.p. electrically-driven winch working through fluid couplings; this plant is sufficiently powerful to raise or lower the gate in 4 minutes. Restricted space required the provision of only one winch, which is located on the north roundhead. In order, however, to pull equally on both sides, and so as not twist the gate, the lifting rope is anchored on the south roundhead, it then passes round pulley sheaves located at the top of each side of the gate, before reaching the winch on the north roundhead. To provide against the breakdown of the power supply, the winch can be operated manually.

When in its lowered position the gate is supported on rests built into the apron which lies beyond the cill; the tops of the rests are sufficiently proud above the surrounding apron for a small amount of debris washed into the entrance of the dock not to interfere with the lowering of the gate. The faces of the seal at cill level are protected from damage by entrapped debris when the gate is being closed, by a flap hinged to the heel. When the gate is lowered the flap covers the gap between the gate and the cill and prevents the entry of the debris to the vicinity of the seal.

Extension to No. 2 Dock.

This part of the contract comprised a straightforward extension of the existing dock and all its facilities by 50 ft. The general form of the walls as constructed in 1924 was retained in the extension; the only change made in the design was the provision of a vented-floor and improved drainage behind the walls, similar to that provided in the construction of the new No. 1 Dock. The new walls of the No. 2 Dock were built in a trench, of which the top part—through the soft upper strata—had to be sheet-piled, although this was not necessary in the deeper limestone measures.

The walls of the extension were constructed with the existing head-wall left in position, so enabling the dock to be retained in service throughout the period of construction. The demolition of the old head-wall, the re-dressing of the surfaces of the side walls and floor from where the old work had been broken-out, and the construction of floor of the extension, was completed while a vessel, berthed clear of the work in progress, was in dock for five months for repair and overhaul.

Extension of Fitting-Out Quay.

In order to obtain the berthing accommodation necessary for the largest ships calling at Sunderland, Messrs. T. W. Greenwell's fitting-out quay has been extended by 210 ft., and the area behind this extension reclaimed from the wave basin. The existing quay constructed in 1924 is, at the north end, founded on well monoliths sunk until they penetrated into the limestone bed rock. In the locality of the new extension the quay cuts across the old beach of the Polka Hole wave basin, where the bed rock has dipped deeply under the river. The site is exposed on all sides to the action of the tide and in bad weather there is a heavy in-run of swell. Apart from the difficulties of construction, a deep cofferdam or open trench at this point would have been liable to heavy risks from a combination of heavy seas and high running tides, and the cost of well monoliths, due to the great depths required to reach the rock, would have been prohibitive. An open piled structure avoided these difficulties, and, moreover, was substantially cheaper than the alternatives; for these reasons this method of construction was adopted.

A total of 177 reinforced concrete piles, 14, 15 or 16-in. square, and of length varying between 70 ft. and 77½ ft., were used; a typical cross-section through the quay is reproduced in Fig. 9, which shows the form of one bent of piles. A 10-ton Scotch derrick, located on the back-lands behind the extension, was used for slinging the piles, which were driven from a pile frame that worked its way out from the existing quay on to temporary staging erected above the already driven piles.

The return wall of the existing quay had been built in timber which, although in fair condition at the time of the reconstruction, would be inaccessible for further maintenance after the construction of the extension; steel sheet piles were therefore driven down the face of this breastwork so that deterioration of the timber would incur no damage to the made-up ground behind the quay. The filling, which was placed behind and under the extension, was obtained from the spoil excavated during the construction of the new graving dock. Under the quay extension this filling is pitched to a slope of 1 in 1½ (see Fig. 9) and at ground level is retained by pre-cast reinforced concrete sheeting beams laid along the back of the rear line of piles. At the most northerly end of the site the filling is particularly exposed to the action of the tides and it has been ptorected by a heavy blanket of hand-pitched and grouted rock, 4 ft. thick, to a depth of 9 ft. below the high-water mark. On top of the filling an 8-ft. high stone wall gives further protection from high seas to the reclaimed land behind the quay.

The caps of the piles of each bent are connected by a reinforced beam which in turn supports the deck system, a composite structure of longitudinal beams with an under-hung slab, as shown in the cross-section. Above the slab is the 3-ft. thick filling and quay surfacing, the rail track and the ducting for the services which have been provided in keeping with those installed elsewhere in the company's premises. The crane track—twin-rails at 17 ft. gauge for a 20-ton crane—has been extended from the existing quay. Bollards have been built at suitable intervals along the quay and sufficient anchorage is available to hold a vessel under a full engine test. The framing of the piles had been further stiffened by a system of reinforced-concrete walings running both longitudinally and across the line of the quay and located about 8 ft. below the pile caps. The connection of these walings to the piles was made by cutting away the concrete of the pile and remaking the joint with concrete cast *in situ*; this work is shown in progress in the photograph reproduced in Fig. 10.

There is a large tide and range in the River Wear during north-easterly storms, and ships at berth tend to ride off and on to their moorings; this had caused the original fixed timber fendering to be broken away soon after it had been put into position and further considerable damage had been done to the concrete face of the existing quay. Items were included in the contract for the repair of the quay and the replacement by a new, but heavier, system of fixed timber fendering. Along the quay extension, a swinging gravity fender has been provided between each bent of piles, the deadweight of the fender being provided by a 17-ton block of concrete slung by four cables from steel clamps fitted to the walings. The contractors avoided the cost of transporting these blocks—which would have been necessary if the blocks had been cast elsewhere in the yards—by suspending the shuttering above the final position the fender was to occupy. When the concrete had been placed and finally cured, the shuttering was struck and the fender lowered to the full stretch of its 4 ft. long suspending cables; these cables give the fender a free travel of 2 ft. back combined with a 2 ft. lift. Secured to the face of the fender is a system of timber and steel rubbing pieces sufficiently long to take the impact whatever the tide and the draught of the ship. In order to make sufficient depth throughout the length of the extended quay, a considerable amount of new dredging had to be done and this area will have to be included with the main shipping lanes for regular maintenance dredging.

THE INSTITUTE OF METALS.

(*Concluded from page 462.*)

To conclude our report of the autumn meeting of the Institute of Metals which took place in Oxford from September 15 to 19, we now deal with session "B," which was held simultaneously with session "A" on the morning of Wednesday, September 17. Professor G. V. Raynor presided and no fewer than 14 papers on physical metallurgy were on the agenda. The first five were on the theme: "Equilibrium Diagrams and Theory of Copper Alloys," and were considered jointly.

Equilibrium Diagrams and Theory of Copper Alloys.

The first paper, which was on "Thermo-elastic Analysis of Transformations in Copper Alloys" constituted a report of an investigation sponsored by the Centre National de la Recherche Scientifique, and was by Mr. R. Cabarat, Mr. P. Gence, Professor L. Guillet and Mr. R. Le Roux, of Paris. The purpose of the investigation was to demonstrate the effect of allotropic transformations on the elastic modulus and logarithmic decrement of copper alloys. To determine these two properties a specimen was subjected to forced longitudinal vibrations of small amplitude and high frequency under reduced pressure. The formation of body-centred cubic phases on heating eutectoid copper-aluminium and copper-tin alloys had been found to result in a marked decrease in the elastic modulus, while the logarithmic decrement assumed large values before and during the transformation.

The second paper dealt with "The Constitution of the Copper-Rich Copper-Zinc-Germanium Alloys," and was by Dr. P. Greenfield and Professor G. V. Raynor, of the University of Birmingham. The authors stated in their paper that as part of a systematic examination of the factors affecting the formation of ternary alloys, the constitution of the system copper-zinc-germanium had been examined by micrographic methods, with confirmatory X-ray experiments. Isothermal diagrams at 550 deg. and at 400 deg. C. had been established and, in general forms, they were similar.

The third paper, which was concerned with "The Equilibrium Diagram of the System Copper-Gallium in the Region 30-100 Atomic per cent. Gallium," described work carried out at the University of Oxford by Dr. J. O. Betterton and Dr. W. Hume-Rothery, O.B.E., F.R.S. The authors stated that according to previous work, published in Germany by F. Weibke in 1934, a phase denoted δ, having a γ-brass structure, existed at low temperatures in the range 30-40 atomic per cent. gallium, and, at high temperatures, underwent a transformation into a phase denoted γ, the structure of which had not been determined. The present work had shown that this transformation was an order-disorder change, and that the high-temperature γ-phase had a typical γ-brass structure. At low temperature the δ phase of Weibke had been found to consist of three different modifications of the γ-brass structure. These and other results suggested that Weibke's diagram required considerable modification in the region 35-100 atomic per cent. gallium.

"The Factors Affecting the Formation of 21/13 Electron Compounds in Alloys of Copper and Silver" was the title of the fourth paper, which also described work conducted at Oxford University. It was by Dr. W. Hume-Rothery, Dr. J. O. Betterton and Mr. J. Reynolds, who stated that an attempt had been made to discover the factors that controlled the composition limits of phases having the γ-brass structure in different alloy systems. Data for copper-aluminium and copper-gallium alloys showed that, when the electron concentration reached about 1·70, atoms began to drop out of the structure in such a manner that the number of electrons per unit cell remained constant. This and other observations had caused the authors to reach the conclusion that the critical electron : atom ratio was 1·70, instead of the previously accepted value, for the full zone of 1·73. This suggested that more detailed calculations for the band structure of γ-phases were desirable.

The fifth paper on the diagrams and theory of copper alloys was entitled "The Equilibrium Diagram of the System Copper-Indium in the Region 25-35 atomic per cent. Indium," and, like the third and fourth papers, described work carried out at Oxford University. It was by Mr. J. Reynolds, Mr. W. A. Wiseman, and Dr. W. Hume-Rothery, who stated that thermal, microscopical, and X-ray methods had been used to determine the diagram under investigation. In the region studied there was a phase having a γ-brass structure, the liquidus of which rose to a maximum at 29·6 atomic per cent. indium and 682 deg. C. On the copper-rich side, the liquidus fell to a eutectic with the β body-centred cubic phase, and on the indium-rich side there was a peritectic horizontal at which an η phase having a normal NiAs type of structure was formed by reaction between γ and liquid.

Equilibrium Diagrams and Theory of Alloys of Transition Elements.

The nine papers considered during the second portion of the morning were concerned with the general theme: "Equilibrium Diagrams and Theory of Alloys of the Transition Elements." The nine papers were considered jointly. The first, which was by Mr. B. R. Coles and Dr. W. Hume-Rothery, dealt with work done at Oxford University on "The Equilibrium Diagram of the System Nickel-Manganese." The authors stated that the diagram above 800 deg. C. had been determined by a combination of thermal, microscopical, and X-ray methods. Some data concerning the diagram at lower temperatures had also been obtained. The liquidus and solidus passed through a smooth minimum at 62-atomic per cent. manganese and 1,018 deg. C. Nickel was freely soluble in γ-manganese and, immediately below the solidus, there was a complete range of solid solution extending across the diagram. At lower temperatures, at about 910 deg. C., this solid solution, in the equi-atomic region, was transformed into a β phase having a body-centred cubic structure which could not be retained by quenching. At a still lower temperature the β phase was transformed into a phase having a face-centred tetragonal super-lattice of the CuAu type. The diagram, in some respects, resembled that of the system nickel-zinc, and this suggested that manganese acted as a divalent element in some of the alloys.

"The Alloys of Molybdenum and Tantalum" was the title of the second paper; it was by Dr. G. A. Geach and Mr. D. Summers-Smith of the Associated Electrical Industries Research Laboratory, Aldermaston, Berkshire. The authors stated that their investigation had shown that molybdenum and tantalum formed a continuous series of solid solutions. This was to be expected on theoretical grounds, as both metals crystallised with a body-centred cubic structure and the atoms were very similar in size. No intermediate phases or super-lattices forming at lower temperatures had been detected. It might be predicted that continuous solid solutions would be formed in alloys of vanadium and titanium, chromium, niobium, molybdenum, tantalum, or tungsten, and in the systems zirconium-niobium and zirconium-tantalum. In the system vanadium-zirconium an intermetallic compound might be expected.

The third paper was on "The Sigma Phase in Binary Alloys of the Transition Elements," and was by Dr. A. H. Sully, of the Fulmer Research Institute, Stoke Poges, Buckinghamshire. He stated that it had first been shown by the American investigators, E. C. Bain and W. E. Griffiths, in 1927, that a hard, brittle, and non-magnetic phase was formed in iron-chromium alloys, of composition close to an equi-atomic ratio, when the alloys were slowly cooled or annealed for long periods of time at temperatures below 950 deg. C. The existence of this "sigma" phase had since been adequately confirmed. As a result of the present investigation it had been shown, on the basis of L. Pauling's theory of 1938 of the electronic structure of the transition metals, that a number of predictions which conformed to experimental facts could be made. Thus, it was possible to explain the non-appearance of the σ phase in alloys of iron, nickel, and cobalt with each other. It was also possible to account for its appearance at approximately the correct composition in the systems iron-chromium, cobalt-chromium, iron-vanadium, cobalt-vanadium, nickel-vanadium, manganese-chromium, and manganese-vanadium. In particular, the hypothesis explained the observed facts that the homogeneous σ-phase field did not include the equiatomic composition in the systems cobalt-chromium, nickel-vanadium, manganese-chromium, and manganese-vanadium. Such consistent agreement with experiment was hardly likely to be fortuitous and strongly suggested that the σ phase was a type of electron compound.

The fourth paper was by Professor P. Duwez, of the California Institute of Technology, Pasadena, U.S.A., and dealt with "Allotropic Transformations in Titanium-Zirconium Alloys." The author stated that, in titanium-zirconium alloys, the transformation from the high-temperature body-centred cubic β solid solution to the low-temperature hexagonal closely-packed α solid solution had been found to take place, at least partially, at all compositions and at rates of cooling as high as 8,000 deg. C., per second. This transformation was not complete, however, and the amount of the β solid solution that was retained was a maximum in alloys containing 50-atomic per cent. of each metal.

"The Formation of the Ni_3Al Phase in Nickel-Aluminium Alloys" was the title of the fifth paper, which was by Mr. R. W. Floyd, of the Mond Nickel Company, Limited, Birmingham, who stated that the Ni_3Al phase was formed so rapidly during the solidification of alloys of nickel and aluminium containing about 25 atomic per cent. of aluminium that the difficulties in interpreting the results of investigations of this part of the phase diagram had led to two different reactions being proposed. The present work had demonstrated that the Ni_3Al phase was the product of a peritectic reaction between the melt and the β (NiAl) phase. This had been established by a comparison of the microstructures of small ingots of a series of binary nickel-aluminium alloys containing from 20 to 30 atomic per cent. of aluminium, with those of a corresponding series in which 2½ atomic per cent. of nickel had been replaced by chromium.

The description of another research conducted at the Birmingham laboratories of the Mond Nickel Company, Limited, formed the subject of the sixth paper, on "The Constitution of Nickel-Rich Alloys of the Nickel-Chromium-Titanium System." It was by Dr. A. Taylor and Mr. R. W. Floyd, and these authors stated that the binary nickel-chromium and nickel-titanium systems had been re-examined by X-ray diffraction and micrographic techniques, and new equilibrium diagrams for them had been drawn. A detailed investigation had also been carried out on nickel-rich nickel-chromium-titanium alloys, from which partial equilibrium diagrams corresponding to the 750 deg., 1,000 deg. and 1,150 deg. C. isothermals had been constructed. The boundary separating magnetic from non-magnetic nickel-chromium-titanium alloys, at room temperature, extended across the composition triangle as a straight line joining 8 atomic per cent. chromium, 92 atomic per cent. nickel, to 9 atomic per cent. titanium, 91 atomic per cent. nickel.

A contribution from the Aeronautical Research Laboratories, Department of Supply, Melbourne, Australia, by Mr. H. T. Greenaway, constituted the seventh paper in the series. It was entitled "The Constitutional Diagram of the Chromium-Tungsten System," and the author stated that the phase diagram of these two metals had been investigated by metallographic, X-ray, and thermal analysis. The liquidus rose, slowly at first and then more rapidly, from the freezing point of chromium towards that of tungsten. Above 1,500 deg. C., the solid alloys consisted of a continuous series of solid solutions; below 1,500 deg. C., the single phase broke down into two limited solutions, which thus formed a solubility gap in the diagram.

The eighth paper was entitled "The Constitution and Structure of Nickel-Vanadium Alloys in the Region 0 to 60 Atomic per cent. Vanadium." It described an investigation carried out at Oxford University by thermal, microscopical, and X-ray methods, and was by Mr. W. B. Pearson, D.F.C., and Dr. W. Hume-Rothery, O.B.E., F.R.S. The authors stated that there was a wide solid solution of vanadium in nickel, and, with increasing vanadium content, the liquidus fell to a eutectic point at 51 atomic per cent. vanadium and 1,202 deg. C. At this temperature the liquid was in equilibrium with the α (nickel-base) solid solution of composition 42·7 atomic per cent. vanadium, and with a phase denoted σ, which had the same general type of crystal structure as the σ phase in iron-chromium alloys. At 1,045 deg. C., the α solid solution gave rise to a phase denoted θ, which was a tetragonal superlattice based on the composition Ni_3V. In the region of 33·5 atomic per cent. vanadium, a second intermediate phase, denoted δ, separated from the α solid solution.

The ninth and last paper also described work conducted at Oxford University and was by Mr. Z. S. Basinski and Dr. J. W. Christian. It was entitled "The Cubic-Tetragonal Transformation in Manganese-Copper Alloys." The authors stated that manganese-rich manganese-copper alloys, quenched from the γ-phase field of the thermal-equilibrium diagram, had been studied by X-ray and microscopical methods. High-temperature Debye-Scherrer photographs taken in the equilibrium γ field showed that the structure was face-centred cubic. Quenched alloys containing more than 82 per cent. of manganese were tetragonal at room temperature and were reconverted to a cubic structure by heating to moderate temperatures (180 deg. C. for 93·5 per cent. of manganese). Alloys in the cubic region at room temperature (containing less than 82 per cent. of manganese) became tetragonal when cooled to lower temperatures.

In the afternoon of Wednesday, September 17, visits were paid to the research laboratory of Associated Electrical Industries, Limited, at Aldermaston; the locomotive, carriage and wagon works of British Railways, at Swindon; the Atomic Energy Research Establishment, at Harwell; the works of the M.G. Car Company, Limited, and Riley Motors, Limited, at Abingdon; the works of Morris Motors, Limited, at Cowley; the works and testing shops of the Northern Aluminium Company, Limited, and Aluminium Laboratories, Limited, at Banbury; the Clarendon Laboratory, at Oxford, and other works and places of interest in Oxford and its vicinity. In the evening a reception was held in the Town Hall by invitation of the Mayor of Oxford.

Grain Boundaries.

On the morning of Thursday, September 18, an informal discussion on "Grain Boundaries," arranged as an experiment by the Metal Physics Committee of the Institute, was held under the chairmanship of Professor A. G. Quarrell. The discussion was opened by Mr. Ronald King, of the Royal Institution, London, who outlined present views of the nature and behaviour of grain boundaries, and by Mr. H. W. G. Hignett, of the development and research department of the Mond Nickel Company, Limited, Birmingham, who spoke of the practical importance of grain boundaries. In his address, Mr. King stated that the old amorphous-cement theory, which gave only a "qualitative" explanation of the behaviour of the grain boundaries, had been discarded. During the last five years it had been shown that all features of the microstructure of a metal could be related to the free energy associated with the grain boundaries. Furthermore, the grain-boundary energy could be used for calculating and evaluating the grain-boundary properties. In the course of his introductory address, Mr. Hignett stated that an important property of grain boundaries was their power of attracting foreign atoms. Even in fully-annealed materials, impurities were to be found in the grain boundaries and it was almost impossible to examine a really pure grain boundary. Impurities in the grain boundaries, both dissolved and undissolved, had an important effect on the properties of the surrounding grains and also on grain growth and recrystallisation.

At the conclusion of the business meeting, votes of thanks to the Oxford local section of the Institute, to the University authorities and to all firms, administrations and individuals who had contributed to the success of the meeting in Oxford were passed with acclamation.

BIRMINGHAM WATERWORKS: THE CLAERWEN DAM.

Fig. 1.

THE CLAERWEN DAM.

The completion of the Claerwen Dam, in central Wales, "opened" yesterday by Her Majesty the Queen, is the culmination of a water-supply scheme which was begun in 1892. Prior to that date, Birmingham's water supply had been obtained from local sources, first from the River Tame, and later from the Rivers Bourne and Blythe, at Whitacre. In 1875, under the Birmingham Corporation Act, the Corporation assumed responsibility for the water supply, which hitherto had been in the hands of a private company. At that time, however, it was becoming evident that some of the sources of supply were not satisfactory, as they were contaminated by industrial waste and, moreover, that the further development of local sources was not practicable. Birmingham was growing rapidly and the demand for water, both for industrial and domestic purposes, was fast outpacing the local supply; the possibility of continued growth of the city and its urban environs was a cause of grave concern. Accordingly, the late Mr. James Mansergh, F.R.S., a former President of the Institution of Civil Engineers, was retained on behalf of the Corporation to report upon the future water supply to the City. Mr. Mansergh confirmed that it would not be possible to develop further the supply from local sources, either surface or underground, and after an exhaustive survey he recommended that the Corporation should acquire control of the gathering grounds of the upper reaches of the River Elan and its tributary, the River Claerwen, in Radnorshire. The necessary powers were granted by Parliament in the Birmingham Corporation Act of 1892, which authorised the construction of three reservoirs on the River Elan and three more on the Claerwen, the building of an aqueduct to carry the water to Birmingham and the construction of a receiving reservoir at Frankley, together with the necessary filtration works, pumping station and trunk mains for the distribution of the water to the users. The gathering ground of 71 square miles is located between 700 and 2,115 ft. above sea level, and comprises slates, grits and conglomerates of the Lower Silurian order. The average annual rainfall is 69·4 in. and the reliable collectable yield is not less than 102 million gallons daily. Of this total, 29 million gallons per day are required as compensation water to agricultural interests.

Between 1892 and 1907, the three dams on the River Elan were constructed together with primary filters in the Elan Valley and other works authorised in the 1892 Act.* It was decided that the reservoirs on the Claerwen should not be constructed until a later date, if and when greater storage capacity should become necessary. Although the scheme was not completed until 1907, Birmingham received its first supply from Wales in July, 1904. The tunnel and the "cut and cover" portions of the aqueduct, 73 miles long, were designed and constructed for an ultimate supply of 75 million gallons per day. Such are the relative levels of the Elan Valley and Birmingham that, after rough filtration and treatment, the water flows by gravity alone to the City boundary, where it receives final treatment before passing to the consumer.

The concern of the responsible authorities lest Birmingham should continue to grow, so giving rise to greater demands for water, were well founded. Since 1900, the population of the area of supply has nearly doubled to its present figure of about 1¼ million; in the same period, the demand for water has increased from 18 to 48 million gallons a day. In 1937, a year of low rainfall, when Birmingham's daily demand had reached 34 million gallons, the two upper reservoirs of Penygareg and Craig Goch were first called on to supplement the supply which up till that time had been taken only from the largest reservoir of Caban Coch. The need to use the upper reservoirs indicated that the time had come to develop additional storage in the Claerwen valley. Expert advice was sought and it was decided to abandon Mansergh's original proposals for the construction of three additional reservoirs on the Claerwen, in favour of a single dam on a site immediately above the confluence of the Rivers Arban and Claerwen. By the Birmingham Corporation Act of 1940, the outstanding commitments of the 1892 Act were waived and powers were obtained to construct a single large dam, capable of forming a reservoir with a capacity considerably greater than that of the three reservoirs originally proposed. The water impounded by the new dam forms a reservoir a little over four miles in length and containing 10,625 million gallons. The combined capacities of the reservoirs on the River Elan amount to 11,175 million gallons, of which 8,609 million gallons are available for supply to the city. Thus the building of the Claerwen Dam has more than doubled Birmingham's water reserves. Because of the war, it was not possible to proceed with the work until 1946.

Features of the Dam.

The Claerwen Dam, the largest in Great Britain, is a concrete gravity dam, curved in plan to a radius of 2,000 ft., and is 1,166 ft. long and 251 ft. high. A general view of the completed structure is given in Fig. 1, above. Below water on the upstream side it is faced with Staffordshire engineering bricks; above the water level on the upstream side and on the downstream side, the dam is faced with gritstone masonry that has been quarried in South Wales or Derbyshire and delivered to the site dressed ready for fixing. This material is also used for the channel retaining walls. The general appearance of the dam has been designed to harmonise with the earlier works in the Elan valley.

Longitudinally, the dam is divided into 23 radial blocks, the concrete in alternate blocks being placed four weeks in advance of that in the intermediate blocks, to assist in dissipating the great amount of heat generated in such a large mass of concrete. A special "low-heat" Portland cement, manufactured at Aberthaw, in South Wales, and delivered in bulk by special trains to Rhayader station, 10 miles by road away from the dam, was used throughout the construction. The joints between the blocks were made water-tight by continuous vertical copper strips. Two inspection galleries have been provided throughout the length of the dam to give access to the valve chambers situated within it; the upper gallery is on the level and near to the crest of the dam, the other is stepped to follow the contour of the valley floor. Electric light is supplied by small turbo-generators working under the head in the reservoir.

When water is required from the reservoir for supplementing the supply to Birmingham, it will be drawn off through discharge pipes of concrete-lined steel, up to 4 ft. in diameter, which discharge into the original river course at the foot of the dam. The stream leads down to a small reservoir formed by the partly constructed Dolymynach Dam, which was to have been the lowest of the three dams originally proposed for the River Claerwen. From this lower reservoir the water will be diverted through a tunnel in the hillside to discharge into the upper Caban Reservoir, whence it can be drawn off through the Foel valve-tower into the main aqueduct for conveyance to Birmingham.

* "The Works for the Supply of Water to the City of Birmingham from Mid-Wales," by E. L. and W. L. Mansergh, MM.I.C.E., *Proc.I.C.E.*, vol. 190, page 3, (1912).

The overflow crest of the new dam, 540 ft. long, is located symmetrically about the centre line of the valley, 1,210 ft. above the Ordnance datum; 60 ft. of the crest, at the centre, is 6 in. lower than the remainder, so that the normal flow will be restricted to this relatively narrow path. The face of the dam below this part of the crest is built in a series of steps between substantial buttresses which spring from the roofs of the two masonry valve houses situated at the toe of the dam. As a result of a model investigation, the crest has been rounded, the experiments having shown that a sharp crest above the stepped face gave rise to a severe breaking-up of the water stream, with the consequent formation of a great deal of spray. In time of flood, the flow over the remainder of the crest will spill down the face of the dam, to be guided by training walls at its foot into a stilling pool and then over a measuring weir to the original water course. The dam is crossed by a 12-ft. roadway, flanked by two footways, which cross the spill weir on 13 elliptical arches. Twelve of these are of 40 ft. span and one of 60 ft. span crosses the centre of the crest.

(*To be continued.*)

THE B.S.R.A. SHIP-STRUCTURE RESEARCH STATION AT GLENGARNOCK.

One of the most important activities of the British Shipbuilding Research Association is the testing of full-size components of ships' structures. In investigations of the structural strength of ships, some guidance can be obtained from small-scale model experiments, but where the quality of workmanship is a significant factor, as it is in all cases where account must be taken of the strength of welded or riveted connections, full-scale testing is essential. It was for this purpose that the Association's testing establishment at Glengarnock, Ayrshire, was set up shortly before the war, and has been extended recently by the addition of a large new machine, capable of applying lateral and axial loads simultaneously.

The full-scale testing of ships' structural members was instigated in 1938, in the first place by the Research Committee of the Institute of Welding, subsequently known as the Welding Research Council. The primary object was to compare the relative merits of riveted and welded stiffening, in view of the extended application of welding to shipbuilding, then taking place. With the transfer of the research activities of the Institute of Welding to the British Welding Research Association towards the end of the war, this work also was carried on by that Association for a time, but it was transferred to the British Shipbuilding Research Association in 1945, since when the scope of the work has been broadened to include a wide variety of types of rolled and built-up sections and different forms of end connections.

The B.S.R.A. Committee concerned with this work includes representatives of the shipbuilding industry, of Lloyd's Register of Shipping, the Marine Division of the Ministry of Transport, and the Admiralty, and in planning the programme of tests the immediate needs of the industry, together with possible new developments likely to lead to structural economies, are kept constantly in mind. Already the investigations have shown that, where welded stiffening is adopted, some reduction in the scantlings of existing riveted standards is justified, and appropriate modifications have been made, accordingly, in the relevant rules and regulations.

When this work was taken over from the British Welding Research Association, the equipment consisted of a single testing machine capable of applying lateral loads only to the specimens, most of which were stiffened areas of plating. The new testing machine now available broadens the field of investigation considerably and enables tests to be carried out on full-scale components such as sections of decks and shell which are stressed by the bending of the main hull girder in addition to locally-applied lateral loads. The two testing machines are described and illustrated below. The original equipment taken over from the B.W.R.A. is now known as No. 1 machine and the new equipment provided by B.S.R.A. as No. 2 machine. These are situated adjacent to each other in a test-house in the works of the Colville Constructional Company, Limited, Glengarnock, who have given valuable and much-appreciated co-operation to the British Shipbuilding Research Association.

No. 1 Machine.

The original machine installed in 1938 under the auspices of the Institute of Welding is used for testing specimens under lateral or beam loading only. It is illustrated in Figs. 1 to 3, on page 532. Fig. 1 shows the method of distributing the load by means of a system of compound levers on the head of each ram. The specimen illustrated, being of unsymmetrical section, twists as the load is applied, and Fig. 2 shows the method of counteracting this twisting tendency by means of levers and weights. Fig. 3 shows the same specimen, tested to destruction.

The original purpose of the investigations was defined as follows: "To compare composite beams, made up of riveted plates and sections, with welded beams under conditions of partial fixity resembling those occurring in ship construction, with a view to obtaining information on the relative merits of riveted as compared with welded stiffening in general." A further object was "to ascertain the soundest, lightest, and most economical methods of welded construction which might safely be substituted on the grounds of equivalent efficiency and strength for riveted bulkhead stiffeners, deck beams and girders, shell framing, etc., as laid down in existing rules and regulations."

Such a programme did not lend itself to hydraulic tank testing; among other reasons, because of the difficulty of access to both sides of the specimen under test, the interference of boundary constraint on stiffeners at varying distances from the sides of the tanks, and the consequent difficulty in obtaining true comparisons between specimens of different strength and stiffness when tested together. Another major consideration was the great cost and the time involved in tank-testing the large number of specimens and varied conditions of end restraint which were contemplated. A test frame was therefore designed and constructed specially for the purpose, consisting of a panel of plating, 16 ft. long by 6 ft. wide, and having three bracketed stiffeners spaced 2 ft. apart; it represented a section of a ships' bulkhead. The base structures to which the ends of the specimen are attached are of cellular construction and are tied together by heavy longitudinal girders at the top and bottom. These base structures of the machine were intended originally to correspond to double-bottom structures in ships and therefore were provided with "skeleton" and "solid" floors. The stiffness of either or both of these structures can be varied, however, to simulate other conditions; for example, end rigidity can be provided equal to that given by a solid floor under the bracket points by welding up all the struts, or these struts can be released to give a reduced stiffness corresponding to that of a deck beam or even that of an unstiffened plate.

To simulate as far as possible the effect of water pressure, the load is distributed along the length of the specimen by means of six 30-ton hydraulic rams, the load from each ram being distributed across the width of the specimen by means of the levers and push rods shown in Fig. 1. It will be noted that the load is applied through the plating, as is normally the case in ships' structures. The longitudinal spacing of the rams can be adjusted so as to simulate, if required, the pressure gradient over a vertical bulkhead subject to water pressure. This six-point longitudinal distribution of load approximates to distributed loading sufficiently to justify the acceptance of results for direct comparison, but these can be easily corrected to the equivalent case where the load is uniformly distributed, for comparison with other data. The machine can take girders 16 ft. and 24 ft. long under a maximum total distributed load of 180 tons, though so far only specimens of 16 ft. span have been tested. Panels of plating up to 9 ft. wide can be accommodated. The clearances above and below the level of the specimen are sufficient to enable brackets up to 35 in. deep to be placed in the machine either way up, so that the load may be applied from either the clear side of the plating or the stiffener side, as required. The push rods have been arranged so that stiffeners spaced either 2 ft. or 3 ft. apart can be accommodated.

The hydraulic equipment for this machine was supplied by the Swiss firm of Messrs. A. J. Amsler and Company. The rams are of the unpacked type, lapped to an oil-tight fit in the cylinders. The absence of packing ensures a virtually frictionless ram, so that the fluid pressure is a direct measure of the load. All rams are subjected to the same pressure and therefore deliver equal thrusts. Pressure is applied to the system by means of a continuously-running pump, which is driven electrically, and the required load is set and measured by means of the well-known Amsler load maintainer and pendulum dynamometer, which maintains a constant applied load irrespective of the distortion of the specimen. The framework of the machine was made by the Colville Constructional Company to designs approved by the Research Committee of the Institute of Welding. In practice, the design has fulfilled the stipulated requirements in all respects, and the whole gear is still as accurate as when it was first installed; the result, no doubt, of the fact that the arrangement is as simple and as free from complication as it could be made.

No. 2 Machine.

The new machine, which was completed and put into operation earlier this year, represents the results of several years of preliminary consideration. It was designed and constructed under the auspices of the British Shipbuilding Research Association, and is intended for tests of the same general type as those made on the No. 1 machine; but the specimens are not restricted to components subject to beam loading only, as arrangements have been made, as mentioned above, for applying both lateral (beam) loads and axial (column) loads, either independently or simultaneously. Provision is also made for the testing of continuous beams. The machine is illustrated in Figs. 4 to 6, on page 533.

The machine was intended for the testing of such components as stiffened areas of bottom plating for both transverse and longitudinal framing, stiffened areas of deck plating, side-framing elements, bulkheads acting as beam columns, pillars with side loads, and large-scale box girders, under-deck girders, hatch coamings, etc.; web-plate girders, both slotted and plain, and continuous beams, with varied loading in adjacent bays. The test length is 24 ft., and specimens up to 9 ft. in width can be accommodated.

The lateral loading arrangements are generally similar to those on No. 1 machine, except that they are on a larger scale, there being six 50-ton rams, giving a maximum distributed load of 300 tons instead of 180 tons. The major difference is the provision of axial loading by means of the three 200-ton double-ended rams which can be seen on the seating or stool in Fig. 5. This ram system can apply a maximum load of 600 tons, either tensile or compressive, and is operated independently of the lateral loading system. Axial loads of this magnitude are sufficient to produce longitudinal direct stresses of from 8 to 10 tons per square inch in the size of specimen contemplated, which covers the range of hogging and sagging stresses normally encountered in practice.

The main framework of the machine consists of a central lower girder which resists the bending reactions of the lateral loading, together with two upper side girders, at the specimen level, which withstand the reactions induced by the axial loading. These two girder systems are connected at the ends by seatings or stools. The right-hand stool forms the seating for the axial-loading rams. The left-hand stool is provided with a heavy cross girder and two large pins which form the anchorage for this loading. The left-hand stool includes a flexible section which permits of a limited degree of freedom in the longitudinal direction. This ensures that the reactions due to the axial loading are not transmitted to the lower central girder, but are resisted entirely by the upper side girders, which are in the same plane as the rams.

RESEARCH ON SHIPS' STRUCTURES.

Fig. 1. No. 1 Machine.

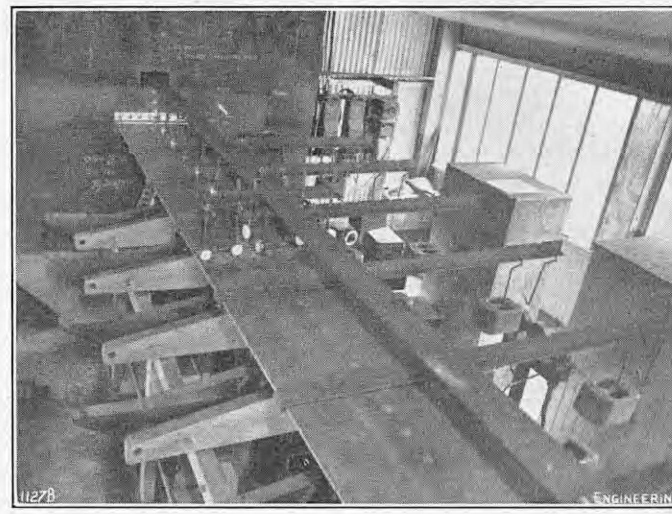


Fig. 2. Test Specimen, Loaded to Prevent Twisting.

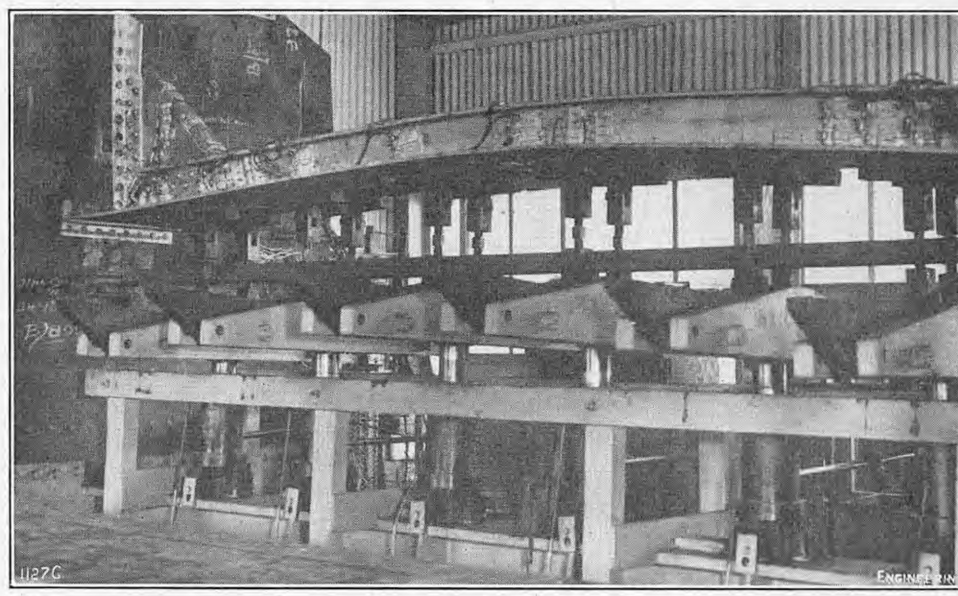


Fig. 3. Test to Destruction of Aluminium-Alloy Component.

The ends of the specimen are attached to mounting boxes of cellular construction, which correspond roughly to the variable-rigidity and structures on the No. 1 machine. These mounting boxes stand on flexible plate diaphragms, as shown in Fig. 3, which resist rotation of the ends of the specimens, but have a degree of freedom in the longitudinal direction to permit the transmission of the axial load to the specimen. When the specimen is under lateral load the diaphragms remote from the specimen are in compression; therefore they have been stiffened over the greater part of their length, to resist buckling. The diaphrams nearer to the specimen are generally in tension and these have been reduced in thickness at the ends where most of the bending takes place, but a thicker section is employed over the greater part of their length to reduce their extensibility to a minimum. Each pair of diaphragms forms, in effect, a parallel-motion mechanism which offers negligible resistance to longitudinal movement of the order encountered in testing.

Arrangements have been made to provide two intermediate elastic supports for the specimen, thus permitting the main span to be subdivided into three if required. This is effected by means of tie rods which connect cross-girders on the specimen to elastic couplings on the base plate, operating on the principle of carriage springs. These couplings consist of light-alloy leaf springs, the stiffness of which may be adjusted over a very wide range, by varying the span and the number of leaves in the spring, from almost complete rigidity to a maximum extension of $\frac{3}{4}$ in. under a pull in the tie rod of 50 tons. The material of the leaf springs is high-strength aluminium alloy, of 40 tons ultimate tensile strength; if steel had been used under the same stress, the springs would have had to be three times the bulk and nine times the weight in order to meet the same requirement. The elastic couplings slide in rails in the base structure and their longitudinal position can be varied within wide limits. One pair of couplings can be dispensed with, if it is desired to sub-divide the span into two. These arrangements allow specimens to be tested under conditions of elastic restraint at one or two positions in their length, as is common in ship structures (e.g., in web girders on bulkheads, deep webs in oil tankers, etc.). An interesting and important feature is that the framework has been designed on the "closed-frame" principle, so that reactions from the loading are taken internally and no forces are transmitted to the foundation.

With regard to the hydraulic equipment, an important difference from the No. 1 machine is that packed rams had to be used instead of the precision-lapped rams, because of the difficulty in obtaining the latter type of equipment in the early post-war years. Owing to the friction in the glands, it was not practicable to use the hydraulic fluid pressure as a measure of the load, so Macklow-Smith hydraulic capsules are used to measure the force actually delivered by each ram. This load-measuring device, which was used to measure the thrust of the jet engines employed to propel the experimental ship Lucy Ashton, was described and illustrated on page 573 of our 170th volume (1950). It consists of a shallow cylinder and a piston enclosing a small quantity of hydraulic fluid, with a pressure connection led to a remote-reading pressure-gauge. Instead of a gland between the piston and the cylinder, the seal is made by an annulus of rubber, bonded to the walls of the cylinder and to the piston. When load is applied to the outer face of the piston, the pressure on the enclosed fluid rises accordingly, the rise being registered on the pressure gauge and measuring the applied force. The displacement of the piston under maximum load is extremely small, so that the resistance set up in the rubber is negligible; in any case, it is accounted for in the calibration of the device. Before installation, all capsules were calibrated in the dead-load testing machine at the National Physical Laboratory, Teddington, which is a National Standard.

Three hydraulic pumps are provided, of the Williams-Janney V.S.G. type. They are electrically driven and run continuously, delivering and maintaining any desired pressure, which can be preset on the spring-loaded control valve. In normal operation, one pump is used for the axial loading and a second for the lateral loading; the third is a stand-by. There is a universal arrangement of valves, however, such that any of the three pumps can be connected to any one or more rams, with the result that a great variety of load distributions is possible. Although the rams are of the packed type in general use in hydraulic machinery, they are of very high quality and have chromium-plated surfaces. This high-grade finish was provided with a view to obtaining uniform gland friction in order to ensure that, as far as possible, each ram within a given group delivered the same thrust at a given hydraulic pressure. Experience has shown that this object has been achieved. As in the case of the earlier machine, the framework was constructed by the Colville Constructional Company, to designs approved by B.S.R.A. The hydraulic equipment was supplied by Brown Brothers, Limited, of Rosebank Ironworks, Edinburgh.

The larger and more versatile No. 2 machine has in no sense superseded the simpler No. 1 machine, which is still in use. A comprehensive series of tests is being carried out at present in the latter machine on aluminium-alloy specimens. The specimen in the new machine at the moment, which can be seen in Figs. 4 to 6, is a panel of plating 24 ft. long and 6 ft. wide, fitted with three 8-in. bulb-angle stiffeners spaced 2 ft. apart. The span is divided into three parts by two intermediate web girders which are restrained by the elastic couplings previously described. It represents a section of a ship's bulkhead and so far has been tested with lateral loading only. Further tests are to be carried out with combined axial and lateral loading.

RESEARCH ON SHIPS' STRUCTURES.

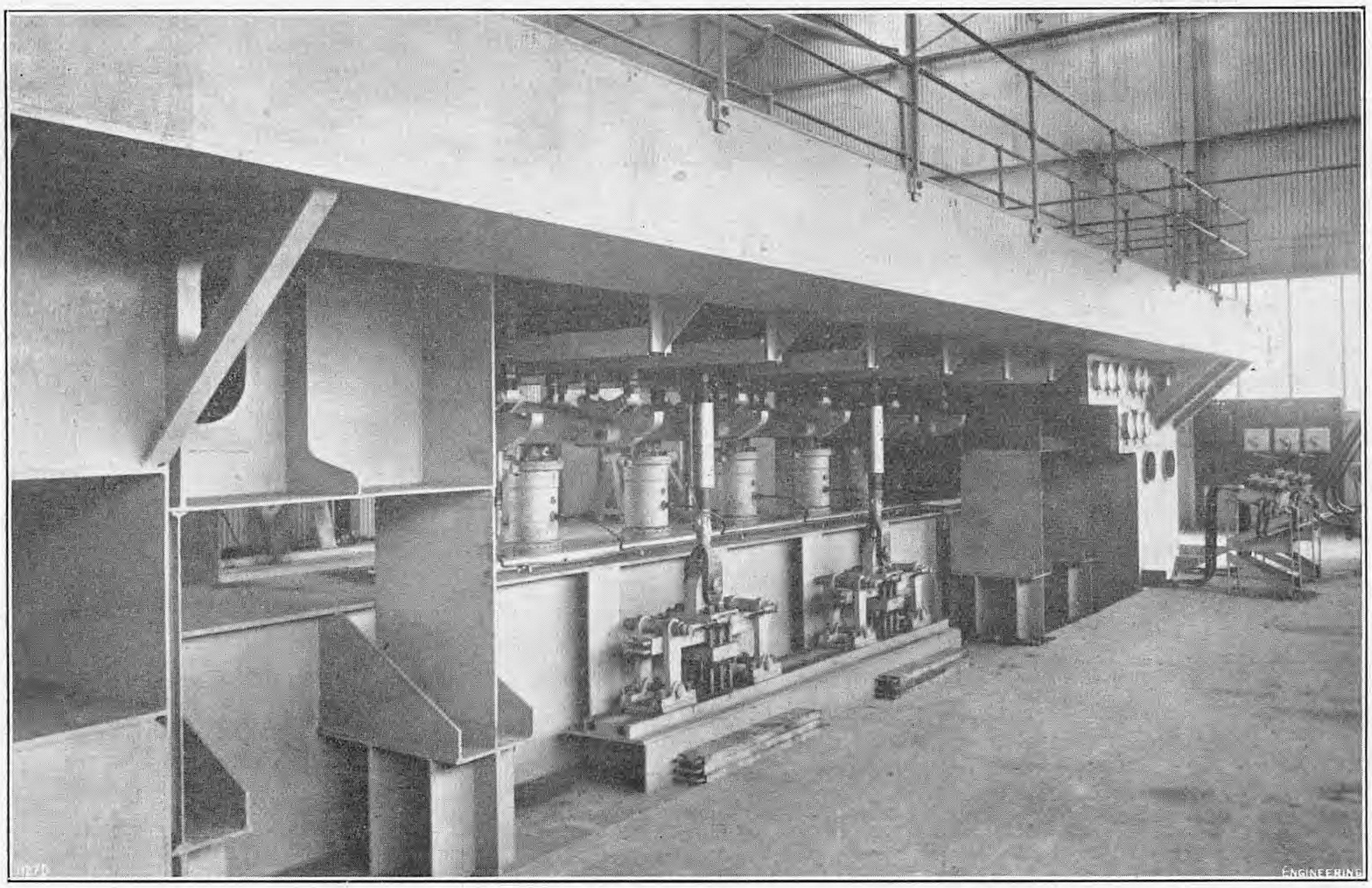


FIG. 4. NO. 2 MACHINE: OPERATING SIDE.

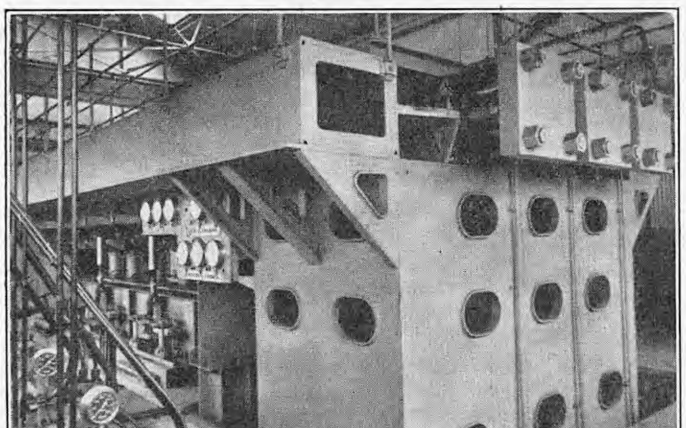


FIG. 5. NO. 2 MACHINE: END STRUCTURE.

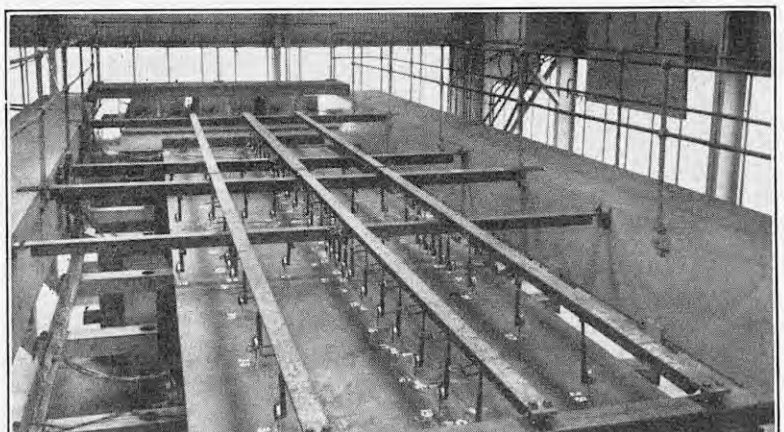


FIG. 6. SPECIMEN IN MACHINE, SHOWING DATUM BARS.

In making tests on both machines, comprehensive measurements of strain and deflection are generally taken at a progressively increasing series of loads. Confirmatory readings are also taken as the load is reduced, in a similar manner. Deflections are measured by means of the usual dial gauges, the measurements being taken from datum bars resting at their ends on ball contacts. In the early days, mechanical extensometers of the Huggenberger type were used to measure strain, but these have now been largely superseded by electrical resistance strain gauges, the connections from which are led to a small office in one corner of the laboratory. Specimens are normally loaded within the yield point of the material, but occasionally tests to destruction are made. The testing is carried out on behalf of the British Shipbuilding Research Association by Lloyd's Register of Shipping. Prior to the amalgamation of Lloyd's Register and the British Corporation, the test-house staff were provided by the latter organisation, whose Chief Surveyor, Mr. J. L. Adam, C.B.E., was closely associated with the development of No. 1 machine and the early work carried out with it.

The results of tests carried out in the No. 1 machine have been published in various papers to technical societies under the general heading of "Ship Structural Members." The references are as follows: Part I, by J. L. Adam, *Trans. I.N.A.*, vol. 82, page 19 (1940); Part II, by C. S. Lillicrap and C. J. G. Jensen, *Trans. Inst. E. & S. Scot.*, vol. 87, page 151 (1943-4); and Part III, by the same authors, *Trans. N.E.C. Inst.*, vol. 61, page 333 (1944-5); Part IV, by C. J. G. Jensen, *Trans. N.E.C. Inst.*, vol. 65, page 99 (1948-9); and Part V, by A. G. Hadjispyrou and H. Lackenby, *Trans. Inst. E. & S. Scot.*, vol. 95, page 563 (1951-52).

BEILBY MEMORIAL AWARD, 1952.—The Administrators of the Sir George Beilby Memorial Fund, representing the Royal Institute of Chemistry, the Society of Chemical Industry, and the Institute of Metals, are to consider making awards from the funds early in 1953 to British scientific investigators, preferably working on problems connected with fuel economy, chemical engineering and metallurgy, in recognition of continuous work of exceptional merit, bearing evidence of distinct advancement in science and practice." Work of the nature indicated may be brought to the notice of the Administrators either by persons desiring to recommend a candidate, or by the candidate himself, in a letter addressed to the Convenor of the Administrators, Sir George Beilby Memorial Fund, Royal Institute of Chemistry, 30, Russell-square, London, W.C.1. The letter should reach the Convenor by December 31, accompanied by a statement of the candidate's date of birth, education, qualifications, and experience, and by eight copies of a list of papers or other works published by the candidate.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

Refresher Course for Plant Engineers.—On account of exceptionally heavy enrolments, a refresher course for works and plant engineers, arranged by the Glasgow branch of Incorporated Plant Engineers, to be held in the Engineering Centre, at Glasgow, has had to be transferred to larger premises, namely, the Rankine Hall of the Institution of Engineers and Shipbuilders in Scotland, at 39, Elmbank-crescent, Glasgow. The first of the 20 weekly lectures was given on October 15, when Mr. A. J. MacIntyre, of James Howden & Co., Ltd., a past-chairman of the branch, delivered an address entitled "Planned Maintenance."

Electricity Supply in Ayrshire.—A scheme to reinforce the electricity network in Ayrshire, north of Kilmarnock, at an estimated cost of 157,000*l*., has been approved. The present 22,000-volt line between Kilmarnock and Kilbirnie has become overloaded and a new 33,000-volt line will be constructed. Later a second 33,000-volt line will be erected. The plans also include a large new substation at Kilbirnie.

Luing-Argyll Ferry.—A new vehicular ferryboat for Cuan Ferry, between the island of Luing and the mainland of Argyll, will be put into service as soon as the slips on both sides of the ferry are completed. It will be a free ferry.

Steel Production in Scotland.—Steel re-rollers in Scotland are in a more comfortable position for raw materials than they have been for many years. Deliveries of billets and sheet bars from the Continent have been steady for some time, and most firms now have some stocks to work on. The home demand for small bars and light sections remains good, and seems likely to continue for some months at least. Export business is practically unprocurable.

Diatomite Production in Skye.—The processing of diatomite is a flourishing new industry in Skye. A deposit of high quality found on the bed of Loch Cuithur is likely to provide employment for a large number of crofters for several years. To get at the deposit the loch has been drained. The diatomite is dried and ground at a factory on the coast 3½ miles away, whence it is shipped to Glasgow and Manchester.

Railway Developments in the Fife Coalfield.—To meet the great increase in coal production expected in Fife within the next ten years, British Railways are planning new marshalling yards, new lines, and signalling on a very large scale in the county. Mr. B. Temple, district commercial superintendent, speaking in Dundee on October 16, said that about 175,000 more wagons will have to be provided to meet the projected increase in output from 7,316,000 tons last year to 10,000,000 tons in 1960. New marshalling yards will be built at Oakley, Thornton, and Alloa, in addition to a number of new lines to the pits.

Coltness Iron Company.—The directors of the Coltness Iron Company, Ltd., announce that they have accepted an offer from G. and J. Weir, Ltd., Cathcart, Glasgow, for the purchase of their foundries and certain ancillary departments at Newmains. It is understood that Messrs. Weir intend to keep the foundries in operation. The works, which had been threatened with closure, employ about 600 men, and comprise a steel foundry, an iron foundry, and engineering shops. The negotiations were conducted on behalf of G. and J. Weir, Ltd., by Mr. J. Russell Lang, chairman of the Weir Housing Corporation.

Railway Improvements at Dumfries.—Work has started at Dumfries, an important junction station on the Glasgow-Kilmarnock-Carlisle main line, on a major scheme of modernisation of signally arrangements and improvement to the permanent-way layout which is designed to accelerate traffic operation. The plans include the provision of colour-light signals and the simplification of the permanent-way layout. Five signal boxes are to be replaced by two modern boxes. The project is to be completed in five stages.

CLEVELAND AND THE NORTHERN COUNTIES.

The Scrap Position in the North-East.—Mr. Harold Boot, managing director of the Consett Iron Co. Ltd., and chairman of the North-East Coast Scrap Drive Committee, has urged the managing directors of firms in the area to make a ruthless search for scrap in their works. In a report on the steel position, submitted to the Northern Regional Board for Industry, Mr. Boot said that the North-East was getting only an average of 9,000 tons of scrap a week and that steel furnaces could utilise a good deal more than this quantity.

River Wear Traffic.—During the first eight months of the present year, coal and coke shipments from the River Wear amounted to 2,091,860 tons, an increase of 80,283 tons on last year but 785,668 tons less than 1938. This year, 526,559 tons were sent overseas, against 323,365 tons last year and 1,365,776 tons in 1938. Other exports totalled 56,870 tons, the chief item being 43,594 tons of petroleum. Imports were 363,427 tons, the chief items being 136,539 tons of iron ore and 117,348 tons of crude oil. Imports during August reached the record figure of 66,658 tons.

Shortage of Skilled Man-Power in Workington.—The possibility that the Distington Engineering Co. Ltd., Workington, may have to place some of their work outside the area for lack of man-power was referred to by Mr. A. H. H. Douglas, director and general manager of the firm, when the company entertained members of the Workington Corporation to lunch. Mr. Douglas said that, if they could secure the men needed, the firm's exports in 1953 should amount in value to nearly one million pounds, most of it for the dollar market. The firm, however, could not continue to work indefinitely at half its capacity because of a shortage of skilled men.

Contract for Blast Furnace.—A contract has been secured by Messrs. Head, Wrightson & Co. Ltd., of Thornaby-on-Tees, for blast-furnace plant for Messrs. John Summers & Sons Ltd., of Shotton. When completed, the plant will produce about 1,000 tons of pig iron a day. The order is one of the biggest ever undertaken by the firm. The new plant will be a duplicate of one Messrs. Head, Wrightson are at present completing at Shotton, which is the largest blast furnace outside the United States. It covers the entire range of iron-making equipment from ore unloading, crushing and screening through sintering for a complete blast-furnace plant with gas clearing equipment and special rolling stock.

LANCASHIRE AND SOUTH YORKSHIRE.

Coal Production.—In the North-West Region, a coal output of 12 million tons has been reached this year in a week less than was taken in 1951, when more saleable coal was produced than in any previous year since the nationalisation of the coal-mining industry. Last week's output of 316,064 tons was the highest for nearly six months.

Liverpool University Extension Course on Corrosion.—The Department of Extra-Mural Studies of the University of Liverpool, in conjunction with the Department of Metallurgy, have arranged for a course of nine extension lectures on corrosion to be held in the Lent Term, 1953. The course, intended as an advanced refresher course for graduates and others in industrial or research establishments, will cover the general principles of corrosion of ferrous and non-ferrous metals under various industrial conditions, protection against corrosion, and testing and selecting materials. The course will commence on January 9, 1953, and the fee will be two guineas. Application forms and further particulars may be obtained from the Director of Extra-Mural Studies, 9, Abercromby-square, Liverpool, 7.

The Late Colonel J. S. A. Walker, T.D., J.P.—We have learned with regret of the death, on October 17, of Colonel James Scarlett Ascroft Walker, T.D., J.P., vice-chairman of Walker Brothers (Wigan), Ltd. He was 65 years of age and had been living in retirement since 1947, though he retained his seat on the board of his firm. Colonel Walker was a member of the Institution of Civil Engineers and of the Institution of Mechanical Engineers, and was a part-time member of the North-Western Electricity Board.

THE MIDLANDS.

Re-development of Birmingham Central Areas.—A meeting is to take place on November 11 between officials of Birmingham Corporation and the Staffordshire, Worcestershire, and Warwickshire County Councils, to discuss problems arising out of the development plan for the Birmingham central areas. Within a short distance of the centre of the city, Birmingham has a considerable amount of sub-standard property which is scheduled for demolition. A large part of this property is residential, but intermingled with the houses are numbers of small factories. In many cases houses and factories are structurally inseparable, and it has been pointed out that demolition of the houses would make it impossible to leave the factories standing, even if it were desirable to do so.

Underground Gasification of Coal.—Progress at the experimental site for underground gasification of coal at Bayton, near Bewdley, Worcestershire, was shown to the Minister of Fuel and Power, Mr. Geoffrey Lloyd, M.P., on October 14. Several seams of coal are known to exist in the area, and until 1950 a small colliery was at work there. A coal seam at a depth of 130 ft. has been ignited by means of a borehole, and for the last three months the gas produced has been used to drive a small horizontal gas engine, which is coupled to an electric generator. Several other boreholes have been put down, and it is hoped, within the next two months, to produce gas from a seam of coal, 3 ft. thick and 250 ft. below ground level, which was formerly worked by underground mining.

Road Transport of Heavy Plant.—A fabricated steel distillation column, 114 ft. long and weighing 40 tons, left Oldbury, Worcestershire, on October 15, on its way to Manchester. Two heavy tractors and two multi-wheeled trailers were used to transport it by road. The vehicles carrying the column had to negotiate what is claimed to be one of the largest traffic islands in the country, at Dudley, Worcestershire, but no difficulties arose. The column has been made by Babcock and Wilcox, Ltd., at Oldbury, for Manchester Oil Refineries, Ltd.

Exports of Bicycles.—The Midland bicycle manufacturers, who have been building up an expanding business with the United States during the past few years, have heard from the United States that the Tariff Commission there have decided not to accede to the American cycle manufacturers' application for protection. The threat of possible tariffs has had an unsettling effect on the industry in the Midlands for the past twelve months, and its removal is welcomed in Birmingham and Coventry.

The B.R.M. Trust.—Mr. A. G. B. Owen, chairman and managing director of Rubery Owen & Co., Ltd., Darlaston, Staffordshire, has confirmed that he has made an offer to buy the B.R.M. business, which designs and builds racing motor cars, and was recently offered for sale. Mr. Owen was chairman of the B.R.M. Trust, but resigned from that office in order to make his offer of purchase.

Steel Supplies.—The steel supply position in the Midlands is becoming easier, and, though there is still a heavy demand for all classes of steel, manufacturers are finding it possible to place orders for reasonably early delivery. A few steelworks are accepting orders for the first quarter of 1953. Steel plates remain, as they have been for a considerable time, among the most difficult of all the kinds of steel to obtain, but several firms have reported that the position is more satisfactory.

SOUTH-WEST ENGLAND AND SOUTH WALES.

South Wales Shipping Trade.—The total trade of the South Wales group of ports from January 1 to October 5 this year was 17,270,011 tons, compared with 15,447,704 tons in the corresponding period a year ago. The expanding oil trade of Swansea accounted for more than half of the total. Cardiff, Barry and Port Talbot had slightly more trade, but Newport, Penarth and Briton Ferry had less. The total imports of iron ore at the South Wales ports over the same period were 1,677,617 tons, against 1,494,714 tons in the same time a year ago and those of iron and steel were 536,883 tons against 388,208 tons. Exports of partly-manufactured iron and steel goods were 39,360 tons less, being 169,665 tons, but tinplate shipments, 193,472 tons, were 34,066 tons up. Foreign exports of coal and coke were 2,772,544 tons, compared with 2,227,619 tons.

New Sewage Works at Hereford.—Hereford's new sewage works, which have cost about 528,000*l*., was opened on October 17 by Sir Richard Cotterell, Bt., Lord Lieutenant of Herefordshire. The original works were built in 1891 and modernised in 1924.

Improvement of the River Ely.—A 49,882*l*. scheme for the improvement of the River Ely, over a stretch of the river running seven miles inland from Cardiff, is recommended by the Land Drainage and Works Committee of the Glamorgan River Board. It is intended that the scheme should be spread over about three years. It will involve extensive dredging.

Coal Shipments to Italy.—About 150,000 tons of Welsh coal are expected to be shipped to Italy in the last quarter of this year. This is more than in the previous quarter, and includes a contract of 50,000 tons for the Italian State Railways, whose order had not been placed in South Wales for some years. There is an inquiry in the market for gas coals for Egypt.

NOTICES OF MEETINGS.

It is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Radio Section:* Monday, October 27, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "The Impact of Television on Sound Broadcasting," opened by Mr. G. Parr. *North-Eastern Centre:* Monday, October 27, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. "275-kV Developments on the British Grid System," by Mr. D. P. Sayers, Dr. J. S. Forrest and Mr. F. J. Lane. *North Midland Centre:* Tuesday, October 28, 7 p.m., Royal Station Hotel, York. "Economic Plant Sizes and Boiler-Set Groupings on the British Grid," by Mr. B. Donkin and Mr. P. H. Margen. *London Students' Section:* Tuesday, October 28, 7 p.m., R.E.M.E. Depot, Arborfield, Berkshire. "The Use of Working Scale Models in the Development of Broadcasting Aerials," by Mr. T. R. Boys. *Supply Section:* Wednesday, October 29, 5.30 p.m., Victoria-embankment, W.C.2. Chairman's Address, by Mr. C. M. Cock.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Scottish Branch:* Monday, October 27, 6 p.m., Ca'doro Restaurant, Union-street, Glasgow. "Aluminium in Structural Engineering," by Mr. M. Bridgewater. *Lancashire and Cheshire Branch:* Wednesday, October 29, 6.30 p.m., College of Technology, Manchester. (i) "Reinforced-Concrete Structures in Coke-Oven Plants," by Mr. John Drinkwater. (ii) "Graphs for Design of Foundations," by Mr. J. W. White. (iii) "Secondary Effects of Details in Stresses in Structural Steelwork," by Mr. R. W. Williams. *Wales and Monmouthshire Branch:* Wednesday, October 29, 6.30 p.m., Mackworth Hotel, Swansea. Chairman's Address, by Col. R. D. Heseltine. *Yorkshire Branch:* Thursday, October 30, 6.30 p.m., The University, Leeds. Chairman's Address, by Mr. D. R. S. Wilson.

ILLUMINATING ENGINEERING SOCIETY.—*Leeds Centre:* Monday, October 27, 6.15 p.m., Lighting Service Bureau, 24, Aire-street, Leeds, 1. "Lighting the Streets," by Mr. H. E. G. Watts. *Birmingham Centre:* Friday, October 31, 6 p.m., Regent House, St. Philip's-place, Colmore-row, Birmingham. "The Evaluation of Lighting," by Mr. R. G. Hopkinson.

INSTITUTE OF MARINE ENGINEERS.—Monday, October 27, 7 p.m., Conway Street Secondary School, Birkenhead. Discussion on "Construction of Steam Turbines."

INSTITUTION OF WORKS MANAGERS.—*Glasgow Branch:* Monday, October 27, 7.15 p.m., Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow, C.2. "British and American Industrial Relations," by Mr. T. G. Belcher.

INSTITUTION OF PRODUCTION ENGINEERS.—*Lincoln Section:* Monday, October 27, 7.30 p.m., Technical College, Gainsborough. "Apprentice Training," by Mr. B. P. Cooper. *Sheffield Graduate Section:* Tuesday, October 28, 6.30 p.m., Royal Victoria Station Hotel, Sheffield. "Optical Instruments Applied to Precision Measurement in Engineering," by Mr. J. W. Harrison. *Luton Section:* Tuesday, October 28, 7.15 p.m., Town Hall, Luton. "Historical Development of Tube Manufacture," by Mr. G. R. Goldsworthy. *Shrewsbury Section:* Wednesday, October 29, 7.30 p.m., Walker Technical College, Oakengates, Shropshire. "Argon Arc Welding Process," by Mr. W. A. Woollcott.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS. —*Bournemouth Branch:* Monday, October 27, 8.15 p.m., Grand Hotel, Bournemouth. "Pyrotenax Cables," by Mr. G. E. D. Redman. *York Branch:* Tuesday, October 28, 7.30 p.m., Creamery Restaurant, Pavement, York. "High-Rupturing Capacity Fuses," by Mr. L. A. Fry. *Luton Branch:* Wednesday, October 29, 8 p.m., George Hotel, Luton. "Motor Starting and Apparatus Therefor," by Mr. R. F. Mathieson.

INSTITUTION OF CIVIL ENGINEERS.—*Public-Health Engineering Division:* Tuesday, October 28, 5.30 p.m., Great George-street, S.W.1. "The Sardinian Project: An Experiment in Malaria Control by Species Eradication," by Dr. John Logan. *Midlands Association:* Wednesday, October 29, 7 p.m., Loughborough College, Loughborough. Chairman's Address, by Mr. C. A. Risbridger. *Yorkshire Association:* Friday, October 31, 7 p.m., Great Northern Station Hotel, Leeds. "The Tinsley Sewerage Scheme, Sheffield," by Mr. N. A. Pritchard.

INSTITUTION OF MECHANICAL ENGINEERS.—*South Wales Branch:* Tuesday, October 28, 6 p.m., Machworth Hotel, Swansea. "Design and Operation of a Large Heat-Transfer Installation," by Mr. N. Brearley. *Birmingham A.D. Centre:* Tuesday, October 28, 6.45 p.m., James Watt Memorial Institute, Birmingham. "Life Assessment Tests for Commercial Vehicles," by Mr. John Alden. *Institution:* Friday, October 31, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Meeting in conjunction with the *Industrial Administration and Production Engineering Group.* "Machine-Tool Simplification, Especially as Applied to Horizontal Boring-Machines," by Mr. C. A. Sparkes.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—*Scottish Branch:* Tuesday, October 28, 6.30 p.m., Engineering Centre, 351, Sauchiehall-street, Glasgow, C.2. "High Temperature Industrial Radiant Panels," by Mr. E. B. T. Tanner.

SOCIETY OF INSTRUMENT TECHNOLOGY.—Tuesday, October 28, 7 p.m., Manson House, 26, Portland-place, W.1. "Design of Sliding Contact Assemblies in Instrument Applications," by Mr. D. O. Walter.

SHEFFIELD METALLURGICAL ASSOCIATION.—Tuesday, October 28, 7 p.m., Grand Hotel, Sheffield. "Recent Research in the Deformation of Metals," by Dr. R. W. K. Honeycombe.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*West Midlands Section:* Tuesday, October 28, 7.15 p.m., Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. "A Survey of Television Development and Its Problems," by Mr. H. J. Barton-Chapple.

ROYAL STATISTICAL SOCIETY.—*Research Section:* Wednesday, October 29, 5.15 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "Sequential Estimation," by Mr. F. J. Anscombe.

MANCHESTER METALLURGICAL SOCIETY.—Wednesday, October 29, 6.30 p.m., Engineers' Club, Manchester. "Cold Working of Metals," by Dr. T. Ll. Richards.

INSTITUTE OF WELDING.—Wednesday, October 29, 6.30 p.m., Institution of Civil Engineers, Great George-street, S.W.1. "Industrial Application of Resistance Welding," by Mr. H. E. Dixon.

INSTITUTE OF BRITISH FOUNDRYMEN.—*London Branch:* Wednesday, October 29, 7.30 p.m., Waldorf Hotel, Aldwych, W.C.2. "Flow of Metal into Moulds," by Mr. E. M. Currie. *Scottish Branch:* Thursday, October 30, 7.15 p.m., University College, Dundee. "The Metallurgist in the Ironfoundry," by Mr. A. J. D. Black. *Falkirk Section:* Friday, October 31, 7.30 p.m., Temperance Café, Lint Riggs, Falkirk. "Apprentice Training," by Mr. N. Curry. *Wales and Monmouth Branch:* Saturday, November 1, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Flow of Metal into Moulds," by Mr. E. M. Currie.

INSTITUTE OF REFRIGERATION.—Thursday, October 30, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. Presidential Address, by Sir Charles G. Darwin, F.R.S.

ROYAL AERONAUTICAL SOCIETY.—Thursday, October 30, 7 p.m., 4, Hamilton-place, W.1. "Temperature Control for Pressure Cabin Jet Aircraft," by Dr. E. W. Still.

INCORPORATED PLANT ENGINEERS.—*South Yorkshire Branch:* Thursday, October 30, 7.30 p.m., Grand Hotel, Sheffield. Discussion on "The Woodhead New Tunnel." *Birmingham Branch:* Friday, October 31, 7.30 p.m., Imperial Hotel, Birmingham. Discussion on "The Tacoma Bridge Failure."

MANCHESTER STATISTICAL SOCIETY.—Friday, October 31, 6 p.m., Portico Library, Charlotte-street, off Mosley-street, Manchester. "What Management Expects of Statisticians," by Mr. R. F. H. Banister.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, October 31, 6.15 p.m., Lecture Theatre of the Literary and Philosophical Society, Westgate-road, Newcastle-upon-Tyne. Parsons Memorial Lecture on "From Stodola to Modern Turbine Engineering," by Mr. Claude Seippel.

MANCHESTER ASSOCIATION OF ENGINEERS.—Friday, October 31, 6.45 p.m., Engineers' Club, Manchester. Open Discussion Meeting.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 31, 7 p.m., Townsend House, Greycoat-place, S.W.1. "Some Problems in the Design of Motion-Picture Sound Equipment," by Mr. W. C. C. Ball.

INSTITUTE OF ECONOMIC ENGINEERING.—*Glasgow Branch:* Saturday, November 1, 10.30 a.m., The Christian Institute, Bothwell-street, Glasgow. "Time Study," by Mr. J. Jones.

INSTITUTION OF ENGINEERING INSPECTION.—*Coventry Branch:* Tuesday, November 4, 7.30 p.m., Technical College, Coventry. "Precision Mechanisms," by Mr. A. Hardman. *South-Western Branch:* Tuesday, November 4, 7.30 p.m., Grand Hotel, Bristol. "Heat Treatment," by Mr. R. F. Coppola.

ROYAL SOCIETY OF ARTS.—Wednesday, November 5, 2.30 p.m., John Adam-street, W.C.2. "The Centenary of the Society's Journal: A Unique Record in Print," by Mr. E. Munro Runtz.

WOMEN'S ENGINEERING SOCIETY.—*Manchester Branch:* Thursday, November 6, 6.30 p.m., Engineers' Club, Manchester. "Glass in Engineering," by Mr. A. M. Robertson.

CHEMICAL SOCIETY.—Thursday, November 6, 7.30 p.m., Burlington House, Piccadilly, W.1. Willstätter Memorial Lecture, by Sir Robert Robinson, F.R.S.

PERSONAL.

MR. P. H. MUIRHEAD, C.B.E., and MAJOR-GENERAL C. A. L. DUNPHIE, C.B., C.B.E., D.S.O., who are directors of Vickers-Armstrongs Ltd., have joined the board of the parent company, Vickers Ltd.

MR. J. H. HUNTLEY has been elected chairman of Sir William Arrol & Co., Ltd., Bridgeton, Glasgow, S.E., in succession to the late MR. HARRY CUNNINGHAM.

MR. W. E. MILLER, M.A. (Cantab.), has now been elected President of the British Institution of Radio Engineers, 9, Bedford-square, London, W.C.1, for the forthcoming year.

MR. F. P. FALL, chief engineer to the Sunderland Division of the Northern Gas Board, Fawcett-street, Sunderland, has retired at the age of 65, after 43 years of service at the Sunderland Gasworks. His successor is MR. H. MILNER.

MR. C. B. CLAPHAM, B.Sc.(Eng.), A.M.I.Mech.E., A.M.Inst.T., assistant secretary, Road Passenger Executive, has been transferred to the London Transport Executive as assistant to the works manager (omnibuses and coaches) in the department of the chief mechanical engineer (road services).

MR. L. H. BRANT, divisional brickworks general manager to the National Coal Board, West Midlands Division, has been elected President of the Institute of Clay Technology.

MR. R. D. BURN has joined the board of the James Bridge Copper Works Ltd., Wallsall, a subsidiary company of the Wolverhampton Metal Co. Ltd., Wednesfield, Staffordshire, and has also become an alternate director of the parent company.

MR. F. C. BARFORD, who has been district manager of the British Thomson-Houston Co. Ltd., in Newcastle-upon-Tyne, for the past six years, is to be transferred to Manchester, where he will be engaged in a similar capacity.

MR. L. CLARK of the technical department, Imperial Chemical Industries Ltd., Billingham-on-Tees, has been appointed research manager to African Explosives and Chemical Industries, Johannesburg, an associate firm of I.C.I.

MR. CHARLES GORMAN, B.Sc., of Alexandria, Dumbartonshire; MR. N. F. ELLIOTT, B.Sc., of Banbridge, Northern Ireland; MR. M. J. COOPER, B.Sc., of Weston Colville, Cambridge; and MR. A. D. OWEN, B.Sc., A.M.I.Struct.E., have been appointed to the Colonial Engineering Service. Messrs. Gorman and Elliot will go to Malaya, and Messrs. Cooper and Owen to Tanganyika.

W. EDWARDS & CO. (LONDON), LTD., Worsley Bridge-road, Lower Sydenham, London, S.E.26, have opened a new establishment at 44, West George-street, Glasgow.

MR. H. V. HENNIKER, M.I.E.E., has retired from his office as joint honorary secretary of the Scottish Centre of the Institution of Electrical Engineers.

MR. S. A. CLARKE has been appointed a director of Gent & Co., Ltd., Faraday Works, Leicester.

MR. A. C. J. WALL has resigned from the board of Rickett, Cockerell & Co., Ltd., East Croydon. He has been succeeded as chairman by MR. H. R. PELLY, previously a managing director of the company.

Arrangements have been completed for the manufacture, under licence, of the new liquid fuel turbine starter developed by the PLESSEY CO., LTD., Ilford, Essex, by the HAMILTON STANDARD DIVISION of the United Aircraft Corporation, Windsor Locks, Connecticut, U.S.A.

MARCONI'S WIRELESS TELEGRAPH CO. LTD., Chelmsford, Essex, have opened a new service depot for users of their very-high-frequency mobile radio equipment at 82-86, Belsize-lane, Hampstead, London, N.W.3. (Telephone: HAMpstead 4114.)

THE G.K.N. GROUP RESEARCH LABORATORY buildings are now nearing completion and, as from November 1, all correspondence, deliveries, invoices, etc., should be addressed to the Laboratory at Birmingham New-road, Lanesfield, near Wolverhampton.

A. C. MORRISON (ENGINEERS), LTD., have removed their offices and sales organisation from Rectory-place, Loughborough, to their factory: Cliff Works, Burton-on-the-Wolds, near Loughborough, Leicestershire. (Telephone: Wymeswold 295-6.)

The Public Relations section of the BRITISH ELECTRICITY AUTHORITY has moved from 170, Great Portland-street, W.1, to the administration headquarters of the Authority, Waring and Gillow Building Winsley-street, Oxford Circus, London, W.1.

PATERSON HUGHES ENGINEERING CO. LTD., Bedford House, Bedford-street, Strand, London, W.C.2, have removed their Midlands office to larger premises at 3, Highfield-road, Edgbaston, Birmingham, 15. (Telephone: Edgbaston 1639). The Midlands area manager is MR. J. FORD and the sales engineer MR. L. R. KEMP.

DOCK RECONSTRUCTION AT SUNDERLAND.

(*For Description, see Page 525.*)

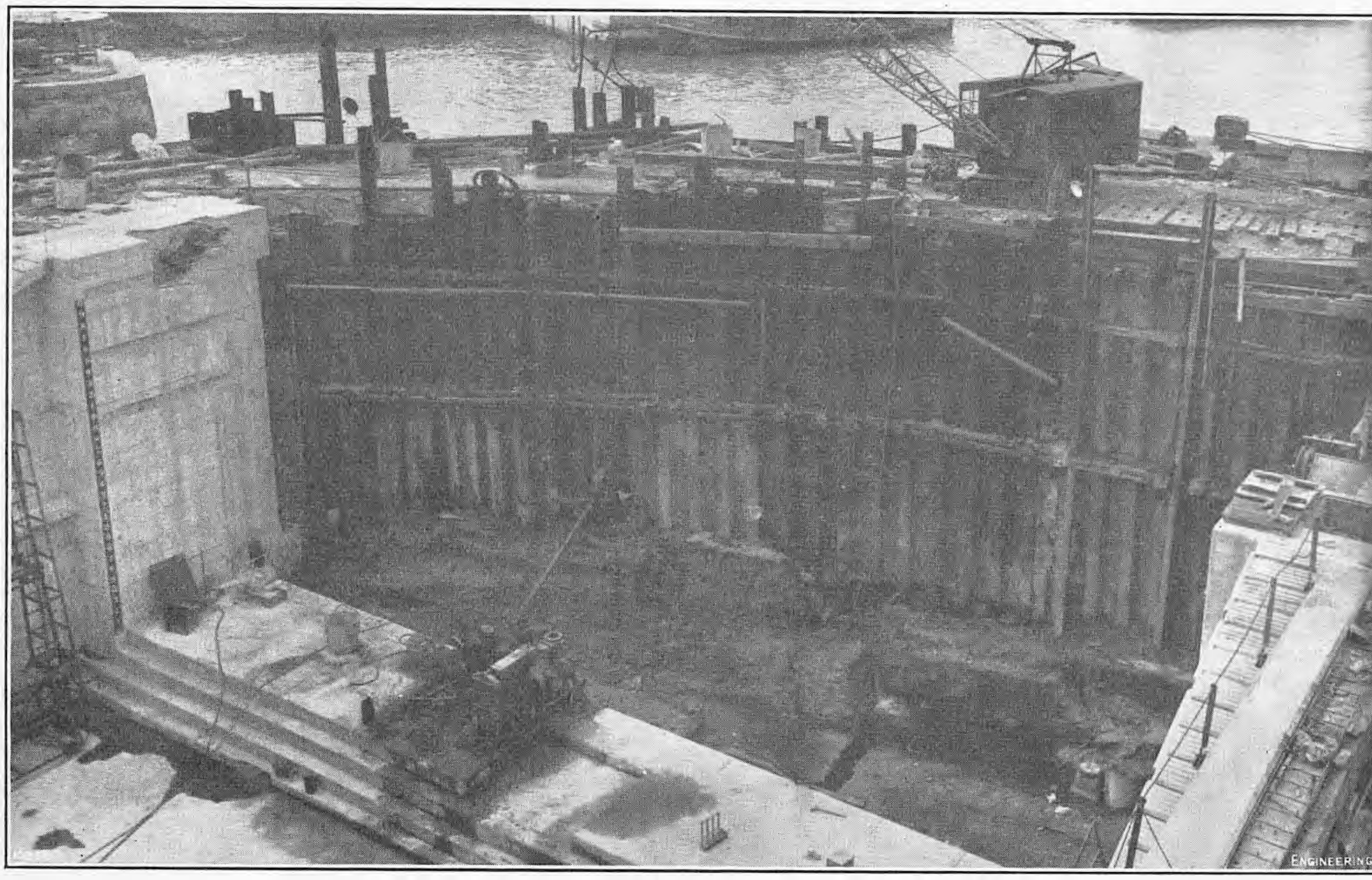


Fig. 13. Cofferdam at the Remodelled Entrance to No. 1 Dock.

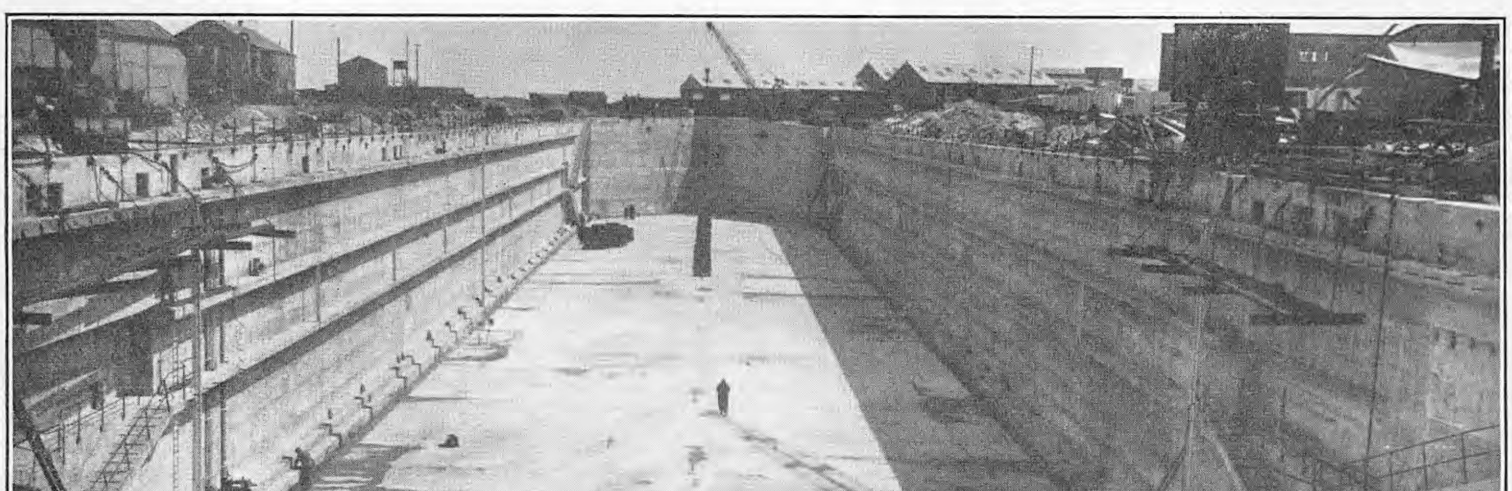


Fig. 14. No. 1 Dock, from the Entrance.

ENGINEERING

35, & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

Registered at the General Post Office as a Newspaper.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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TEMPLE BAR 3663 and 3664.

All editorial correspondence should be addressed to the Editor and all other correspondence to the Manager.

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For Canada	£5 5 0

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ADVERTISEMENT RATES.

Terms for displayed advertisements can be obtained on application tothe Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10*s.* for the first four lines or under, and 2*s.* 6*d.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received 14 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, OCTOBER 24, 1952.

VOL. 174. No. 4526.

ENGINEERING, SERVANT OF MANKIND.

THE engineering industry of this country has taken such a large part in the restoration of national solvency since the war, it has been called upon so often to increase its efforts, and it has so often met these requests, that no one can object if those who are concerned with its future prospects inquire whether it is being asked to do the right things. Indeed, since many engineers are employed or controlled, directly or indirectly, by the State, they might themselves ask the same question from the professional and personal point of view. If this savours of altruism, it is characteristic of a profession in which monetary reward is usually regarded as secondary to scope for the practice of engineering. The paramount need for exports cannot be doubted and neither can the urgency of re-armament, but, granted those two factors, are the industry and the profession being used to the best advantage? In particular, will their present work ensure future prosperity?

The contribution that engineering can make to the life of an industrial society is pre-eminent, since it provides a high proportion of the requirements in consumer goods and almost the whole of the equipment needed for capital investment. Moreover, it was engineering that started the Industrial Revolution and it will always be engineering that holds the key to the practical application of science, to that development of new luxuries and necessities which is commonly called "progress," and to the increasing productivity that an industrial nation is compelled to seek. These facts are widely appreciated to-day, though they are not so widely accepted as to form the basis for policy and action. In a recent series of articles in *The Observer*,* it was stated that the nation's eventual aim should be "to build an engineering industry capable of meeting every demand as promptly and as cheaply as technical knowledge allows. . . . In order to give industrialists the confidence and the means to build such an industry, it may be necessary to favour engineering—in all its branches, including aeronautical engineering—above other industries; to make more capital more easily available to it; even to favour it in taxation."

That judgment, by an independent newspaper, is no exaggeration, but unfortunately it is not a foundation of national policy. It has, indeed, been accepted broadly in respect of certain industries, notably in the coal mines—where, however, it is doubtful if the nation is yet reaping the profit; in iron and steel, where the heavy investment since the war has paid handsomely; and in oil refining and chemicals, where a growth in capacity is more relevant than an increase in man-power. The current *Bulletin for Industry*, a monthly review published by H.M. Treasury, gives some figures in this connection. The investment during the three years 1948-50 on plant, machinery, vehicles, buildings and works, in the main groups of industries, was 151,000,000*l.* in metal manufacture, 188,000,000*l.* in engineering, ships and electrical goods, 93,000,000*l.* in the vehicle industry, 75,000,000*l.* in other metal goods, 148,000,000*l.* in chemicals, 56,000,000*l.* in oil refining, and 142,000,000*l.* in textiles. These figures, however, are only significant in relation to the annual turnover of each industry, and to the long-term importance of the industry in relation to other industries. The *Bulletin* makes no attempt to give this background. Only in the last paragraph is the larger picture sketched: "Industrial growth is a continuous process. Its roots are in the laboratory and its sustenance is found partly in continued renewal and improvement of manufacturing capacity, partly in the initiative and adaptability of the industrial army, its readiness to let new ideas and methods supplement new machines, or if necessary, for a time, be a substitute for them. The rate of industrial growth is the main determinant of Britain's future living standard and position in the world. Its speed depends upon how flexible the economy can prove itself and how big a share of resources the nation decides to set aside for this purpose." The last phrase ought to be the dominant theme of any survey which is mindful of the future.

In 1935, according to the same source, the metal and metal-using industries produced one-quarter of the total industrial output of the United Kingdom; in 1948, more than one-third. Again, from 1948 to 1951, though the average annual increase in all manufacturing was 7 per cent., output of vehicles went up by 8 per cent.; the large group which includes engineering, shipbuilding and electrical goods by 9 per cent.; and chemicals, including oil refining, by 11 per cent. These large increases per annum depend mainly on the work of engineers as a whole, rather than on the "engineering industry" in the narrow sense which is necessarily used in Treasury and Board of Trade statistics. In certain specialised fields the increases have been even more striking; for example, the monthly average output of steam turbo-alternators and turbines increased in capacity between 1948 and the first half of 1952 from 137,000 kW to 240,000 kW. In the same period, the value of the output of conveyors and elevators was doubled; earth-moving machinery went up from 264,000*l.* to 1,090,000*l.*; typewriters from 5,000 to 14,000 in number; accounting machinery from 500,000*l.* to 1,300,000*l.*; and watches from 67,000 to 142,000. No figures are given for aircraft, but they are hardly necessary, as the whole world knows of the success which has been achieved in this field since the war.

These results, however, though a credit to everyone concerned, must not be allowed to distract attention from the effects that may arise from a

* *Re-Thinking Our Future: The Outline of a New, Arduous, but Hopeful Policy for Britain.* Reprinted from *The Observer*. 22, Tudor-street, London, E.C.4. [Price 9*d.*]

change in world supply and demand, even while re-armament is still under way. It is here that the industry and the profession may feel that their services are not being used rightly. There are two main aspects of the problem: capital investment, and the question of making special provisions for those branches of the industry which are likely to give the best return when trade is conducted in a buyers' market. It would be unwise to assume that, because demand has exceeded supply throughout the world for the past 14 years, it will continue thus; or that enlightened governments to-day have discovered completely effective methods of staving off trade depressions. The solution propounded in *The Observer* is to switch capital and labour away from obsolescent export industries to those which produce the goods still needed by the world. As examples of exports of this type, coal, aircraft, agricultural equipment and electronic apparatus are cited. "The guiding aim in all our export industries," it is argued, "should be to concentrate on exploiting to the utmost the technical skill, mechanical inventiveness and experience which are our heritage as the oldest industrialised of the nations of the world." The significance of textiles as exports generally, it is suggested, must decline, since the cost of the imported raw materials is high and the skills required are usually fairly simple and can be quickly acquired by Japanese, Indian, Egyptian or Brazilian workers.

Clearly, if the country is to follow this suggestion, Government action can only be broadly based. The detail must be left to individual industries and firms, who, if they accept the diagnosis, can draw the conclusion that salvation is to be found by switching to products which less well-developed countries are unlikely to be able to make for themselves. Ideally, there should be a continuous re-alignment of function, with new and more highly developed products coming out of the shops as fast as the latest scientific and technological results can be applied in the design office. That is already being done on a wide scale, but it will have to be done more and more.

All this, however, can be achieved only if industry is allowed to set its own house in order. The extent to which the engineering industry needs re-equipping is impossible to compute, but it is certainly large. Some figures are available for one important field, namely, inland transport, which, though it is only an indirect service, accounted in 1950 for no less than 14 per cent. of the total value of all goods and services produced in Great Britain. Mr. Christopher T. Brunner, in his recent presidential address to the Institute of Transport, remarked that the total expenditure on new road construction and major road improvements has amounted to only some 400,000,000*l*. since the beginning of this century, compared, for example, with 600,000,000*l*. spent on the capital development of the electricity industry in the first six years since the end of the war. The provision of housing at about half the economic rent (another example he quoted) has absorbed more capital than the whole of the export industry and has received it at a rate much below the market rate paid by export industry. Investment in electricity supply could hardly have been reduced, particularly as it is a vital prerequisite for the modernising of industry, but it is evident that there is scope for a greater concentration on essentials. If a time of industrial depression should come, it would appear preferable to press forward with the re-equipment of the engineering industry, rather than to embark on vast schemes of public works which, generally speaking, do not require the types of labour that a depression chiefly affects. Engineers and engineering, as the principal servants of mankind, have a right to expect their services to be used in accordance with mankind's true needs.

NOTES.

The Institution of Mechanical Engineers.

Both at the annual dinner of the Institution of Mechanical Engineers on October 16, and in his presidential address delivered the following day, Sir David Pye, F.R.S., questioned the appropriateness of university training for engineers, in this country and the United States. That part of his presidential address which dealt with the education of engineers is reprinted on page 542 of this issue. Sir David was diffident in adding to the mass of literature which already exists on this subject, but he had no occasion to be as he illuminated it in a characteristically original way, and his bold attack on the reverence accorded to mathematics in the academic engineering world was heard—and will be read—with sympathy by the many practical engineers who manage very well with only a modicum. This approach was particularly welcome from one who, in view of his academic experience, might have been expected to adopt the opposite approach. His address, which included recollections of some of his early experimental work, was also notable in that, clearly, it had been written to be spoken. This welcome feature will be apparent even in the printed page. At the annual dinner, which was held at the Dorchester Hotel, London, Sir David said that in the United States and Canada there was nothing which corresponded to the qualification for membership of British professional institutions, with its theoretical and practical training combined with professional experience. Anyone who held the degree of an accredited university could claim to be an engineer. It was a position which was causing increasing uneasiness to those who had at heart the high standing of the profession. A British engineer who had qualified by obtaining a Higher National Certificate might find himself at a serious and quite undeserved disadvantage if he went to Canada. Referring to the expiry of the lease of the Institution building in 1974, Sir David said he was glad to be able to announce the successful conclusion of negotiations with the ground landlords, the Church Commissioners, whereby the site and buildings would be secured to the Institution for all time as its own freehold. The toast of "The Institution," to which Sir David had replied, was proposed by the Rt. Hon. the Lord De L'Isle and Dudley, V.C., Bt., M.P., Secretary of State for Air, who, speaking of civil and military aviation, said that the essential unity of all aviation should never be forgotten. Air power was much more than military air power. The toast of "Our Guests"—which can be a snare or a glorious opportunity, according to the ability of the speaker—was very ably proposed by Mr. A. Roebuck, vice-President, and equally ably acknowledged by Dr. E. D. Adrian, O.M., President of the Royal Society.

The Institution of Engineers and Shipbuilders in Scotland.

The Rt. Hon. Lord Brabazon of Tara, M.C., was the principal guest at the James Watt Dinner of the Institution of Engineers and Shipbuilders in Scotland, held in Glasgow on Friday, October 17, under the chairmanship of the newly-elected President, Sir William Wallace, C.B.E., F.R.S.E. Nearly 400 members and guests were present—a larger number, Sir William stated, than on any previous occasion. In accordance with the custom of the Institution, the toast of "James Watt" was drunk in silence. The next toast, that of "Engineering and Shipbuilding," was proposed by Lord Brabazon, who explained that he had been persuaded to do so by Sir Maurice Denny, who had founded the Air Registration Board, in the chairmanship of which he, Lord Brabazon, had succeeded Sir Maurice. Continuing in characteristic vein, Lord Brabazon said that there were two things in ship development that had always puzzled him: first, why the famous tea and wool clippers, which lost so much time drifting in the Doldrums, did not carry a steam launch to tow them through calms; and secondly, why the fore-and-aft rig came into use so comparatively recently. Proceeding to discuss modern ship-design, he protested against the practice of devoting so much of the 'midship space in a ship to machinery instead of reserving it for passengers, because the pitching motion was least there. The machinery could be put forward or aft—especially if a Diesel-electric drive was used. Concluding on a more serious note, he commented on the remarkable safety record of modern sea travel; in 1950, on the railways, there were three deaths per 1,000 million miles travelled, in motor vehicles 12, in aviation 62—but in the British Mercantile Marine, none. Sir Maurice Denny, who replied to the toast, spoke mainly of the immediate prospects facing the engineering and shipbuilding industries. They were living, he said, under unprecedented conditions, having had continuous full employment since 1939. Previously, there had been recurrent booms and slumps, but there was also the steadying effect of Britain's overseas investments, most of which had now gone; in the future, he emphasised, they could rely only on the great traditions and the inherent qualities of the British race. Management was the sole group, he declared, whose actions could be decisive in bringing about the desired increase in productivity; the major responsibility rested with them, but they must have the co-operation of labour, and it was most heartening to note that important men in trade-union circles were now publicly endorsing the view that the only way to higher living standards was through better and more efficient productive methods. The remaining toast, that of "The Guests," was proposed by Mr. C. Connell, M.A., vice-President, and acknowledged by Bailie W. W. Finlay, M.A., B.Com., of Glasgow. Much favourable comment was aroused among the members and guests by the fact that the omission of the musical programme, long a feature of James Watt Dinners, enabled the formal proceedings to be terminated by 9.35 p.m., thus leaving ample time for the friendly reunions which, when they are possible, add so greatly to the pleasure and value of such gatherings.

The "Model Engineer" Exhibition.

The 27th *Model Engineer* Exhibition was formally declared open by H.R.H. the Duke of Edinburgh at the New Horticultural Hall, London, S.W.1, on Monday, October 20, and will remain open daily (Sunday excepted) from 11 a.m. to 9 p.m. until Wednesday, October 29. As a souvenir of the occasion, His Royal Highness accepted a scale model of the frigate H.M.S. Magpie, which he commanded in the Mediterranean. Of the exhibition itself it may be said that it is fully up to the highest level of general craftsmanship and variety yet attained. Apart from the many loan exhibits and the displays on the various trade stands, there are nearly 400 models which have been entered for the various competition awards; and in the demonstration section, a number of models can be seen in process of construction. As always, locomotives continue to vie with aircraft and ships in popularity, but there are also many models of machine tools, and of mechanical devices which display a refreshing originality; for example, a carpet loom, a Fowler reversing plough for use with two ploughing engines, an "opposed-piston" petrol engine of considerable ingenuity and novelty, a hydraulic press, a model of Matthew Murray's hypocycloidal engine, and a V.2 rocket. Radio-controlled models are increasingly numerous, and some are capable of a remarkable variety of operations.

Rolls-Royce "Conway" By-pass Engine.

It was announced officially yesterday that Rolls-Royce, Limited, Derby, have constructed an aircraft engine of the by-pass type, designated the Conway RCo2. The firm have issued the following statement on the principle of the by-pass engine: "In a simple jet engine, the whole of the air is compressed and then heated by the admission of fuel, expanded through the turbine, and finally ejected at high velocity. In a by-pass engine, only a proportion of the air is compressed and heated, the remainder by-passing the combustion system and turbine, but rejoining the heated gases in the jet pipe to mix with them and lower their temperature before the whole mixture is ejected at a lower velocity than that of the simple jet engine. The lower velocity of jet discharge gives a high propulsive efficiency and is shown up in practice as a lower fuel consumption for any given thrust. This type of engine offers fuel consumption lower than any simple jet engine yet produced. It is specially suitable for long-range subsonic transport and bomber aircraft. The Rolls-Royce Conway is the first practical mechanical application of the by-pass principle to a large aero-engine." It may be recalled that the original patent covering a by-pass engine (British Patent 471,368) was applied for in 1936 by Air-Commodore Sir Frank Whittle (then a serving flight lieutenant), and was due to expire on March 3 this year. In February, however, it was granted an extended life of ten years by Mr. Justice Lloyd-Jacob in the Chancery Division.

THE PRESENTATION OF TECHNICAL INFORMATION.

Senior members of technical management met in London on Thursday, October 16, to discuss the presentation of technical information. The meeting was organised by the Communication Training Centre (a department of the British Association for Commercial and Industrial Education), and the director of the Training Centre, Mr. A. C. Leyton, B.A., Ll.D., was one of the three speakers who addressed the meeting. The two other speakers were Professor Reginald O. Kapp, B.Sc., M.I.E.E., and Mr. B. C. Brookes, M.A. In opening the discussion, Professor Kapp said that successful industrial effort depended largely on the effectiveness with which information was conveyed from one mind to another. Reports and instructions that were badly set out led to misunderstandings. In industry much friction could be avoided by better techniques of exchanging information. He emphasised that the subject under consideration was not the same as English composition; a technical report could be grammatically correct and in good English, and still fail in its purpose. The next speaker, Mr. Brookes, described the methods he used in teaching technical writing to engineering students at University College, London. The essential factor was to present the information in a way that the reader could understand. Thus, both the technical content of a report, and the choice of words and construction, must be suited to the degree of specialised knowledge and educational attainments of the intended reader. Students should be taught to avoid clichés and debased words, to state clearly what were facts and what were inferences and opinions, and to develop their subject logically; exercises in criticism were perhaps the best method for developing the faculty of clear technical writing. Mr. Leyton, the final speaker, said that, in writing, an analytical approach was essential to ensure that a combination of words conveyed the same idea to the reader as it did to the writer. Discussing technical reports circulated within industry, he said that the first requisite was that the information in it should be reliable and the recommendations based on it should be sound. Secondly, it should be expressed clearly and directly and its form should be suited to the intended reader. A complaint often made by management about technical reports compiled by junior staff was that the recommendations made were not supported by the facts contained in the report. It was important that all the facts leading to the opinions stated should be given. He endorsed Mr. Brookes' opinion of the value of mutual criticism in developing the analytical faculty. A one-day conference on the same subject, for engineers and technologists, is to be held on January 5, 1953, at University College, London. Particulars may be obtained from the Communication Training Centre, Management House, 8, Hill-street, London, W.1.

BRITISH ELECTRICITY CONSUMPTION.

The monthly statistics setting out the amount of electricity sold by the British Electricity Authority to the Area Boards and sent out by the Boards to their consumers during September, 1952, show a reversal of the downward trend in consumption noted in previous returns. The actual sales amounted to 4,387 million kWh, compared with 4,062 million kWh in September, 1951, an increase of 8 per cent. When corrected for the number of working days and the weather, the increase is, however, 2·5 per cent. During the year ended September 30, 1952, 55,252 million kWh were sold, an increase of 1·9 per cent. over the figure for the previous 12 months. When this figure is adjusted to normal weather and standard working days it becomes 3·2 per cent. The total electricity sold in the "mainly industrial" areas during September, 1952, was 2,363·7 million kWh, an increase of 5·6 per cent. over the corresponding period in 1951, while in the "mainly non-industrial" areas it was 1,542·1 million kWh, an increase of no less than 12·6 per cent. The largest increase (17·1 per cent.) occurred in the "mainly non-industrial" Southern Area, and the largest decrease (— 2·1 per cent.) in the "mainly industrial" Mersey and North Wales Area. It is pointed out that the rates of development in the Southern and South Wales areas were still being influenced by the connection of the Fawley oil refinery and of the new steel works at Margam and Trostre, while that in the Merseyside and North Wales and North Eastern Areas was affected by reductions in energy interchange. In South Wales and in the North Western Area, two very large consumers substantially reduced their consumption during the month.

OUTPUT OF STEEL IN EUROPE.

During the second quarter of this year, the record rate of production of steel ingots and castings, attained in Europe during the first quarter, was substantially maintained. This is disclosed in the *Quarterly Bulletin of Steel Statistics*, No. 8, published recently by the secretariat of the United Nations Economic Commission for Europe (E.C.E.) at Geneva and issued by the London Information Centre of United Nations, Russell Square House, Russell-square, W.C.1. Copies of the publication, price 3*s*. 9*d*., post free, are obtainable from H.M. Stationery Office. It is estimated that, during the second quarter of 1952, the steel production of Western Europe was at an annual rate of about 61,900,000 metric tons, compared with 62,420,000 metric tons during the first quarter. Estimated figures show that the annual rate of production of steel in Poland, Czechoslovakia, Eastern Germany, Hungary and Roumania, was 10,488,000 metric tons in the first quarter of 1952, and 10,728,000 metric tons in the second. Corresponding estimates for the U.S.S.R. were 33,300,000 and 34,100,000 metric tons. The United States figures, appended for purposes of comparison, reflect a heavy loss of production due to the recent stoppage in the steel-works; the annual rate in the first quarter was 98,692,000 metric tons, against 64,704,000 metric tons in the second. The publication shows that the steel production in the United Kingdom, during the second quarter of 1952, was at an annual rate of 16,360,000 metric tons, compared with 16,244,000 metric tons in the first quarter. In the course of his speech at Trostre on October 7 during the Iron and Steel Institute Swansea meeting, Mr. Duncan Sandys, the Minister of Supply, stated that as a result of increased pig-iron production, there were good prospects that the output of steel, this year, would be over 16,000,000 ingot tons (16,256,000 metric tons) and that, provided no unexpected difficulties over raw materials arose, Britain's steel production in 1953 would beat the previous all-time record of 16¼ million tons (16,520,000 metric tons) by a substantial margin.

TRAINING FOR MANAGEMENT AT COAL MINES.

The National Coal Board have issued a guide to their scheme for training young men for supervisory and managerial positions in the industry. The Board plan to recruit about 200 trainees a year from the universities and training colleges, and from among their own employees who have obtained a Higher National Certificate; arrangements will be made for undergraduates who intend to apply to join the scheme to obtain prior training during their vacations. The period of training under the scheme, which was originally devised by the Institution of Mining Engineers, will be for three years, and during that time trainees will be paid a salary of 450*l*., increasing to 500*l*. per annum. Considerable emphasis is laid on practical training, either at the coal face for mining engineers or in the shops for mechanical and electrical engineers; also on executive training under the supervision of a qualified official. In conjunction with the practical training, some time is to be spent in the specialist offices, including the accountant's office, so that the trainee will become aware of the financial implications of his work. Two residential courses are also provided for instruction in the organisation of the Board and basic managerial problems. Generally, most of the training will be taken at one coalfield only, but during the last year of training a period of secondment to a colliery in another Division, or on the Continent, will be arranged to give the maximum breadth to the training. Electrical and mechanical trainees will spend a corresponding period on power station maintenance at an establishment of the British Electricity Authority. An important feature of the professional training will be the preparation by the trainee of a periodic report for submission to his supervising officer, who will normally be an area or sub-area production manager, or an agent. The guide contains detailed syllabuses of training for the various classes of engineers and ends by summarising the prospects available in the industry, by enumerating the posts and the emoluments at present paid. Copies of the guide can be obtained from the National Coal Board, Hobart House, Grosvenor-place, London, S.W.1.

LETTER TO THE EDITOR.

TEN YEARS OF R.E.M.E.

TO THE EDITOR OF ENGINEERING.

SIR,—The editorial in your issue of October 3, praising the achievements and efficiency of R.E.M.E., will be read with appreciation by all soldiers, but I submit that the birth of the Corps was about 40 years overdue. Like the Royal Army Veterinary Corps and the Remount Service, which officialdom brought to a high pitch of excellence just when the horse was becoming obsolete, R.E.M.E. has been developed when heavy armour becomes, or should become, a thing of the past. We know that the 3·5-in. rocket launcher, carried by one man, can perforate 11 in. of armour.

R.E.M.E. is an excellent and smart Corps, but the deplorable circumstance about its creation is that it adds yet another item to the great centralisation of technical effort which dogs our military effort. We—or, rather, Whitehall—have lost an interminable series of wars and battles since 1793, when Whitehall took over the management of armies. Few people realise that since that year, with one exception (Maida) no army commanded by a War Office general, administered by the War Office or Whitehall and armed with War Office weapons, has ever been successful in an independent campaign. Our armies have, indeed, won victories, but when commanded by a "Sepoy" or H.E.I.C.S. General, like Wellington, or by a Foch or an Eisenhower, and armed with "private-enterprise" weapons, such as Wellesley's Baker rifles and Henry Shrapnel's spherical case shot in 1803, or Mr. Churchill's "land-ships" in 1916-18, or Messrs. Chrysler's Shermans at Alamein, or the Hurricanes and Spitfires, of private design, in 1940. Centralisation of technical effort results in stagnation and failure to progress. With small armies, locally administered, like that of New Zealand or Nepal, there is great efficiency. While Whitehall (or Calcutta) were losing all their battles, the locally-administered Punjab (now Pakistan) Army achieved a hundred years of unbroken victories. It makes me very sad to see the engineering industry tending to drift downwards on the Whitehall current. In R.E.M.E. the technical men spend all their time on repair and maintenance of the old, and none at all on the development of the weapons of to-morrow—an activity which is so centralised that it is squeezed down almost to nothing. Some of us would like to see the relative expenditure reversed.

I am, Sir,
Your obedient servant,
STEWART BLACKER,
Lieut. Colonel.

Coldhayes,
Liss,
Hants.
October 19, 1952.

INTERNATIONAL MOTOR SHOW, EARL'S COURT.

THE International Motor Exhibition opened at Earl's Court on October 22 and will remain open until the evening of Saturday, November 1. This is the 37th of an annual series and, in general, the layout follows the pattern of its predecessors, with cars taking pride of place in the centre of the main hall, flanked at one side with river and ocean-going craft and, at the other side, with representative selections of the body-builder's craft. The galleries are given over to the accessory manufacturers and the producers of garage equipment, the equipment on view covering practically every conceivable component used in the manufacturing and servicing of motor vehicles. Like the Commercial Motor Show, this year's Motor Show coincides with the jubilee of the organisers, the Society of Motor Manufacturers and Traders, and every effort has been made, therefore, to make it more attractive than ever before. There is little doubt that these efforts have succeeded and it is probably true to say that this year's show is the largest yet staged. Altogether, 63 different makes of car are on view, this number including 32 British manufacturers who are showing 197 cars, the remaining 31 covering exhibitors from the United States, Canada, France, Italy and, for the first time, Spain, who, together, are showing over 90 different cars. There are 18 exhibitors in the coachwork section, 261 in the accessory and component section, 15 in the tyre section, 36 in the marine section, 85 in the transport-service equipment section, and 20 in the caravan section, this last named section being one of the most popular in the show. Some 52 different models are on view, 20 of them for the first time. The range extends from a 6-ft. 6-in. tent trailer weighing $5\frac{1}{2}$ cwt. to 22-ft. living caravans, weighing upwards of 30 cwt., eminently suitable as permanent homes. Many of the new caravans have been designed for towing behind small cars and should find a wide market. Caravans are one of the few classes of exhibits not subject to purchase tax, though, in some cases, the equipment installed is taxed to a small extent.

In general, there are few surprise exhibits at this year's show, most of the cars on view being improved versions of earlier and well-tried models. That this should be so is not surprising, as the motor industry of this country is, at present, passing through a difficult phase brought about by such factors as shortage of materials and currency restrictions overseas, which have hampered severely the export drive and forced manufacturers to find even newer markets. They are wise, therefore, to concentrate at this juncture on production and to refrain from the introduction of new models. Most of the cars on view, therefore, have been seen before and, apart from detailed improvements, bear a close resemblance to their predecessors. Many of the design changes are, of course, not readily apparent and can only become known by reference to the specifications. There is, for example, a definite trend towards the use of the so-called "square" engine, in which the bore and stroke are roughly the same. This arrangement gives reduced piston speeds and permits the use of larger inlet and exhaust valves. The shorter stroke also permits a greater degree of journal and crankpin overlap to be incorporated in the crankshaft design without excessive bearing diameters. The movement towards the use of overhead valves is now almost complete, only a few cars being fitted with side valves. Varying methods are used for valve operation, ranging from twin overhead-camshafts to the more conventional single-camshaft push-rod and rocking-lever arrangement, the latter appearing to be the most popular. It certainly has the advantage of simplicity, particularly in routine adjustments.

So far as chassis design is concerned, the movement towards the integral vehicle in which the body and chassis form a single unit continues, and examples are to be found on the Vauxhall, Ford, Morris and Wolseley stands, to mention a few. Independent front suspension is now incorporated in almost all chassis, designs employing swinging wishbone-shaped links being dominant. Torsion-bar springing, however, is still used by a number of manufacturers, and one, namely Lanchester, fit longitudinally-disposed torsion bars of laminated construction. In most cases, semi-elliptical leaf-type springs are used at the rear in conjunction with a rigid axle.

In the transmission field, most British manufacturers fit either a three-speed or four-speed synchromesh gearbox, but Daimler, Lanchester and Armstrong Siddeley still remain faithful to the Wilson epicyclic preselective gearbox. It is difficult to see how the synchromesh form of gearbox can be displaced generally, as it is a very efficient unit, gives exceptionally easy gear-changing and, above all, is comparatively simple and cheap to produce. Hydraulic torque converters are, of course, used widely in the United States but they are comparatively expensive to produce and not really suitable for use in the smaller British cars. It looks, therefore, as though the synchromesh unit will maintain its popularity until such time as a simple automatic transmission, easy to manufacture, can be developed. It is common knowledge, however, that much work is being done in this field and it is quite possible that, in the not far distant future, an automatic transmission unit, such as the Hobbs, which already has been used with success on commercial vehicles, will be applied generally. Nevertheless, there are two British makes of car, namely, Rolls-Royce and Bentley, which are fitted (optionally) with an automatic gearbox. These vehicles, however, are fitted with a modified version of the Dual-Range Hydra-Matic transmission as developed by the General Motors Corporation of America. Rear-axle designs are very much as before, but more manufacturers are fitting the hypoid type of final-drive unit so as to obtain a lower floor allied with greater strength, a hypoid pinion being up to 30 per cent. larger than a commensurate spiral-bevel pinion.

Four-wheel brakes are now taken for granted and all cars are so equipped. The introduction of independent front suspension led, of course, to a much greater use of hydraulic systems, as they provide a convenient means for front-brake application without recourse to complicated linkages. Several manufacturers, however, employ hydraulic means for applying the front brakes and mechanical means for the rear brakes, a system generally known as hydro-mechanical and one that certainly possesses safety features in that failure of the hydraulic system does not necessarily mean the loss of all braking power. Nevertheless, it is a somewhat complicated system and there appears to be a move away from it; Riley, for example, now fit hydraulic brakes all round, the rear brakes being designed so that they can be applied by a mechanical linkage connected to the hand brake. In recent years, the faster speeds attained by cars generally, and the difficulties of ventilating adequately the brake shoes and drums, has led to the appearance of a phenomenon known as brake fade, in which the brakes tend to lose their efficiency after repeated applications. This is particularly noticeable on high-speed streamlined cars and much work is in progress to overcome this trouble. Present indications are that a form of disc or plate brake is the answer, and although they are not fitted to any cars at Earl's Court, two manufacturers, namely, Girling Limited, and the Lockheed Hydraulic Brake Company, Limited, are showing such brakes on their stands.

The Girling brake, which is known as the Hydrastatic disc brake, is illustrated in Fig. 1, herewith. It consists, in principle, of a flat metal disc which replaces the normal brake drum. Parallel to the axis of the disc and disposed at each side are pairs of hydraulically-actuated piston and cylinder assemblies the pistons of which are fitted with pads of brake-lining material. The cylinders are arranged coaxially so that, when hydraulic pressure is applied, the pads move towards each other and clamp the disc between them, the number of pairs of cylinders used depending on the braking load involved. The U-section, or caliper, housing in which the cylinders are mounted is of box construction to obtain maximum rigidity, and is mounted along the horizontal centre-line, measurement of the deflection under varying driving conditions having shown that it is a minimum at this point. No springs are fitted in the cylinders, the pistons, together with their lining pads, being held in light rubbing contact with the brake disc by means of the static head in the fluid system; thus, as lining wear occurs, the brake pads are adjusted automatically towards the disc. As will be seen from the illustration, the disc is left completely open to the atmosphere; it will be apparent, therefore, that ventilation is ideal and the resistance to brake fade much greater than that of a normal drum brake. Furthermore, tests have shown that servo-assistance is not required and the retardation of the car is, therefore, proportional to pedal effort, thus giving stable braking. As the brake is open to the atmosphere, a number of tests were carried out to determine the effect of water and grit. Water on the disc was found to have only a slight effect on the braking power and there was no tendency towards uneven braking; so far as road grit was concerned, it was found that the disc is largely self-cleaning and at present is not considered a problem at all. Tests are still in hand, however, to determine the type of finish that will give maximum protection against corrosion, etc. Other tests have shown that the rate of lining wear is about equal to that experienced with drum brakes, and under normal driving conditions a life of some 30,000 miles can be expected.

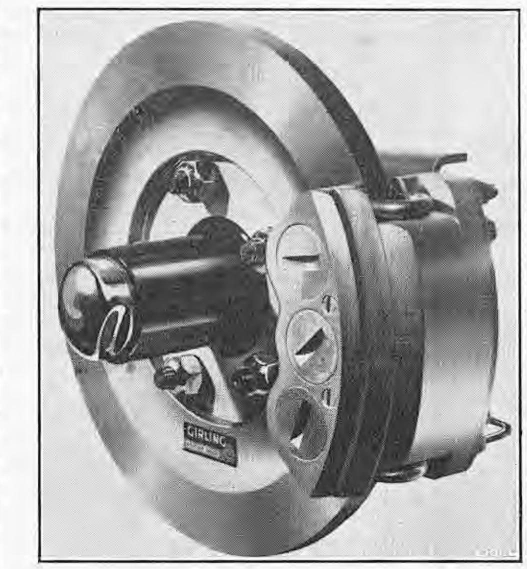


FIG. 1. PROTOTYPE DISC BRAKE; GIRLING, LTD.

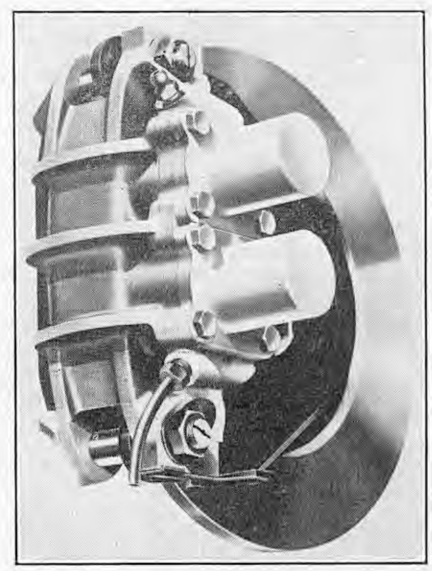


FIG. 2. HYDRAULIC DISC BRAKE; LOCKHEED HYDRAULIC BRAKE CO., LTD.

The disc brake being shown by the Lockheed Hydraulic Brake Company, Limited, is illustrated in Fig. 2, herewith. It consists, basically, of a light-alloy casting which forms a saddle over the disc, the saddle being strengthened by the provision of a steel pin at each end which holds the two ends of the saddle together. Further strengthening is provided by ribs which run longitudinally between the pins and transversely over the saddle, the resulting structure being exceptionally rigid and

EXHIBITS AT THE MOTOR SHOW.

FIG. 3. "SAPPHIRE" SIX-LIGHT SALOON CAR; ARMSTRONG-SIDDELEY MOTORS, LTD.

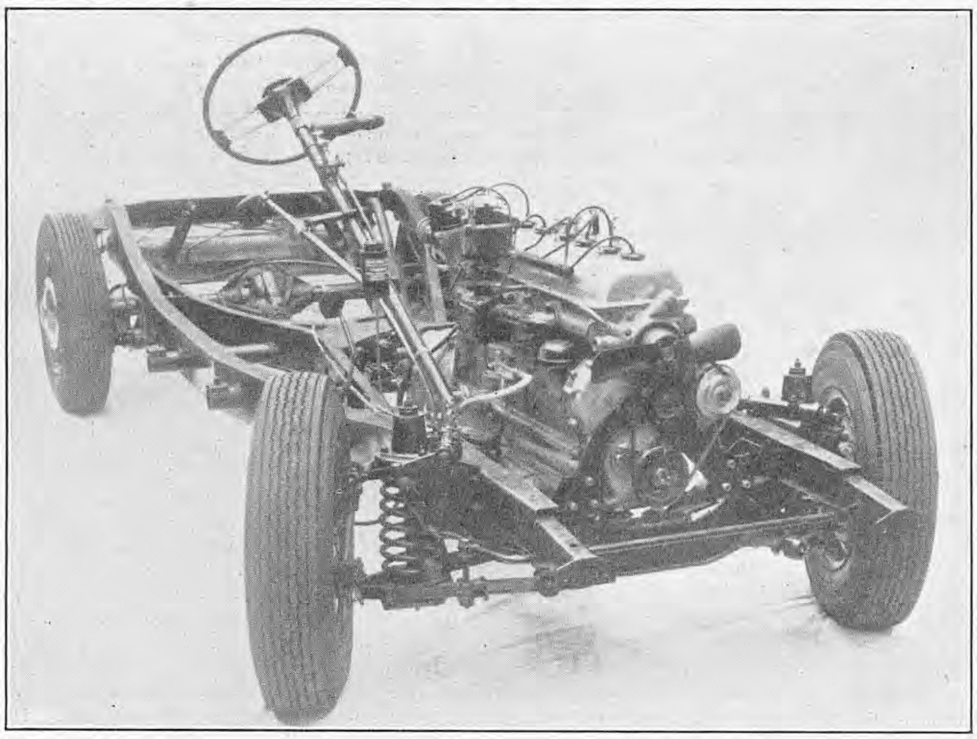


FIG. 4. CHASSIS FOR "SAPPHIRE" FOUR-LIGHT AND SIX-LIGHT SALOON CARS.

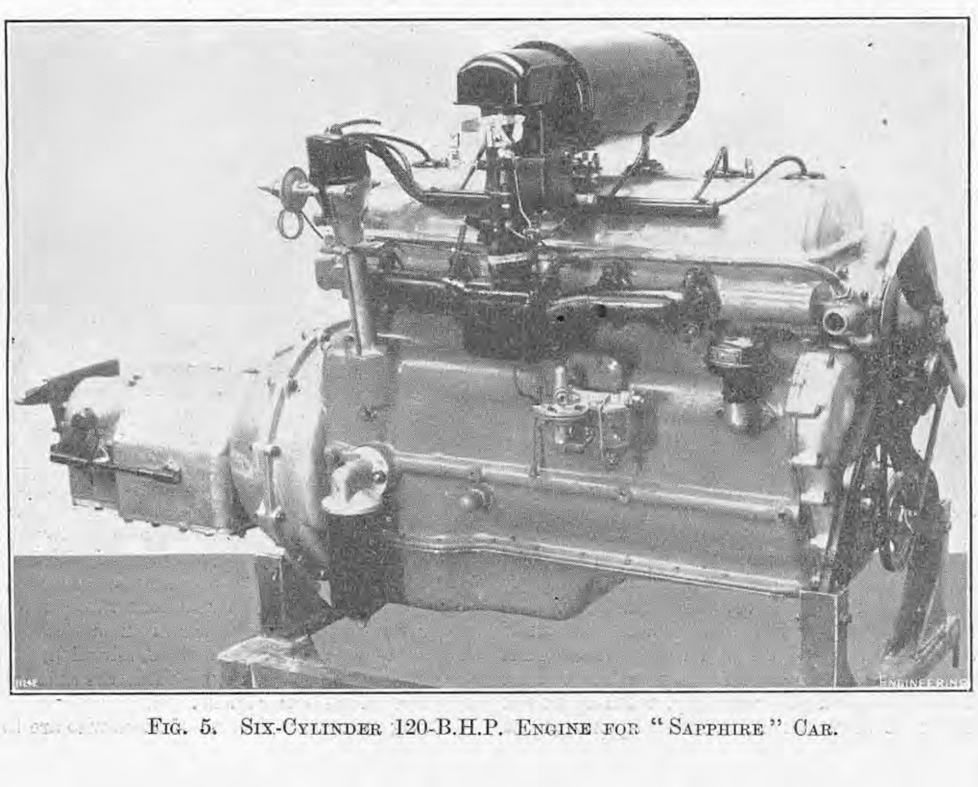


FIG. 5. SIX-CYLINDER 120-B.H.P. ENGINE FOR "SAPPHIRE" CAR.

fully capable of carrying the braking stresses. Two hydraulic cylinders and piston assemblies are mounted on the inside of the saddle, and when the brake pedal is applied the pistons bring a segment of brake lining into contact with the disc, the reaction on the saddle bringing a further segment of brake lining fitted to the other side of the saddle into contact with the disc. This form of construction, the manufacturers claim, possesses several advantages. The use of hydraulic cylinders inboard of the disc ensures that the cylinders are cooled more adequately than if they were enshrouded by the wheel, while the exceptional rigidity of the saddle, or bridge-piece, permits the use of high leverages and, therefore, gives a comparatively light pedal operation.

Firms showing new models at Earl's Court include Armstrong-Siddeley Motors, Limited, Humber, Limited, Wolseley Motors, Limited, and the Triumph Motor Company (1945), Limited. The new Armstrong-Siddeley model, which is known as the Sapphire, is illustrated in Fig. 3, herewith. It is available in two styles, namely, as a six-light saloon as shown in the illustration, or as a four-light saloon; except for the number of windows, however, the two models are identical. The chassis for this model is illustrated separately in Fig. 4 and the engine in Fig. 5, on this page. The engine is a six-cylinder unit having an equal bore and stroke of 90 mm. and developing 120 brake horse-power at 4,200 r.p.m. A maximum torque of 165 lb.-ft. is developed at 2,000 r.p.m., the brake mean effective pressure at this speed being 120 lb. per square inch. The brake horse-power per litre is 35, the brake horse-power per square inch of piston area is 2·03 and the piston speed at 4,200 r.p.m. is 2,480 ft. per minute. Overhead valves are employed and these are set at an included angle of 70 deg., thus making it possible to incorporate a hemispherical combustion chamber, a feature that undoubtedly plays an important part in the achievement of such a high output. Only a single camshaft is used, the motion being transferred to the rocking arms through short inclined push-rods. Individual exhaust ports are provided, connected to two separate manifolds each of which covers three ports, the exhaust pipes being led separately to a primary silencer. The crankshaft is machined from a steel forging and is supported by four main bearings, both the main and big-end bearings being of the steel-backed whitemetal-lined type with the big-end bearings split at an angle.

Power from the engine is transmitted through a dry single-plate centrifugally-operated clutch to a preselector gearbox of the Wilson epicyclic type, a notable feature of which is the provision of solenoids for operating the bands of the epicyclic gears. The solenoids are connected to a miniature gear lever mounted on the steering column which is used to select the gear required, movement of the gear-changing pedal, which takes the place of the normal clutch pedal, completing the electrical circuit to the solenoid for that gear selected. In most other respects, the chassis design follows standard practice, the final drive to the rear axle comprising open tubular propeller shafts and a hypoid gear pinion. The main frame is of cruciform construction and is fitted with semi-elliptical springs at the rear and coil springs at the front, the latter working in conjunction with wishbone links of unequal length to give independent suspension. Anti-roll bars are fitted and the springing is controlled by Girling telescopic dampers, those at the front being installed inside the coiled springs. Both bodies are of all-steel construction. An interesting and most useful feature is the provision of a removable instrument panel which can be pulled forward to gain access to the wiring.

(To be continued.)

NON-INFLAMMABLE CONVEYOR BELTING.—The Scientific Department of the National Coal Board, Hobart House, Grosvenor-place, London, S.W.1, have issued a research paper entitled "The Use of P.V.C. in the Manufacture of Non-Inflammable Conveyor Belts," by J. T. Barclay. The report describes the results of tests on 23 types of conveyor belts in which polyvinyl chloride, which is non-inflammable, has been employed in place of rubber. It is concluded that the use of completely non-inflammable belting would eliminate many of the most serious fire hazards on conveyors.

THE ART OF THE PRACTICAL ENGINEER.*

By Sir David Pye, C.B., M.A., Sc.D., F.R.S.

The national problem of providing the engineers that the country must have is vital and unsolved to-day, and when the question of my presidential address was first discussed it was suggested that an appropriate subject would be engineering education. I am happy to think that there are probably some members of my audience who have not read as many reports and letters to *The Times* on that subject as I have done. I shuddered at the thought of adding yet another address to the mounting pile of reports, memoranda, lectures, and White Papers, with which any member of our Education Committee is already faced. I am afraid those concerned with technological education are a little tired of reports and addresses; we all know what we want to achieve, and if we do not know how to get it that is not for lack of papers and printer's ink.

I decided therefore that if I were to talk about engineering education it must be from a text of broad and simple significance drawn from my own experience, and that I must leave to the experts, at another time and place, important questions like the proper balance between the teaching of the fundamental and the applied sciences. Looking back on my experience, I ask myself whether I have a worth-while contribution to make. I think it is possible that I may have, because of my earlier experience in teaching young men how to pass examinations in engineering subjects, followed up later by the years during which I occupied a ring-side seat, as it were, watching the real work of designing and producing in the shops the new things that were to change the course of engineering. These two periods have left me with a profound sense of the yawning gap between the product of a university course and the qualified engineer, and—more particularly—of the importance in any organisation of the man of whom one feels that he is by nature an instinctive engineer, though it may be with little or no scientific training as ordinarily understood.

Of course, none of us ever imagined a student and an engineer to be the same thing. Before he can be an associate member of this Institution, the university graduate must have supplemented his theory by practical training and responsible experience; and this combination may provide the basis for his becoming a real engineer. But I have been led to feel how small a part of the way all the theoretical training, in which we teach him to manipulate formulæ on paper and to record experiments in a laboratory, can ever take him; by the time he has "grown up" as an engineer, indeed, his book learning will have become hardly more than a vaguely-felt background to his experience. For the art of engineering includes a very great deal that lies outside of formulated theory. The rule of thumb plays, and will always play, an important part; and rules of thumb are accumulated by experience.

I have said that all engineers know what they want to see achieved by engineering education; I take that to be a young generation coming forward eager to take responsibility and competent to do so at all levels, each in his proper sphere. I emphasise "at all levels" because, although the majority of those who are vocal on the subject of engineering education tend to come from the universities and are apt to concentrate upon training at the higher levels, I suggest that the technical and technological man-power of the nation should be thought of as a whole, beginning with the skilled craftsmen and including draughtsman, designers, research and development staff—junior and senior, and those who become managers and directors. Men of special quality are to be found at all levels, and it should be the constant aim of those in authority to spot them early and to bring them forward to the maximum of their capacity.

I want to take as an example designers; not because I have ever been a designer myself, but because I doubt whether more than a very few of the able men who are teaching at universities and technical colleges normally reflect much on the work of a design section, which is the creative centre of any works, and because what I shall call the creative designer may begin to show his quality when he is a junior draughtsman, and the creative spark is precious and must be fostered above all things. Recently, I was at a small works where you might say that the spirit of design was rampant; where they produced the most complex machines and seldom built more than two or three of the same type. I asked the managing director: "How do you recruit your designers for this sort of design work?" His reply was that for the most part they were recruited direct from school. Continuity of employment, of course, was an essential factor; within a year or two a few of the recruits began to show the necessary spark of originality for promotion to group leaders, and ultimately to designers and above.

It is obvious that these men, who come up the hard way, must have constantly before them the essentially positive aim of the engineer: to devise and construct something that is better for its purpose, whatever that may be, than that which has existed before. While they are gaining their background at evening classes, these budding designers have all the time the stimulus of meeting known requirements. Now it is just this positive aim of the engineer in his profession about which, as it seems to me, there is a fundamental difficulty in the presentation of any real picture as a part of a university course. A university, it is true, is a place of learning and research, but it presents itself so often in the mind of the student as a place where he has to acquire a degree in the shortest possible time. That does not make the atmosphere conducive to the blossoming of a flair for ingenious design; nor are university examinations the circumstances in which it would be detected. They do not lend themselves readily to the assessment of a man's quality as a designer, and there appears to be a danger that where there is no clear method of differentiating between the good and the poor student, the teacher and examiner may lose interest in design as a subject in the award of a degree—quite apart from the fact that the teachers and examiners are for the most part themselves of an analytical turn of mind; skilled in those methods of research whereby such mighty results have been achieved, but only incidentally interested in new opportunities for design and construction.

The atmosphere of a laboratory is fundamentally different from that of a design office, which should be more like an artist's studio or an architect's *atelier*. In a design office, things are not right or wrong; trial and error lead gradually towards the best compromise in the special circumstances. And since compromise is fundamental in the solution of almost every engineering problem, as it occurs in practice, the student at some stage should be made familiar with it. There is a real danger in concentration upon the "examples class," admirable as it is for testing the understanding by a student of what he has been taught, and for the exposure of muddled thinking, but deadening to originality of thought. In working out examples the student employs well taught mathematical techniques to find the solution of problems that are analogous to those in engineering, but different in form from those encountered in practice.

The growing tendency to-day is to recruit from among those who have taken university degrees; we may perhaps assume as a working hypothesis, but with many notable exceptions, that as a class the ablest recruits to the engineering profession find their way to the universities. We should therefore look to the universities to feed back into industry first-class minds with a well-balanced scientific and technical background; many of them minds that are ready to be stimulated to creative activity by contact with the practical needs of industry. Are we choosing the right way to set about the task of providing the needed background while at the same time retaining sufficient flexibility in the courses to allow the spark of originality, when it exists, to grow? I have touched already upon some of the fundamental difficulties of what I have called a more positive approach to engineering education as contained in a degree course; but even if one cannot hope to introduce the atmosphere of a design office it would be something achieved if the university student could be made more aware of the importance of design in the progress of engineering. I know of a few courses of university standing where a serious effort is being made, chiefly at the post-graduate stage, to introduce some of the realities of the design office to a small team of students; but it is always subject to the handicap that the atmosphere of discussion and compromise can become real only if it is confined to a small group. Ideally the group should be organised by a man who is actually engaged in responsible design work himself; he is therefore not primarily a teacher and serious difficulties of administration are introduced.

Nevertheless, the problem should be faced. Can it be said that the creative mind is typical of the university graduate in engineering to-day? If it is not, can this deficiency be laid to the charge of the courses provided, and are there any practicable modifications by which the position can be improved? To my mind, questions should first be asked about the methods whereby selection is made of those young men who are to be allowed to embark upon honours degree courses. I would suggest that this selection is in danger of being left too much in the hands of the mathematicians. Some chemistry and physics may form part of the qualifying examination; but it is a candidate's ability in tackling the mathematics that is often crucial. Mathematical tests are ideal from the examiner's point of view; easy to set and easy to mark; producing a definite order of merit, easily translated into first-, second-, and third-class honours. But indicative of what? Not, certainly, of the seeds of a creative or instinctive engineer.

The mathematical test contains no element whatever of the positive approach to engineering education that would from first to last place some emphasis upon the ultimate aim of the engineer; which is to devise and construct. Do not imagine I am belittling the importance of mathematics as the basis of an engineering education, or, at its higher levels, as equipment that may be essential for some research engineers. All I am suggesting at present is that to rely upon competence in mathematics for the selection of young men to be admitted to an honours course in engineering is to risk the exclusion of quite a number who might have developed into the finest engineers. There are those who do not take kindly to the mathematical approach, and they should not be thrown out at the first hurdle. Under present-day arrangements, and with the mathematical standards now expected, it is largely true to say that the mathematicians decide who shall be our future university-trained engineers. And this is the more dangerous if it is true, as several men have assured me they believe, that a moderately clever and hard-working boy in the hands of an able teacher can be coached in mathematics to show a form in an examination that is quite unreal as an indication of his general intelligence.

An understanding of the processes of mathematics up to, say, the solution of first-degree differential equations is desirable as forming part of the normal shorthand used in engineering education. At a much higher level, mathematics can be a powerful tool in the hands of anyone competent to use it. But, in my opinion, it would be wise to keep the two categories of mathematics quite separate, and to encourage only those young engineers to whom it comes easily, as a friendly tool, to attempt to go beyond the stage of understanding it as a form of shorthand. For it is only they who will be the better engineers for the study of it. If the mathematicians are allowed to get the bit in their teeth and go galloping off with half of their unfortunate students trailing behind, unable to keep up, then the only benefit those students will ever get from their higher mathematics will be a few odd marks at their final examination, at the price of many wasted and painful hours that might have been much better spent.

Having made our selection of those who are to be

* Presidential address to the Institution of Mechanical Engineers, delivered in London on October 17, 1952. Abridged.

THE ART OF THE PRACTICAL ENGINEER.

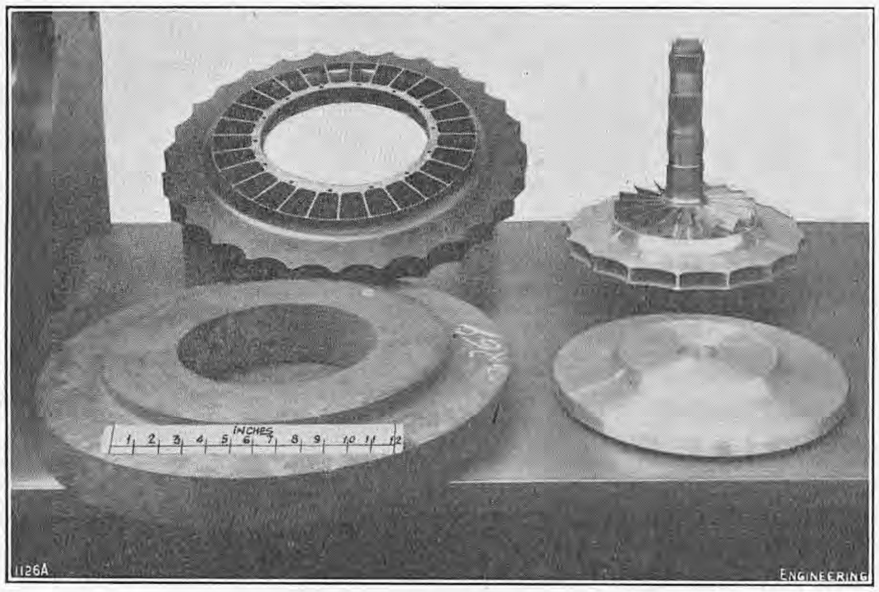


FIG. 1. SHROUDED IMPELLERS, AND FORGINGS FROM WHICH THEY ARE MADE.

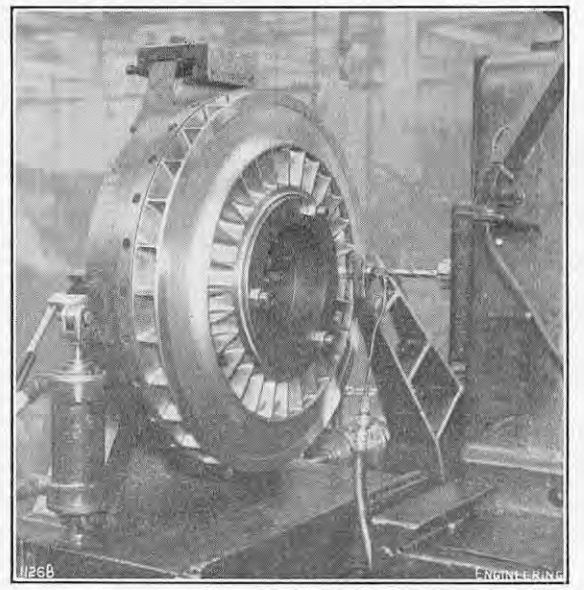


FIG. 2. MILLING FRONT POCKET OF IMPELLER.

given the elements of a basic training in engineering subjects—in machine design, prime-movers of various kinds, hydraulics, and applied electricity—we proceed in most engineering courses to put the young men into a mental "strait jacket" in which for a year they study mathemetics, physics, chemistry, and machine drawing, with scarcely a hint of real engineering to encourage them. In the second year they are taught to apply scientific techniques to the solving of simple engineering problems, and at the same time to enlarge the scope of their analytical work—which is to come in the third year—by reading and descriptive exercises. The third-year work is devoted almost entirely to the solution of problems analogous to those which arise in engineering practice; and the solutions of nearly all these problems involve mathematical techniques. The students who reach their final year, therefore, do so by passing tests and examinations in technical and scientific subjects only, and there is no place in many university engineering departments to-day for a man who has not acquired the technique of mathematical analysis in the solution of technical problems. He may never have been brought into touch with design as the living stimulus towards improvement of function. All the pressure of an over-full programme is brought to bear upon the somewhat sterile pursuit of solving artificial problems in engineering, invented for examination purposes.

I speak as one who has had no direct contact with engineering teaching for many years, and perhaps I should hold my peace. But I have had many discussions with engineering teachers, and have compared modern examination papers with those of my own student days. Current papers reproduce the character of their predecessors of 45 years ago with extraordinary fidelity, except in details and except for the higher standard of mathematics often expected. Moreover, professors whom I have consulted have told me that, whereas when they were themselves students time was spent in going through the steps of actual designs, of late years pressure on the time-table from all sides has forced them to cut out even those attempts at a positive approach. To work through the steps of a design will not carry a class very far towards the realities of a design office; but must even these attempts to retain some constructive element in the training of our best students be abandoned? Cannot time be found if we are sufficiently drastic with the present time-table? You could turn out a very good engineer by teaching a man nothing but physics, with some chemistry and mathematics (not too much unless he is a natural mathematician) and engineering drawing; and by leaving all the rest that he finds he needs in practice to be picked up by post-graduate reading.

My impression, for what it is worth, is that many university courses have become overcrowded and stereotyped and lack the flexibility to allow for the exceptional man. I know of a few teaching departments of university rank—but I believe them to be a small minority—where a serious attempt is being made to give some experience of the reality of design procedure. In too many engineering courses, however, we seem to be making little attempt to develop more than one side of an engineering student's work—the analytical and mathematical one—and not to be giving the potential works manager, or the administrator, any greater opportunity to show his quality than that given to the designer. In this connection the interesting innovation at Durham University described by Professor Burstall to the British Association a year or two ago is of particular interest.

My final remark in this connection—deliberately provocative—is that I deplore the almost pathetic faith shown in the advertisements from all Government departments (and some research associations, who should know better) in the first-class or second-class honours degree. May I suggest that there are jewels to be found, by those who will take the trouble to look, among the supposed refuse of third classes and passes. An ounce of instinct is worth a pound of information.

I have called my address "The Art of the Practical Engineer" and I have spoken of the "art of engineering" because I want to insist that so much of the work of the designer, in mechanical engineering especially, calls in practice rather for the instinctive skill of the artist than for the calculations of the mathematician. As an example of what I mean, Fig. 1 illustrates the fully-shrouded impellers of the centrifugal superchargers in the Proteus jet engine and the Hercules piston engine. In front of each is the forging—the one in steel, the other in aluminium alloy—from which each impeller is produced from the solid by a continuous milling operation. The relative movements of the work and of the cutter are controlled automatically so as to provide an almost continuous machining process throughout. Fig. 2 shows a milling machine in operation on one of the front pockets of the steel impeller.

I should perhaps explain, for the benefit of those not familiar with centrifugal superchargers, that air enters the impeller in an axial direction—parallel to the shaft—and leaves it in a direction at right-angles with the shaft, through the slots round the periphery of the wheel. The steel and aluminium-alloy impellers revolve at speeds of about 12,000 r.p.m. and 20,000 r.p.m., respectively, and the efficiency of the superchargers depends upon the exactly correct shaping of the passages, which in these designs have to be milled out of the solid forging. I think you will agree that the mind capable of conceiving and designing the milling machine to carry out the extremely complex movements involved exhibits an imaginative power of a high order. Mathematics, apart from simple arithmetic, has no part to play. There is an engineering intuition required in such a design, something born of experience, which arrives at conclusions by no traceable process of analysis as to what can or cannot be made to work. Such an instinct goes a long way towards the make-up of the "creative engineer," or the man with a touch of the artist in his composition. Here I have used the words "artist" and "creator" as almost synonymous terms, and indeed I think that every artist must be, in some sense, a creator.

Normally, when we speak of art or of an arti st we think of the fine arts—drawing, painting, or sculpture—and it is perhaps worth pointing out that the creative engineer and the artist have this in common: that, just as the engineer without detailed knowledge of his materials is like a blind man groping in the dark, so the painter or sculptor is helpless, dumb, until he has a knowledge of his materials and what can be done with them—whether paints or marble—which is so intimate that he can make them express not only his concrete needs but his ideas also. The engineer is not as a rule called upon to express only ideas in his creations; although certainly the engineer who designed and built the Skylon at the South Bank Exhibition last year may be said to have done so, and he—quite as much as the painter and the sculptor—would have been helpless without a very accurate knowledge of his materials. If you are going to create something, whether it is a work in one of the fine arts or a locomotive, an essential prerequisite is complete familiarity with the materials to be used in creating it. That is universally true.

The supreme phenomenon of the creative engineer is found when a designer of genius appears, almost untaught. The classic example must surely have been Sir Henry Royce. As a young man he became a tester in one of the new electric lighting companies of that time—strange training indeed for the inspired designer of aeroplane engines whose genius enabled this country to hold the speed records of the world, by land, sea, and air, all at the same time. Of course, his inspired faculty for designing complicated mechanisms was based on sound science; but he was largely self-taught. In all he did his work showed unusual exactness and thoroughness, and he had a phenomenal memory. He once remarked, in reply to an inquiry: "My night-school education made it imperative never to forget anything that was worth remembering, and I have never outgrown the habit." He was always intelligently absorbing and selectively remembering, so that in time he acquired that distilled wisdom which is garnered from wide experience and held ready to be applied to each new problem as it arises.

Royce was a man who reached his mature skill as a designer almost without formal training. Our great benefactor James Clayton, in the field of textile machinery, was another. Such men are rare, and with the growing complexity of engineering are likely to become rarer still, for it is only men of genius who can now survive the handicap of an absence of early training. But if we go outside the class to which the word "genius" can apply there are many men, both trained and untrained, who have a certain audacity of imagination, or peculiar perceptiveness, which puts them into a special class. And such men may appear, as we have seen, at all levels. They may or may not show originality as designers. There are other ways of being classed as a creative engineer. I have in mind, for example, a man who was in charge of the test-beds at a well-known works; an uneducated man, but one with an uncanny instinct for machines. If anything were going wrong, and puzzling those responsible, it would always be worth while to give this man his head. He would often "scent out" the trouble after trying this and that; sometimes for what appeared to the experts to be faulty reasons. It is this kind of instinct which, in taking a broad view of engineering training, we should strive to preserve and develop no less than that of the successful designer. I have in mind, too, another type of man whose skill may be of peculiar value within a limited sphere, a typical product of the works floor; the man of supreme skill of hand in some specialised line; the manipulative wizard, one might call him, whose work has no more of the creative faculty than that of a juggler, except possibly for creating records of speed in manipulation. And his skill is valuable only if it cannot be copied and multiplied by machines. Sometimes it cannot, and the man gets his proportionate reward.

Apart from such men with special qualities of instinct or skill, I come back to the man who has the truly creative faculty of the designer. When discussing design one should speak not of an individual, but of a team; though a team with an acknowledged leader. Probably there is no department in a works where leadership is so important, or where the stimulus of one man may be so widely felt, as in the design office. And in speaking of the creative designer one must not forget to mention, in passing, his natural complement: the wise man of varied and long experience, the critic rather than the originator. One might perhaps suggest that every successful team must have its *advocatus diaboli*; its critic as well as its creator; the successful practitioner to balance the brilliant originator, the latter always fertile and the former patiently backing him up and getting the best out of any novel design. Sometimes, of course, the qualities of the innovator and the successful practitioner are combined. One suspects that they were so combined, for example, in Sir Charles Parsons. Genius as a designer in many fields he certainly had; and also the wisdom of the successful practitioner; but who knows there was not also a valued critic in the background?

All these men practise the art of the engineer: to devise and create. Their importance cannot be over-estimated. And along with our designers of genius and our successful practitioners we must cherish also those types one may meet in any works from time to time: men who would never have passed the first of the examinations considered essential among the qualifications of an engineer, who may give the wrong reasons but will find the right answers. They, within their range, are, like the great ones, guided by an instinct that seems to achieve a distillation of relevant experience and can be counted upon to solve a practical problem in the most direct way.

Rubber Factory at Brynmawr.—The new factory for Brynmawr Rubber, Ltd., South Wales, with its barrel roof, has probably attracted more attention and comment than any other industrial building completed in Britain since the end of the war. The Cement and Concrete Association, 52, Grosvenor-gardens, London, S.W.1, have issued a well-illustrated booklet describing the construction of the factory, and copies of the booklet may be obtained, free of charge, on application to the Association.

LABOUR NOTES.

Offers of an increase of 7*s*. 4*d*. a week for adult male engineering employees were made by representatives of the Engineering and Allied Employers' National Federation at a joint meeting with the negotiating committee of the Confederation of Shipbuilding and Engineering Unions in London on Tuesday. This was the concluding offer made by the employers' representatives, after some hours' negotiations, and was equivalent to an all-round advance of 2*d*. an hour in the wages of adult men. If, as would be most likely, such an advance were accompanied by proportionate increases in the pay of women, apprentices and juveniles, the cost to the engineering industry would be in the region of forty million pounds a year. There appears to have been considerable difference of opinion on the Confederation side as to whether or not the offer should be accepted. It was ultimately decided to call a conference of executive officials of all the 38 unions affiliated to the Confederation, on October 29, and to place the employers' offer before the delegates, unaccompanied by any recommendation.

A new atmosphere surrounded the negotiations last Tuesday, in that the two sides were able to meet without being hampered by statements made at earlier stages in the dispute, which, it may be recalled, commenced several months back. The Confederation officials had declared that their original claim for an all-round advance of 40*s*. a week would no longer be pressed, and had announced the withdrawal of the threatened imposition of a limitation of piecework and a ban on overtime. On their side, the employers' representatives had been authorised to ignore previous affirmations that no increase could be considered and to make an offer. At an early stage in the discussions, the employers' representatives are believed to have suggested an advance of 5*s*. 6*d*. a week, representing an increase of 1½*d*. an hour, for adult men. This offer was later raised to 7*s*. 4*d*. a week, as reported above.

On their side, the Confederation officials asked for a minimum advance of 11*s*. a week, equal to 3*d*. an hour, with an increase of 15*s*. a week for engineering employees working at plain time rates. Some of these officials appear to have remained firm on these demands, but there are indications that the delegates from other unions would have been willing to compromise at 2½*d*. an hour, had the employers' representatives felt in a position to increase their offer to that figure. The negotiations on engineering wages were followed by a meeting in London, on Wednesday, between representatives of the Shipbuilding Employers' Federation and officials of the Confederation, to discuss wage claims in the shipbuilding and ship-repairing industries. The employers offered an increase of 7*s*. 6*d*. a week. The Confederation officials declined this but agreed to place it before next Wednesday's conference.

Increases in railway wages, of 7*s*. a week for adult male employees, with proportionate advances for women and juveniles, are recommended by the Railway Staff National Tribunal in an award, the terms of which were announced on Wednesday. The award is the outcome of the recent arbitration on the joint claims of the three principal railway unions for a general increase of 10 per cent., claims which were twice rejected outright by the Railway Executive. The Tribunal's recommendation is not binding upon any of the parties, but it has already been accepted by the National Union of Railwaymen, the largest of the unions concerned, and acceptance by the Executive is confidently expected. The executive committee of the Transport Salaried Staffs' Association will meet in London on Sunday to consider the Tribunal's proposals.

About 450,000 railway employees would benefit from the implementation of the award. The greater proportion of these would receive the full increase of 7*s*. a week and the Tribunal recommended that, of the remainder, adult women should be paid an extra 5*s*. 6*d*. a week, male juveniles an additional 4*s*. a week, and girls a further 3*s*. a week. The full rate of increase represents an addition of about 7 per cent. in the wages of railway employees engaged in the lower-paid grades, as are most of those belonging to the National Union of Railwaymen. For employees in the higher grades, however, the percentage increase is naturally much smaller. To an engine driver receiving 8*l*. 1*s*. 6*d*., for example, the increase is less than 4 per cent. The narrowing of the differentials between the rates of pay for employees in the skilled grades and those engaged at minimum rates, which a flat-rate increase entails, is certain to cause concern to the Associated Society of Locomotive Engineers and Firemen and the Transport Salaried Staffs' Association, to which the skilled staffs, in the main, belong.

For the first time, miners employed at British coalfields will be permitted to take two weeks holiday with pay next year, in accordance with an arrangement between the National Coal Board and the executive committee of the National Union of Mineworkers, announced on Friday last. The Board conceded the principle of a second week's paid holiday last year. In order to maintain production, however, the Board asked that the men should receive the extra pay for the second week, but remain at work, and the union agreed to that course of action being taken. It is considered that the statutory days off and one week's annual holiday are equivalent to the production of about eight and a half million tons of coal. The concession of a second week's holiday will increase that figure by a further four million tons.

Pleas to Scottish engineers and other highly-skilled operatives to remain in their home country are contained in the October issue of *Scotland*, the official journal of the Scottish Council (Development and Industry). Asking Scottish chambers of commerce, trade unions and industrialists to exert their influence to prevent the emigration of skilled men, the journal states that it is not sufficiently realised that one of the big difficulties facing Scotland in past decades has been the shortage of skilled persons produced by the great outward flow of Scottish craftsmen in the early years of the present century.

If any general emigration were to take place under existing conditions, the journal considers that it is inevitable that the same process would commence again, but on a far wider scale. In fact, there would be no stopping the trouble before it had gone so far as to do the country irreparable harm. In the highly complex technical world of to-day, it is essential for Scotland to keep abreast or ahead of its competitors. If Scotland falls behind it will fall down, and there is no middle course. This means, it is affirmed, that everything possible must be done in Scotland by those concerned, not only to train and use more engineers, scientists, and skilled men generally, but to see that their services are retained in their own country.

The importance of training sufficient engineers and technologists to satisfy the growing needs of industry was referred to by the Duke of Edinburgh when he opened an extension of the Portsmouth Municipal College on Tuesday. His Royal Highness stated that, whereas in the early days of industrial development, many great men in the world of engineering were entirely self-taught, such achievements were hardly possible at the present time, when the whole field of technology had become so much more complicated. Modern developments depended on the technical knowledge of highly-trained men and women. Without adequate training no one could be expected to make any contribution of importance. It was for these reasons that it was so necessary to ensure that ample teaching facilities existed for educating those who might wish to become scientists, technologists or engineers. The Duke considered that provision should, in fact, be made for a greater number of persons than those who had positively decided on such careers, so that there might be room for the waverers who could be encouraged to take service in the technical professions.

SHOT PEENING AND THE FATIGUE LIFE OF STEEL.

Fig. 1.

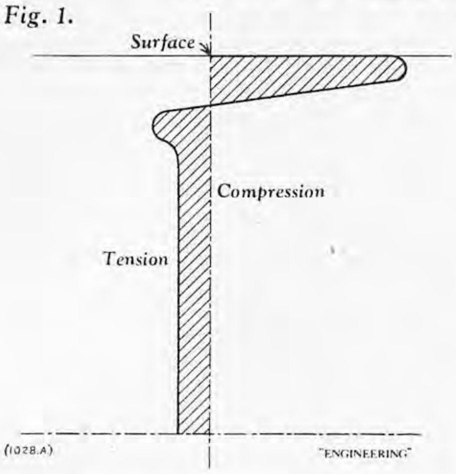


Fig. 2.

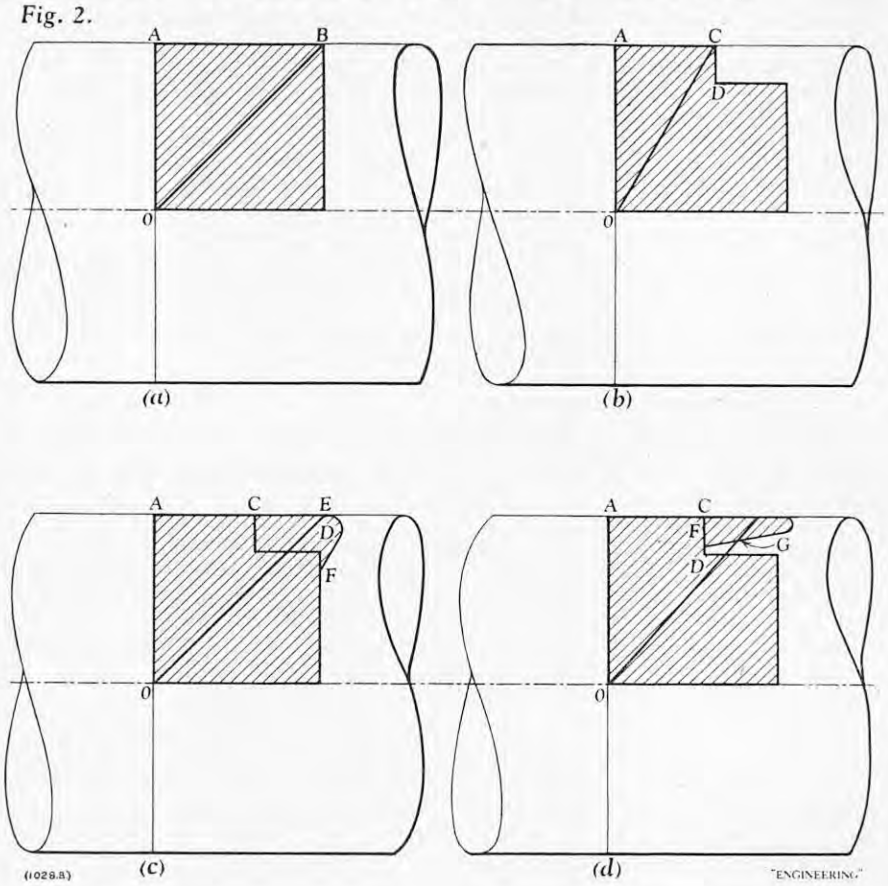
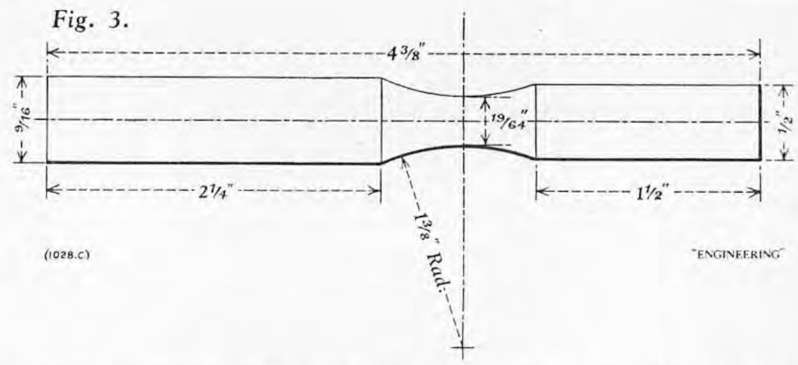


Fig. 3.



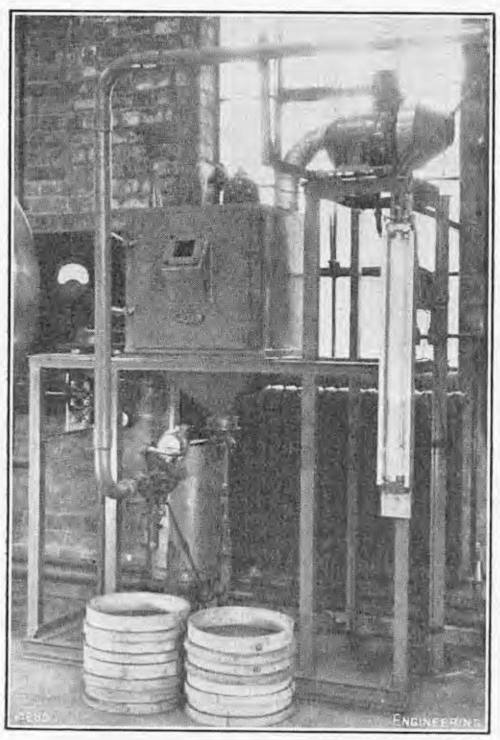


FIG. 4. AIR-SUCTION TYPE PEENING APPARATUS.

THE EFFECT OF SHOT PEENING ON THE FATIGUE LIFE OF STEEL.*

By A. G. H. COOMBS, Ph.D.

ALTHOUGH shot peening as it is known to-day may be regarded as a comparatively modern process, the principles upon which the method rests have been practised for a great number of years. For example, the early blacksmiths and swordsmiths used hammer peening to improve the mechanical properties of their products. In modern engineering practice, shot peening, in which the surface of a material is hammered by hard-steel or chilled cast-iron pellets, has become an effective method by which the resistance of the material to damage by fatigue may be increased. Under the impact of the pellets, the surface layers of the material are caused to flow plastically, while the bulk of the material remains elastic. This process results in a compressive residual stress system of high orders being induced in the surface layers of the material, the relatively low balancing tensile stresses being spread over the core.

The theoretical basis for the improvements obtained in fatigue is illustrated by the work of J. O. Smith.† His correlation of a large number of fatigue tests in direct stress shows that, where the applied mean stress is compressive, the fatigue strength is increased. The increase in strength of plain polished specimens is small but where notches are present a big improvement is observed. For notched torsion specimens it can be shown theoretically that the principal tensile stress may be increased considerably over the numerical value of the applied shear stress.* In practice, the theoretical stress concentration factor is not achieved but the effect may still be sufficient to increase the tensile stresses into the unsafe range for tensile fatigue. It is evident therefore that the application of a mean compressive stress for notched components in torsion would be advantageous. The residual compressive stress system which results from shot peening ensures that a part which is placed in service under fatigue conditions, although it may be free from an external mean stress, is actually working with a mean residual compressive stress.

The value of the residual compressive stress varies from point to point below the surface of the material. Föppl† has shown that there is a layer (between those which have residual compressive stresses and those occupied by the balancing tensile stresses) where the tensile stress is slightly greater than the mean over the core (Fig. 1). In residual stress measurements on specimens of a shot-peened aluminium alloy, the depth to which the compressive residual stress penetrates has been shown by Richards* to vary with the shot size, exposure to the shot stream and line pressure in the peening apparatus. This point is important when specifying the treatment to be given to a notched part. If the effect of the stress concentration is present at a greater depth than the residual compressive stress, the treatment will not be so effective as that which would have been obtained with adequate penetration.

An example of this is shown in Fig. 2, where the case of a bar stressed either in bending or in torsion is being considered. In Fig. 2*a*, the bar is represented in the polished condition and has uniform strength throughout. The maximum strength at the surface is represented by A B. In Fig. 2*b*, the effect of a notch on the surface strength is shown. The stress concentration effect due to this notch penetrates to a depth C D and the strength at the surface has been reduced from A B, Fig. 2*a*, to A C, Fig. 2*b*. In Figs. 2*c* and 2*d* the effects of two different shot-peening penetrations are shown. The first case represents good peening practice, and it will be observed that the point F (to which the beneficial effect penetrates) is below the point D. The strength of the surface has been increased from A C, Fig. 2*b*, to A E Fig. 2*c*. In the second case, Fig. 2*d*, the penetration has been shallow and it will be observed that, although the strength of the immediate surface layers has been increased, it is possible for a sub-surface failure to occur if the load-

* Paper read before Section G of the British Association at Belfast on Tuesday, September 9, 1952.

† J. O. Smith, "The Effect of Range of Stress on the Fatigue Strength of Metals." *Univ. Ill. Bull.*, vol. 39, No. 26, Feb. 17, 1942.

* R. V. Southwell, Result of Mathematical Analysis Reported by H. J. Gough, D.Sc., F.R.S., in *The Fatigue of Metals*, page 170.

† H. Föppl, "The Evaluation of Macroscopic Residual Stresses in Cylindrical Bars." *Jl. Iron & Steel Institute*, vol. 168, May, 1951.

* D. G. Richards, "A Study of Certain Mechanically Induced Residual Stresses." *S.E.S.A.*, vol. III, No. 1.

ing line passes out of the cross-hatched region (as, for example, at G).

An example of a surface defect which may affect the strength of a material to varying depths below the surface, is the decarburisation which occurs in some heat-treatment operations. Frequently, the decarburised layer cannot be machined off (for example, in helical springs) and other methods must be used to combat the deleterious effects. A knowledge of the depth to which the stress-concentration effect is felt, and the penetration of beneficial effect which may be obtained from suitable peening conditions, is essential in order to improve the fatigue life of the material.

The experiments which are to be reported now are part of a research programme which was carried out at Nottingham University. The object of this programme was to examine the effect of shot velocity, size and energy on the penetration of the shot-peening effect, with special reference to the fatigue life of the material. In such an investigation it is desirable that only one factor should be varied during a single series of tests. For this purpose an attempt was made to estimate the mean shot velocity in the stream over the range of nozzle pressures used in an air suction type of apparatus. Using this figure and the mean rate of shot flow obtained by sampling, the total kinetic energy of the shot stream was calculated, and this was kept constant during the tests on shot size and velocity. The estimation of the shot velocity, however, had several practical difficulties, and the figures obtained are only considered as being representative of the order of the velocity.

Material and Specimens.—The steel used in this work was of the following chemical composition: C 0·77, Si 0·12, Mn 0·67, S 0·045, P 0·037, Ni 0·28, and Cr 0·22. The analysis is similar to that of spring steels. Continuous-radius fatigue specimens were machined from $\frac{5}{8}$-in. nominal diameter bars, supplied in the as-rolled condition, to the dimensions shown in Fig. 3. The fatigue specimens were finished on the critical diameter before heat treatment with No. 0 emery cloth. In view of the subsequent heat treatments and shot-peening operations contemplated, the shanks of the fatigue specimens were left oversize, in order that they could be ground after the specimens had been treated. In order to obtain results for the material, in a hardness condition similar to that used in spring manufacture, the steel was hardened from a salt bath at 800 deg. C., by quenching in oil. After hardening, the specimens were tempered for one hour in an air-circulating furnace at 400 deg. C. The hardness of the material in this condition was 530 Vickers diamond, with an approximate ultimate strength of 116 tons per square inch. During transfer of the specimens from the salt bath to the quenching oil a small amount of decarburisation is known to have occurred. The depth of the decarburised layer was estimated from hardness measurements and this layer was removed with a smooth file.

Shot Peening and Testing Equipment.—The heat-treated specimens were shot peened in the air-suction type of apparatus illustrated in Fig. 4. The pressure unit is fitted with a reducing valve giving control of the pressure across the nozzle over the range 10 lb. to 60 lb. per square inch. The shot, as supplied by the manufacturer, was a nominally round chilled steel material. In order to remove chipped particles, and shot of sizes other than that under consideration, the shot was riddled frequently. The particles were not of uniform curvature and some had flashes left from the manufacturing process. During the course of operation, the points and irregularities of the shot were reduced, and this resulted in some dust and grit formation which was removed by means of an exhaust fan. Fatigue tests were carried out using constant-bending fatigue machines. These machines, which were built in the University workshop, employed self-extracting spring collets to grip the specimens and were arranged to test two specimens simultaneously.

Method Used to Estimate Penetration of Beneficial Depth.—It has been mentioned that in residual-stress measurements on shot-peened bars the value of the residual compressive stress is shown to vary from point to point below the surface of the material. For any given value of the stress-concentration factor there is a minimum value of the compressive residual stress and penetration which must be induced before a beneficial effect is obtained. In the present series of tests it was desirable, therefore, to relate the penetration of the shot-peening effect directly to the fatigue life of the material. With this object in mind the method used was as follows. A series of heat-treated and shot-peened specimens were prepared, and increasing amounts of material polished from the surface of each specimen before testing in rotating bending at constant stress. Each specimen was finished with No. 000 emery paper, the centre-line average for the Talysurf record being approximately 7 to 8 micro-inches. In view of the fact that the residual compressive stress varies from layer to layer below the surface, it was considered that the variation in fatigue life at constant stress would give an indication of the extent of the plastically strained zone.

(*To be continued.*)

IMPROVEMENTS IN IRON-FOUNDING.

As part of their current Annual Convention, the Joint Iron Council, a body which represents British iron producers and ironfounders, held an open meeting on Thursday, October 9, at the Connaught Rooms, Kingsway, London, W.C.2, at which the subject tabled for discussion was "Co-operation between Purchaser and Supplier in its Design and Research Aspects." The meeting was well attended by members of the iron industry and by invited guests, many of them users of cast-iron products. The chairman of the Council of Ironfoundry Associations, Mr. N. P. Newman, presided. The discussion was opened by Sir Ewart Smith, technical director of Imperial Chemical Industries, Limited, who analysed the inter-relations of designers, producers, research workers, salesmen and users, and suggested that designers occupied a central position in industry, the importance of which was not always fully appreciated. It was a designer's duty to interpret correctly a customer's requirements and also to offer him advice. He must not only be experienced in the art of design but must also have an up-to-date knowledge of research and be able to talk on level terms with research staffs. He required to have a good knowledge of production methods, based on personal experience, and to know what was easy and what was difficult to produce. Too often, the importance of first-class design was overlooked. A good draughtsman did not necessarily make a good designer, for design required a wide knowledge of research, production and usage which could only be acquired after years of experience in these different fields. Sir Ewart said also that he had been greatly impressed by the reports of the productivity teams which had visited America. He thought that there was no limit to what could be done to improve industrial efficiency provided those concerned were clear as to their goal and the means to be adopted to reach it. "Why," "where" and "how" were among the most significant words in the English language. For an industrial organisation to be efficient, there must be complete understanding and collaboration between all its departments, and the results of research must be used to the fullest extent. Research alone, without a subsequent application of its results, was valueless.

Dr. J. C. Pearce, Director of the British Cast Iron Research Association, spoke of the present as a period of great developments in the iron industry. Some of these were novel processes which did not concern users, but others called for their active co-operation, in their own interests as well as those of the industry. One of the most spectacular improvements in recent times, which had achieved more for the industry at one stroke than 25 years of research, was the development of nodular-graphite iron. In castings, free carbon or graphite in lamellar form was often troublesome, but the graphite could be made to assume a nodular or spheroidal form by the addition of cerium during casting. The resulting iron had twice the strength of the common variety and better resistance to shock loads. It had also greater ductility. Cast iron could now be produced which had an ultimate tensile strength of 35 to 45 tons per square inch and an elongation of 7 per cent., or a strength of 25 to 35 tons per square inch and an elongation of 20 per cent. Virtually, therefore, a new material was at the disposal of engineers, as the process could be applied to any machinable cast iron. The first nodular-iron castings to be made were copies of standard designs, but the best use could be made of the new material only by a radical redesign of cast-iron parts to take advantage of the improved physical properties and to offset the higher cost. It was necessary to point out that the process required very careful control, but there was no doubt that in some cases steel castings, as used at present, could be replaced by nodular-iron castings.

Dr. Pearce continued by giving an account of another novel process, namely, shell moulding. The demands made on a core material were high, but a hard and permeable core could be made of silica sand bonded by linseed oil. During the past few years, it had been found that synthetic resins could be used as the bonding material, in place of linseed oil, and shell moulding was a development of that principle. When castings were required in sufficient quantity to justify metal patterns, the conventional mould could be replaced by a comparatively thin shell. The process of making the mould consisted in mixing a suitable sand with a suitable resin in a suitable ratio. The metal pattern was then heated and the sand-resin mixture allowed to fall on it. The resin melted and a hard skin, $\frac{1}{8}$ in., $\frac{1}{4}$ in., or so, thick, was formed. The remaining sand-resin mixture was then shaken off and could be used again. Manufacture was completed by curing the mould in an oven. The process was a good deal more expensive than the ordinary one owing to the higher cost of both metal patterns and synthetic resins, but shell-moulded castings had a much smoother surface than ordinary castings and their dimensions were more accurate, so much so that it was possible almost to dispense with machining and grinding. A new mould was required for each casting but the patterns could be stored indefinitely without losing their shape.

Shell-moulding, continued Dr. Pearce, filled the gap between conventional casting and precision casting as, for example, by the lost wax process. As regards accuracy, castings could be made with dimensions correct to within 0·003 in. per inch and to within 0·01 in. per foot. Shell-moulded cores could also be produced. The basic idea, said Dr. Pearce, originated in Germany, but the patent rights had become void and there seemed to be no restriction on experiment or development of the process by anyone interested. An American car company was making large quantities of nodular-iron castings in shell moulds and, at present, some 2,000,000 lb. to 3,000,000 lb. of synthetic resin was used annually in America for shell-mould construction. It had been suggested that, by 1957, 5 per cent. of all castings in America would be made by this method and this would require some 80,000,000 lb. of synthetic resin annually. Castings weighing up to 50 lb. or 60 lb. could be produced by the process.

The chairman then declared the meeting open for discussion. A number of speakers alluded to the suggestions made by Sir Ewart Smith, and there was some criticism by users of the quality of iron-castings supplied to them. In the time remaining, Dr. H. T. Angus, development manager of the British Cast Iron Research Association, added some general observations on the remarks of the previous speakers in the course of a short address from the platform. He suggested, in particular, that co-operation within industry, as elsewhere, presupposed an attitude of mind amenable to co-operation. As regards castings, he remarked that the British Standard Specifications were generally admirable in defining the properties of iron but they could not define the properties of a casting. There were three questions which a designer should ask, answers to which he would not find in standard specifications. The first concerned the conditions to which the casting would be subjected in service, the second the properties required of the material, and the third was whether the service requirements were consistent with the properties of the material.

SOME BRITISH CONTRIBUTIONS TO EXPERIMENTAL PHYSICS.*

By PROFESSOR A. M. TYNDALL, C.B.E., F.R.S.

(*Concluded from page* 487.)

PERHAPS the best illustration of all comes from the field of nuclear physics. Much has been written on our past contribution to the foundations of the subject. Less has been said of Britain's present contribution, although, in one aspect of the subject resulting from the study of cosmic rays, it still leads the world. Moreover, in the techniques of detection of particles, whether by the trigger methods of scintillations or ionisation counters, or by the track methods of cloud chamber or photographic plate, Britain has from the start been a pioneer.

I have been privileged to watch the progress of the photographic emulsion technique perfected by Professor Powell in the Wills Laboratory at Bristol. As an example of the striking consequences of following up a simple idea, there can be few better examples in the history of physics. The primary purpose of the cyclotron and its successors is to create artificially particles of high energy and to study the consequences of collisions between them and atomic nuclei. Machines are now under construction which will produce energies up to about 6×10^9 electron volts (6 BeV). But by suspending a box of plates from a balloon at $\sim$ 85,000 ft. the properties of charged particles of far higher energies, up to 12,000 BeV, are being studied, as primary cosmic rays from outer space. Fundamental nuclear processes are thus under observation which are, and may always be, beyond the range of any laboratory machine. Moreover, these rich dividends come from an exceedingly modest expenditure, compared with that normally associated with a large synchrotron.

MESONS AND V PARTICLES.

Particle.	Symbol.	Discovery.	Mass.	Average Lifetime, Secs.	Remarks.
Electron	e^-	Cambridge 1897 ..	1	Stable	Can combine to give a
	e^+	Pasadena 1932 ..	1	Stable	γ-ray pair.
Neutrino	ν°		<1	Never direct	ly observed.
Mu-meson	μ^+	Pasadena 1936-38 ..	209	$2 \cdot 2 \times 10^{-6}$	$\mu^+ \rightarrow e^+ + 2\nu^\circ$
	μ^-	,, ,, ..	209	$2 \cdot 2 \times 10^{-6}$	$\mu^- \rightarrow e^- + 2\nu^\circ$
pi-meson	π^+	Bristol 1947	276	2×10^{-8}	$\pi^+ \rightarrow \mu^+ + \nu^\circ$
	π^-	,, ,, ...	276	2×10^{-8}	$\pi^- \rightarrow \mu^- + \nu^\circ$
	π°	Berkeley 1950 ..	262	$<10^{-14}$	$\pi^\circ \rightarrow 2h\gamma$. Occasionally. $\pi^\circ \rightarrow \gamma + \beta^+ + \beta^-$
zeta-meson	ζ	Bristol 1951	535	$>10^{-11}$	$\zeta^\pm = \pi^\circ + \pi^\pm$
	ζ°	,, 1952	550	$<10^{-14}$	$\zeta^\circ \rightarrow \pi^+ + \pi^-$
Neutral V	V_2°	Manchester 1947 ..	$\sim$800	$\gg 10^{-9}$	$V_2^\circ \rightarrow \pi^+ + \pi^- + ?$
tau-meson	τ	Bristol 1949	970	$\sim 10^{-9}$	$\tau^\pm \rightarrow \pi^\pm + \pi^+ + \pi^-$
Charged V	$V^\pm$	Manchester 1947 ..	$\sim$1,000	$\sim 10^{-9}$	$V^\pm \rightarrow ?^+ + ?^\circ$ Possibly identical with a kappa meson.
kappa-meson	κ	Bristol 1951	1,079	$\gg 10^{-9}$	$\kappa \rightarrow \mu + ?^\circ + ?^\circ$
chi-meson	χ	,, ,, ...	1,450	$\gg 10^{-9}$	$\chi \rightarrow \pi + ?^\circ$
Proton	P^+	Manchester 1911 ..	1,836	Stable	
Neutron	N°	Cambridge 1932 ..	1,836	12 mins.	$N^\circ \rightarrow P^+ + e^- + \nu^\circ$
Neutral V	V_1°	Manchester 1951 ..	$\sim$2,200	$\sim 10^{-9}$	$V_1^\circ \rightarrow P^+ + \pi^-$

It is interesting to recall that measurements on α-ray tracks in emulsions were being made in Rutherford's laboratory in Manchester as early as 1910, before the invention of the cloud chamber; but the results were quantitatively not promising, a conclusion again reached as late as 1935. However, in 1938, Powell showed that, even with the emulsions available at that time, the method had great potentialities. Later, thanks to the cooperative investigations of the photographic industry in England, standardised plates sensitive enough to record tracks of minimum ionisation, and with emulsions as thick as 600 μ were made available; and the method is now in world-wide use.

Some of the principles of measurement on the tracks are taken over from those of a cloud chamber. Provided that the particle is not moving at relativistic speed, the grain density may be used to estimate the speed of the particle at any point in the track. The particle also experiences small angle scattering as it shoots through the assembly of atoms in the emulsion; from this we may deduce its momentum at any point. These measurements may thus be combined to eliminate the velocity and to give the rest mass of the particle. An additional check is possible when a track ends in the emulsion, since the length of the track is a measure of the initial kinetic energy of the particle. The quantities Mv^2, Mv and v are then all known.

To identify particles of charge greater than unity another measurement is necessary, because grain-counting in sensitive plates is impossible when the track becomes continuous. This is furnished by a study of the density of delta rays, which, as electron tracks, appear like hairs on the main track. Alternatively, insensitive plates have recently been used so that grain-counting can be undertaken.

Many relativistic particles, giving thin tracks, arise in high energy disintegrations; in some cases, the tracks have been long enough to permit a mass determination to be made as the particle slows up. It must be appreciated that the accuracy of such mass determinations is not high judged on the standard of mass spectroscopy. Deduced from a single track, the possible error may be as high as 15 per cent.; but, even so, the evidence for several new types of meson, included in the accompanying table, together with information on their properties, is strong.

The μ-meson of mass 209 electron masses, known before the war, was regarded then as confirming Yukawa's theory that a particle of a transient type could arise in a collision of sufficient speed between a nucleon and a nucleus. The first new type to be discovered by this technique was the π-meson of mass 276, found at the Pic du Midi observatory (altitude 9,000 ft.), and produced by a collision between a nucleus and an incident proton in cosmic rays. This is a particle which interacts strongly with nuclei, disintegrating any with which it may collide, but transforming into a μ-meson and a neutral particle at the end of its free life. On the other hand, the μ-meson, owing to its weak interaction with nuclei, can pass freely by them. These facts were disturbing to the Yukawa theory, which had no place for a weakly interacting meson, nor, indeed, for a whole range of transient particles.

Reference to the modes of decay given later will show how important these two mesons are in the general scheme. Indeed, the discovery of the $\pi \rightarrow \mu \rightarrow e$ transformation, historically the first, was also probably the most important in its influence on the research. Firstly, it brought into relief the special characteristics of different types of track, and the advantage of having a medium of high stopping power in the study of transient charged particles. Secondly, it provided data and experience used later in the study of many types of nuclear "stars" and in the detection and properties of the still heavier particles. Thirdly, a photograph of this event gives indirect though unequivocal evidence of the existence of the neutrino, a neutral particle of small mass, postulated before the war as an accompaniment to β decay, but never isolated. From the principle of conservation of momentum, it is obvious that there must be a neutral particle ejected at the end of a π-track to balance the μ-meson shooting off from the same spot. Owing to the range of velocities of electrons from the $\mu \rightarrow e$ decay, at least two neutrinos are necessary in that transformation. Yet again, the result of introducing also the principle of conservation of mass energy, illustrates how beautifully the stages of the event hang together to show that the rest mass of the neutrino is less than twice that of an electron and may even be zero.

When nuclear disintegrations are caused by protons of relatively low energy, most of the fast secondary particles other than protons are π-mesons. At the extreme altitudes reached in balloon flights, high energy components of cosmic rays produce disintegrations in which the whole nucleus is violently disturbed. Accompanying the many nucleons evaporated in such processes are heavier mesons of several other types. The masses of these new bodies are still not known with any precision, but there is evidence of at least four particles, zeta-, tau-, kappa- and chi-mesons having separate identities and masses of the order of 530, 970, 1,070 and 1,450, respectively. Of these, kappa-mesons and chi-mesons have not been observed when the incident particle has an energy less than

$$1 \cdot 5 \times 10^{10}\, e\,V \text{ (15 BeV).}$$

Even this is far beyond the range available in the laboratory, so that it is possible that they will not be produced artificially, as π-mesons have been, for some time to come.

In the accompanying table of mesons and V particles, with their estimated masses, lifetimes and modes of decay, the proton, neutron and electron have been added for completeness. At first sight, this table appears to present a picture of considerable complexity, but closer examination shows that some order is beginning to emerge. Thus the constant appearance of the π-meson as a product of decay is significant. The zeta-meson, charged or neutral, appears to decay into two π-mesons; the tau-meson into three π-mesons. The chi-meson decays into a π-meson, and a heavy neutral particle. I am informed that a search is now being made for the decay products of this neutral particle. Tentatively, it is suggested that this may be a neutral tau-meson giving the reaction

$$\chi^\pm \rightarrow \pi^\pm + \tau^\circ \rightarrow \pi^\pm + \pi^+ + \pi^- + \pi^\circ$$

There are still outstanding difficulties, some of which may possibly be removed when more accurate data are available. It is possible, for instance, that a particle designated V is in some cases identical with one named differently by the Bristol group.

In any case, a wealth of new information is arising from a study of these collisions of great energy, and some remarkable phenomena are now being recorded. One example may be given in which an incident particle of energy about $2 \times 10^{13}\, eV$ collides with a nucleus in a box of plates at 85,000 ft. A widely spread star of tracks of 22 heavy nuclei so produced is accompanied by a narrow jet of 76 particles following the direction of the primary. This jet can be followed through 20 successive emulsions in its passage through the whole box, with a secondary, tertiary and quarternary star en route, each initiated by a jet particle from the previous star. There is also evidence of the presence of high-speed neutral particles in the body of the jet.

We have thus come to realise that the stable forms of matter, protons and electrons, which make up our familiar world, are only a small part of the variety of forms that matter can take. In the search for a theoretical explanation of the processes, the clues may already exist unrecognised in present data, or more surprises may yet be in store in the study of these events. Meanwhile the facts accumulate. It is gratifying to recall that, of the eight to ten transient new particles which have been discovered since the war, all but one have been found by experimental workers in the laboratories of Great Britain.

In stressing the fruitfulness of our traditional national approach to problems in experimental physics, it is not my wish to exaggerate. Science knows no boundaries, or should not; and many nations contribute, each by methods which may,

* Presidential address to Section A of the British Association, delivered at Belfast on September 4, 1952. Abridged.

in their own way, be equally traditional. But I believe that we can still take great pride in our continuing contributions to the subject, and there is something to be said for emphasising them at a time when, in some other respects, we no longer hold the position that we did in world affairs. On the other hand, I have little belief in the importance of trying to establish claims to priority, whether national or individual. It is often the circumstances in which a discovery is made that determine whether any use is made of it; two independent discoveries of the same fact may therefore suffer very different fates. So, in mentioning individual names, I have just thought of them as men who, by simple means, have had a profound influence as pioneering leaders in a given field to which others have also contributed.

But, having said this, I also feel that, in changing circumstances, it is important for us to preserve conditions of work and training favourable to the development of these national qualities in those at the threshold of their careers. Fifty or more years ago, the manipulative versatility of many of our physicists often evoked surprised comment from Continental visitors, more dependent upon aid from technicians than we were. Many of us learnt with varying degrees of success to be our own carpenter, metal worker and glassblower in the simpler tasks, but to-day technicians are frequently available, and material equipment is more lavishly supplied to speed the progress of research. On the other hand, at the undergraduate level the introduction into the subject of new principles—relativity, quantum theory, wave mechanics, and the like—has increased the scope of the theoretical background necessary to a physicist, and has presented problems to the teacher in preserving a proper balance between theory and experiment without damping the ardour of the practically-minded young man.

It would be a platitude to say that training in the subject should be such as to stifle neither an Einstein nor a Faraday, and I do not feel that any danger lies there. Some time ago, a friend said to me "We don't train Vernon Boys nowadays": one who was said to have personally worked and fashioned every material known to man. Here I think the answer is that we never did. To such a person, the door of a university is still wide open and he will find no conditions which he cannot surmount in the exercise of his genius.

The group that I have in mind is a much larger one, but at the same time containing many of promise in constructive ability. In my young days, few of these ever entered the profession of physicist, because neither industry nor the civil service employed them, and university and even school appointments were relatively few in number. I refer to the group that mostly remain in the university for an additional two or three years in pursuit of a Ph.D. degree. Nowadays, the success of many a research project, particularly in these days of increasing team-work, will depend enormously on the degree of initiative and resource that these men can show, when closely concerned with the details of the work. Indeed, there may also be others, apparently less able, in whom dormant faculties may be awakened by stimulus coming from without, and to which, in my experience, they are often specially sensitive.

For these men, the type of experience that they acquire in the Ph.D. course may be of vital consequence. In most cases, at the time of embarking upon it, only three years have elapsed since sixth-form work at school. If, therefore, in prosecuting research a student spends much of his time in collecting new data by an established technique with standard equipment, he may publish papers and write an impeccable informative Ph.D. thesis and yet fail in the end to be a trained physicist in the best sense of the word.

It is obvious that all possible technical assistance should be given to fully trained men, so that their work can progress at maximum speed. On the other hand, I would plead that young post-graduate students, if no longer dependent upon their own efforts at the lathe or blowpipe, should still be so trained as to be able to design an apparatus on sound mechanical lines and follow it intelligently through the various stages of workshop practice. It is sometimes easier to buy a new piece of expensive apparatus than to think. It was from the presidential chair of a previous meeting that I learned of the charwoman, who, complimented by her mistress on the clever way in which she had surmounted some difficulty, said "Well, it's like this, Mum, if you 'aven't 'ad education, you've just *got* to use your brains." So a spur to the development of ingenuity should be preserved for the young physicist in these formative years.

It is true that the modern range of technical knowledge in either theory or experiment calls for a degree of specialisation not necessary to Stokes, Maxwell or Rayleigh, whose equal facility in either sphere we are not likely to repeat to-day. For that reason, the recent growth of theoretical research schools in close association with experimental teams is to be wholeheartedly welcomed. Judging from the titles of their posts, it seems a matter of accident whether these men are called applied mathematicians or theoretical physicists. Some would say that, in any case, they are one and the same, except that the former work on hydrodynamics and the latter on solid or nuclear physics. My own view is that a true association of theorists and experimenters in close contact gives to the theorist a method of approach which is physical in conception rather than mathematical.

Horace Lamb, in Cambridge in 1904, spoke of his delight in watching Stokes's optical demonstrations, but added that, at the time, he thought it a little unnecessary to show practically that the height of the lecture room could be measured by the barometer, or to verify the calculated period of oscillation of water in a tank by actually timing the waves. I would say that this was not the standpoint of a physicist, but of a mathematician. Still less would I wish to claim for my profession a young man of my acquaintance who, invited to acquaint himself with the contents of an elementary laboratory course, criticised the inclusion of the simple—pendulum experiment. He said that he had looked up Kaye and Laby's tables and found that the value of g was 981·17. He could not see how the student could be expected to improve on this value with the apparatus available!

It must be accepted that some measure of central planning of research has come to stay, if only with a view to preventing duplication in fields of heavy expenditure; but the inception of a new research is usually the effort of an individual, even though it may lead to team work. It may, indeed, arise as a bright idea in the mind of a young man not yet established in reputation. Its ultimate direction will never be inspired unless it is in the hands of men following their noses on the job. Indeed, its very progress may depend upon some observation of stray occurrence made in this way. I am therefore conscious of the dangers of central financial control of research projects by panels of experts in given fields. It must be realised that they will not be supermen, but ordinary human beings meeting in an office, having their own, and may be preconceived, views on what is important. For instance, from opinions expressed to me at the time, I am confident that no such body would have voted funds from the public purse in 1938 to enable a newcomer into the field of nuclear physics to reopen the study of particle tracks in emulsions.

Again, the establishment of special research institutes each confined to certain fields of work no doubt has certain advantages; a project should not thus suffer from lack of resources. But in the one laboratory that I have directed, I always resisted the temptation to concentrate the resources in one field, and I believe that the Wills Laboratory in Bristol has not suffered from its versatility.

Rutherford once explained in a letter to the *Philosophical Magazine* how, as a young man, he was led to investigate the ionisation method of studying radioactive radiations. It arose, he said, because at Cambridge the supply of radioactive material was too meagre for the standard method of photographic blackening to be applied. Being Rutherford, had he gone to Paris, where the necessary facilities were to be found, he might still have blazed a trail, even though a different one and not in Cambridge. The story emphasises an aspect of research which any co-ordinating plan must at all costs safeguard, and it will have to be an intelligent one to do so.

STATIC ELECTRICITY IN INDUSTRY.

In a paper read before the Birmingham Private Fire Brigades Association on Tuesday, April 1, 1952, which has only recently become available, Mr. R. C. Smart dealt with "Static Electricity in Industry." Static electricity, he said, resulted from the alternate pressing together and rapid separation of two suitably dissimilar materials; and when the accumulated electrical charge caused by this movement broke down the resistance of the air the resultant spark caused fires and explosions. Static electricity was also produced by the flow of liquids and dusts through pipes and by belting, mixers, grinders and threshing machines, as well as in the moulding of rubber tyres and in the continuous coating of textile fabrics.

The chief essentials in dealing with the hazards of static electricity were to control both the inflammable material involved and the generation of the electricity itself. Close attention must therefore be paid to the reduction of dust during processing and to the handling of inflammable liquids. With inflammable dusts the problem was serious owing to their wide diversity and extent. The more dangerous and finer dusts were difficult to confine, and only small amounts in the form of a dust cloud became highly inflammable and explosive. The principal methods of controlling and removing dust included the operation of plant under negative pressure; efficient screening; spiral tube precipitators; cyclones; water scrubbers; oil air filters; roto-clones; bag filters; and electronic and electrostatic precipitators. The recovery of dust could also be effected by high-frequency sound waves according to the method developed by the Ultrasonic Corporation. In this, the intense sound waves caused a wide velocity distribution among the particles, thus leading to more collisions and to agglomeration. While particles of 50 to 100 microns were the largest to be affected in this way, subsequent separation by a cyclone separator was greatly facilitated.

Radioactive materials were also being used as ionisers to disperse static electricity in the printing and textile industries. For instance, trouble in the printing of Cellophane wrapping, caused by the way this material accumulated static electricity and "ballooned" in the machines, had been eliminated by placing flat bars faced with gold or platinum foil containing a radium salt across the parts most affected. The α, β and γ emanations from the salt, especially the first two, ionised the air in the immediate vicinity of the moving Cellophane strip and so dissipated the charges upon it. The earthing of belting and textile fabrics which were being coated with rubber, was usually effected by brass combs, which made contact with the material and were connected to an earth wire. The bodies of mixers, grinders and milling machines must also be earthed. Earthing, however, was only a protection when the materials were conducting. In fact, a spark was most dangerous when it was discharged to a badly earthed conductor or when it was caused by the ineffective earthing of charged non-conductive materials.

In addition to close care and attention to the factors mentioned there were two other essentials, neglect of which might cause failure. The first was the measurement of dust concentrations so as to maintain conditions free from explosion hazards during processing and manufacture. The second was the measurement of static charges by some such instrument as the Statigun, which had been produced as the result of researches in the laboratories of the Dunlop Rubber Company.

American Motor Car to be Made in Birmingham.—Arrangements have been made for a new light car of American design to be built in Birmingham, for export to the United States and Canada. It is to be made for the Nash-Kelvinator Corporation of Detroit. Bodies will be manufactured by Fisher and Ludlow, Ltd., Erdington, and the final assembly will be undertaken by the Austin Motor Co., Ltd., Northfield. The latter company will also be responsible for engine and chassis manufacture. Details of the car have not yet been announced, but it is expected that it will go into production during the latter part of 1953.

VARLEY PUMPS AND ENGINEERING, LIMITED.

ALTHOUGH "coming of age" is regarded as an event of great importance in the life of an individual, and is usually suitably celebrated, it is not so generally marked in the case of an engineering organisation. In this respect, Messrs. Varley Pumps and Engineering, Limited, are the exception, as the 21st anniversary of the foundation of this firm, which they celebrated at a cocktail party in London, on Friday, October 10, marks an important stage in the development of the firm. The origin of the business, which antedates the foundation of the firm by some years, is interesting and arose from the fact that a young naval officer, Lieut. C. H. Varley, while engaged in the submarine service during the first World War, evolved a pumping system to enable a submarine to rise to within a few feet of the surface and then dive to the maximum permissible depth without using the main motors. The system, although approved by the Admiralty, was not fully operated by the time hostilities ceased and the submarine became of less immediate importance.

Soon after the war Commander Varley, as he had then become, retired from the Navy and went to live at Gorton, near Lowestoft, where, with the aid of one or two assistants, he designed and perfected a range of "paracyclic" pumps. For the manufacture of these pumps, which were principally used for dispensing petrol, a company, bearing the name in the heading of this article, was formally registered on October 10, 1931, with a small works in Sunbeam-road, North Acton, London, N.W.10. With a staff at that time, of about ten persons, thousands of pumps were produced and the pumps were also made under licence in the United States. Three years after the foundation, the company had to move to larger premises in Standard-road, close to the original factory, and Commander Varley there designed a range of pumps for different applications, including machine-tool coolant pumps, double-helical and straight-tooth gear-type pumps, vane oil pumps and internal-gear type pumps, to meet the growing demand for these types. Progress was steady and continuous until early in the second World War, when the works were completely destroyed by enemy action in September, 1940. They were re-established, early in the following year, at Weston-super-Mare, in Somerset, but here the company's efforts were directed mainly to the production of hydraulic firing gear and other precision equipment required for the prosecution of the war, although some pumps were made for aircraft and for a midget submarine which was developed by Commander Varley in a subsidiary company formed for the purpose. By 1944, the submarine was put into full scale production in the shipyards and Commander Varley returned to the parent company.

After the restoration of peace, the factory in North Acton was rebuilt and pump manufacture was well under way again by September, 1946, a staff of about 50 persons being employed. Since then, the works and office staff has been more than doubled and new applications have been found for the pumps, of which perhaps the most important is for operating the hydraulic power lift for the implements of agricultural tractors. As a result, the capacity of the present works has been exceeded and the company's activities will shortly be transferred to a new factory in Ferry-lane, Brentford, Middlesex, where fabricated steel and structural work will be carried on in addition to pump manufacture. Unfortunately, Commander Varley, who died in November, 1949, did not live to see the latest developments in the business he initiated, which will be continued by the present management in the same good team spirit that has proved successful in the past. Mr. J. H. Bentley, B.Sc., A.M.I.Mech.E., is managing director, and Mr. R. C. Chapman is general manager and director of the company.

NEED FOR ECONOMY IN CEMENT.—The Ministry of Works has issued an appeal to all users of cement to exercise the utmost economy, so that the present delivery of 20,000 tons of cement a week shall be used to the greatest benefit.

HARWELL ISOTOPE SCHOOL.

REFERENCE has been made in ENGINEERING on previous occasions to the Ministry of Supply's Isotope School at Harwell, which was established in April, 1951, primarily to instruct industrialists and scientists in the use of radioactive materials. Radioactive isotopes are produced in considerable quantities as by-products at the Atomic Energy Research Establishment, and their ever-widening application has been reflected in a steadily growing demand for the instruction offered at Harwell. The school had modest beginnings in a converted wooden hut but, in January, 1952, was transferred to permanent headquarters in a brick building affording ample laboratory space and provided with the most modern equipment. Since the start of regular courses of instruction, 150 scientists, doctors and engineers, about three-quarters of them British, have attended the school. Of the remainder, one-third have come from Commonwealth countries and the rest from Europe. Universities, technical colleges, research institutions, industrial organisations, medical centres and Government departments have all been represented. More than half of the students have been chemists and biochemists, but about 50 engineers, physicists and medical men have also taken courses. The training is in fundamentals, and consists of lectures and laboratory work designed to provide sound instruction in methods of handling and using radioactive materials. The specialised techniques used in hospitals to administer isotopes to patients, however, are not covered. Courses last for four weeks and the next will commence early in 1953. Further details of these, and application forms, can be obtained from Dr. J. E. Johnston, Isotope School, Atomic Energy Research Establishment, Harwell.

UNIVERSITY COURSES FOR ROYAL AIR FORCE TECHNICAL CADETS.—To satisfy the need for highly qualified technical officers in the Royal Air Force, university cadetships have been introduced in the Technical Branch. The first 20 cadets to take part in this scheme are beginning their training this month. They will spend a year at the Royal Air Force Technical College, Henlow, Bedfordshire, to train in the duties and responsibilities of an officer, and will continue their scientific education to the standard of the qualifying examination for the Mechanical Sciences Tripos of Cambridge University. They will then go to a university for a three-year honours-degree course, and will also train as pilots with the University Air Squadron, if medically fit. After graduation, they will return to the Technical College for six months further training in applying their technical knowledge. Technical cadets are selected each year in August, from candidates between 17 and 19½ years old who are suitably qualified for admission.

BRITISH INSTITUTION OF RADIO ENGINEERS.—The 26th annual report of the British Institution of Radio Engineers, which covers the twelve months ended on March 31, 1952, is a lengthy statement occupying 14 pages of the September issue of the Institution's *Journal*. Among the many items mentioned, it records general progress by way of increased membership and a wider recognition of status of the Institution. The number of entries for the graduateship examinations has increased, but a somewhat poor showing by recent candidates has been noticed, which is attributed to the lack of sufficient training facilities. Five new sections of the Institution have been established in India. The principal event of the year was the 1951 Convention, arranged in connection with the Festival of Britain. The Convention, although highly successful was more costly than expected.

BULLETIN ON SCHOOL BUILDING.—The Ministry of Education have issued No. 8 in their series of building bulletins, which relate generally to the planning and erection of modern schools. The new bulletin describes in considerable detail, with the aid of ample illustrations, the design and building of a complete school at Wokingham, Berkshire, that has been developed under the auspices of the Architects and Building Branch of the Ministry. The school, for 600 young people, forms a representative example of a large building, including a four-storey block, with large rooms and halls, designed to overcome the present shortages of material and labour and yet maintain the modern requirements of heating, lighting and ventilation. The bulletin is published, at 3*s*. 6*d*., by H.M. Stationery Office, Kingsway, London, W.C.2.

THE ST. LAWRENCE SEAWAY.*

ON June 30, 1952, the Governments of Canada and the United States applied to the International Joint Commission for the approval of works to develop power in the International Rapids section of the St. Lawrence River. In its application, the Canadian Government affirmed its intention of carrying out concurrently, and alone, the remaining works necessary to provide deep-draught navigation between Lake Erie and Montreal. Before the double project can be carried out, it remains for the International Joint Commission, a body set up under the Boundary Waters Treaty of 1909, to approve the power project; for the United States to appoint an authority to co-operate with the Province of Ontario in carrying it out; and for that authority to obtain a licence from the United States Federal Power Commission.

The quick and easy transit of these remaining steps is by no means a foregone conclusion. Hearings before both the International Joint Commission and the Federal Power Commission may be protracted. There is the possibility of the interests in the United States that have opposed the Seaway in the past attempting to challenge the validity of the proceedings in the Courts. There is also the more remote possibility of action by the United States Congress to prevent existing bodies from exercising the jurisdiction they have under the present laws. Yet, in spite of these uncertainties, it now seems that this almost legendary project, after a troubled history spanning several decades, has a good chance of becoming a reality.

The construction of a deep-draught waterway linking the Great Lakes with the Atlantic Ocean has interested the Governments of both the United States and Canada since 1895. Over that period, several commissions and boards of engineers have reported favourably on its economic and engineering feasibility and for more than 30 years the combined navigation and power project has been the subject of negotiation between the two countries. Every United States Administration since that of President Woodrow Wilson has favoured immediate construction of the Seaway, and since 1928 every Canadian Government has given the plan active support. In 1932, a treaty was negotiated, providing for the joint development of the seaway and power project, but after extended hearings in the United States Senate it failed to obtain the two-thirds majority necessary for ratification. Further negotiations, beginning in 1938, resulted in the drawing-up of the Great Lakes-St. Lawrence Basin Agreement in 1941; but repeated efforts, the latest of them made this year, have failed to obtain favourable consideration by the United States Congress.

In 1948, the Governments of the State of New York and the Province of Ontario tried to get permission to proceed with the power development only, but the United States authorities, fearful that separate construction of the power facilities would mean indefinite postponement of the Seaway, refused. Canada's decision to proceed alone with the navigation part of the project, and the concession made by the United States in submitting the power proposal to the International joint Commission, both stem from the reluctant conclusion that there is little hope of obtaining Congressional approval for joint U.S.-Canadian participation in the St. Lawrence Seaway and Power Project. Nevertheless, the St. Lawrence Seaway Authority, as it was established by Act of Parliament on December 12, 1951, is empowered to construct and maintain the Seaway either as an all-Canadian undertaking or jointly with the United States, and the door will be left open to United States participation as long as is feasible.

President Truman, when he again submitted the St. Lawrence project to Congress last January, thus expressed the point of view of his Administration: "The question before the Congress . . . no longer is whether the St. Lawrence Seaway should be built. The question before the Congress now

* From the *Monthly Review* of the Bank of Nova Scotia, Toronto, Canada; No. 74 (July-August, 1952). Abridged.

THE ST. LAWRENCE SEAWAY.

Fig. 1.

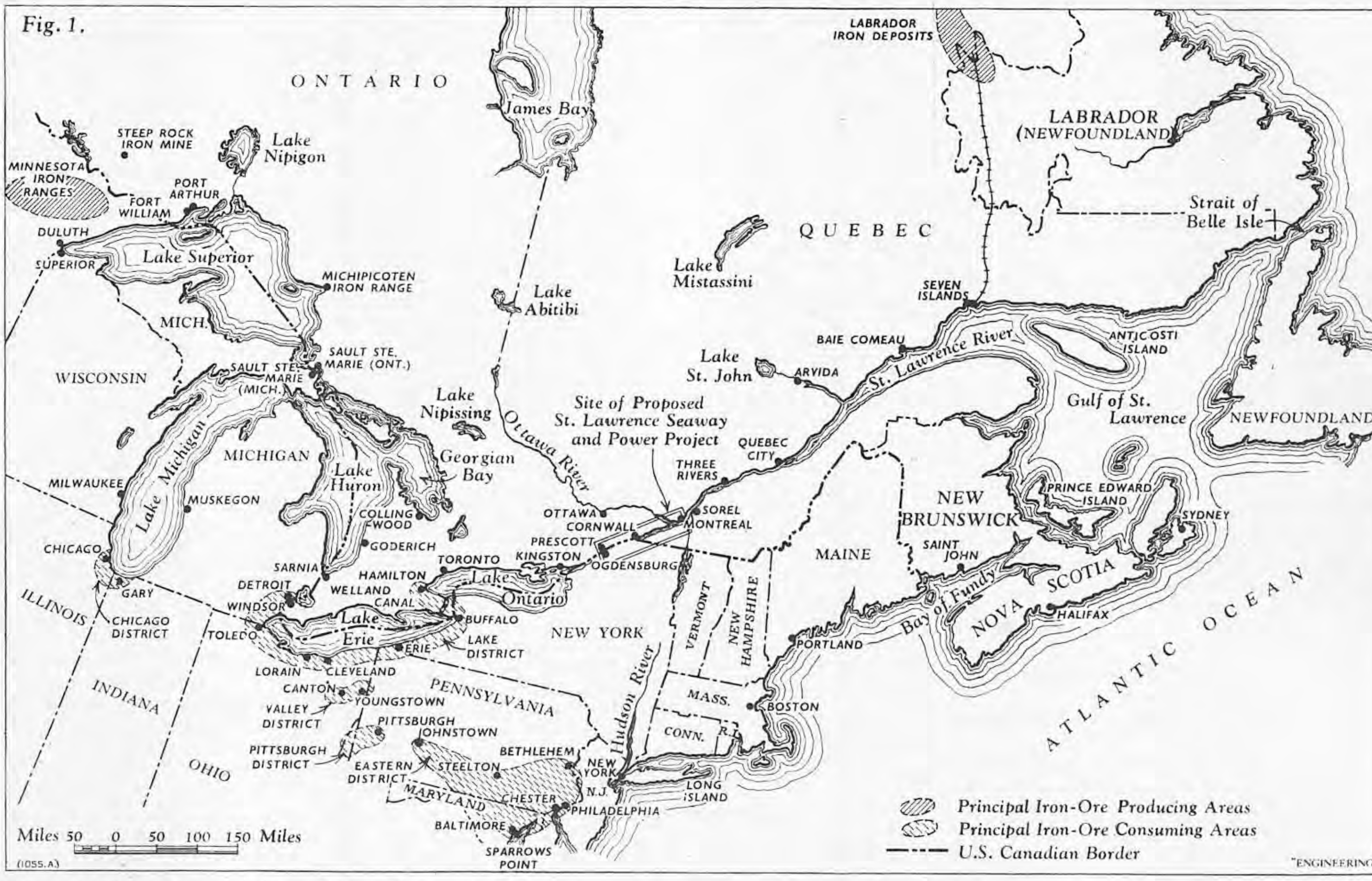


Fig. 2. PROPOSED DAMS AND POWER INSTALLATIONS.

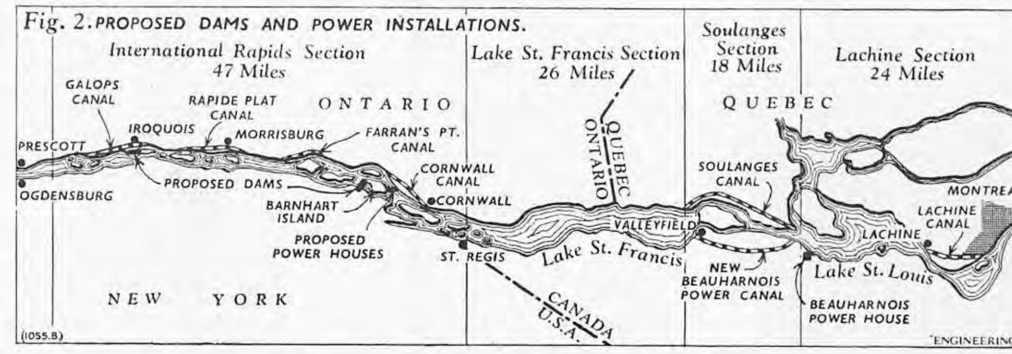


Fig. 3. WATER LEVEL PROFILE.

is whether the United States shall participate in its construction, and thus maintain joint operation and control over this development which is so important to our security and our economic progress. . . . The project is to be built, whether or not we take part in the construction of the Seaway."

From Canada's point of view there are both advantages and disadvantages to independent action. The cost to the Federal Government of carrying out the navigation works single-handed will be very much greater than Canada's share of a joint venture, more particularly since, under the joint scheme, Canada was to have received credit for her substantial outlays on the Welland Ship Canal. On the other hand, the project is planned to be self-liquidating and, as the Minister of Transport has said, " If the costs not borne by power are covered by tolls on shipping, it is of much less consequence who makes the initial expenditures, and Canada can do any necessary financing." Moreover, if the new navigation facilities belong entirely to Canada, the toll revenues will also be entirely hers; such matters as the setting of toll rates will be entirely in her hands; and the complicated business of apportioning toll revenues between the two countries will be avoided.

The present review describes briefly the navigation and power aspects of the proposed St. Lawrence project, and attempts to bring them into perspective against the development of the Great Lakes-St. Lawrence Basin over a period of some two centuries. The main features of the Great Lakes-St. Lawrence area are shown in Fig. 1, herewith; and some of the details of the present power and navigation project are presented in the table, opposite, and in Figs. 2 and 3.

The Seaway in Perspective.

The twenty-year stalemate over the Seaway, and some of the very large estimates of cost made by its opponents, have created in the public mind the impression of a new and untried project of enormous size, difficulty and costliness. In fact, the present project is the final link in an almost completed chain. Deep-draught navigation is already an accomplished fact through most of the great waterway that stretches from the Strait of Belle Isle to Duluth. The St. Lawrence Ship Channel provides a minimum depth of 32½ ft. for 1,000 miles from the mouth of the Gulf of St. Lawrence to Montreal. Above Prescott, through the Thousand Islands and the entire chain of the Great Lakes, there is a channel depth of at least 25 ft. downbound and 21 ft. upbound. This is capable of being increased to 27 ft., mainly by dredging, since the locks in the Welland Canal and the MacArthur Lock at Saulte Ste. Marie have a depth of 30 ft. To provide 27-ft. navigation through the entire waterway, what remains to be done in addition to the deepening of existing channels is to construct about 40 miles of canals, with seven locks and eight movable bridges, in the 115-mile bottleneck between Prescott and Montreal, where the existing canals have a limiting depth of 14 ft.

Efforts to improve navigation on this greatest of all inland waterways go back to the days of the fur traders. History relates that an 18-in. waterway to by-pass the turbulent rapids of the St. Lawrence at Lachine was undertaken as early as 1700, but never completed; by 1783, four short canals with a depth of 2½ ft., had been built at the Cascades; and the North West Company, about 1797, constructed a primitive canal at Sault Ste. Marie "upwards of three thousand feet in length, with a lock which raises the water nine feet." By 1850, with the building of the old Welland Canal to carry navigation around Niagara Falls and the construction of a uniform series of canals from Montreal to Kingston, 9-ft. navigation had been achieved as far as Sault Ste. Marie. The following half-century saw the construction of locks at the Sault, the

THE ST. LAWRENCE SEAWAY.

NAVIGATION FEATURES OF THE GREAT LAKES–ST. LAWRENCE BASIN DEVELOPMENT.

Section.	Total Length, Ft. William to Belle Isle, Miles.	Average Diff. in Level, Ft.	Navigation Works.							
			Existing.				Proposed.			
			Canal, Miles.	Minimum Depth, Ft.	Locks, No.	Movable Bridges, No.	Canal, Miles.	Minimum Depth, Ft.	Locks, No.	Movable Bridges (a), No.
Upper Lakes Channels										
Lake Superior ..	258·0									
St. Mary's River ..	63·0	23	1·6	Down-bound = 25 ft. Upbound = 21 ft.	1 (b)	1	1·6		1 (b)	1
Lake Huron ..	219·0									
St. Clair River ..	39·0	5								
Detroit River ..	18·0									
Lake Erie	32·0	3								
Niagara River ..	219·0									
Welland Ship Canal ..	27·6	326	27·6	25	8	20	27·6	27	8	20
Lake Ontario	155·4									
St. Lawrence River (to Montreal)—										
Thousand Islands ..	68·0	1		27						
International Rapids	47·0	92	12·0 (c)	14	7 (d)	3 (e)	11·2		3	2
Lake St. Francis ..	26·0	1		14						
Soulanges	18·0	83	14·7	14	5	8	15·5		2	4
Lachine	24·0	46	8·7	14	5	11	11·2		2	2
Lower St. Lawrence and Gulf	1,011·0	23		32·5				35		
Totals	2,225·0	603	64·6		26	43	67·1		16	29

NOTES.—
(a) Bridges—Service bridges at locks not included.
(b) Only one lock at Sault is required to overcome the lift of 23 ft., but there are four locks on U.S. side and one on Canadian.
(c), (d), (e) Figures shown are for downbound route only. On upbound route there are 11·5 miles additional canal, four more locks and two more bridges.

Minimum lock dimensions on completion of deep waterway will be 80 ft. wide, 860 ft. long, and 30 ft. depth of water on sills.

further deepening of the Welland Canal, and the enlargement of the St. Lawrence canals to their present depth, so that, early in this century, there was 14-ft. navigation from tidewater to the head of the Lakes. By that time, the dream of opening the lakes to large ocean ships had been born; and the latest half-century in the history of the waterway has seen much progress towards its realisation. The completion by Canada in 1932 of the Welland Ship Canal, one of the world's major engineering achievements, was an important step. Another was the construction of the MacArthur lock at Sault Ste. Marie by the United States during World War II. The St. Lawrence project as now proposed will clear away the final barrier.

Though it is true that a 27-ft. waterway will still not accommodate the largest ocean-going vessels, ocean ships will no doubt enter the lakes in considerable numbers, especially tramp steamers at seasons of the year when Lake shipping is overburdened. But the greater part of the freight through the Seaway is likely to be carried in the efficient bulk freighters of the Great Lakes, with trans-shipment of ocean cargoes at lower St. Lawrence ports. The Seaway, as now planned, will be able to accommodate enough vessels of this type to carry a very large volume of traffic, even though the navigation season is limited to between seven and eight months each year. If, at some future time, further expansion in capacity should be required, it would be practicable to duplicate the single locks in the Welland and St. Lawrence canals.

Viewed in perspective, the Seaway emerges as a further logical step in a long process. It is a practical engineering project. The latest published estimate of the cost, at December, 1950, prices, of a joint U.S.-Canadian power and navigation project is 704 million dols. Allowing for the extra 34 million dols. involved in constructing an all-Canadian waterway in the International Rapids section, but subtracting approximately 90 million dols. for dredging the Upper Lakes Channels (an undertaking which the United States will presumably carry out in any case) the cost of the project is put at somewhat less than 650 million dols.; but of this cost, some 400 million dols.,* according to these estimates, is chargeable to power and will be borne by the Hydro-Electric Power Commission of Ontario and the corresponding United States authority in equal amounts. It has always been expected that the power development would be a paying proposition even if, as proposed by the Province of Ontario and the State of New York in 1948, it were built without the navigation part of the project and bore the full cost of the works required for a separate power project. To speed up the commencement of the project, the Canadian Government has agreed to lighten the burden chargeable to power in some measure, including a contribution of 15 million dols. towards costs which the power interests were prepared to pay. Allowing for this sum, for the increase in prices since 1950, and for interest charges during the period of construction, the cost of the navigation project to the Canadian Government is not expected to exceed 300 million dols. Even if the estimates of cost should prove over-optimistic, proponents of the Seaway point out that the cost in real terms would be no greater than the 132 million dols. spent on the Welland Ship Canal 20 years ago, and that the burden, in view of Canada's larger population and greatly increased national production, would be relatively lighter. No tolls have ever been charged on the Welland Canal, whereas the costs of construction and maintenance of the new canals are expected to be covered by charges against the traffic using them.

(*To be continued.*)

* This includes, as well as the cost of dams and power-houses, expropriation of land, rehabilitation of flooded communities, and the necessary re-location of highways and railways.

CONTRACTS.

MCGHEE AND MURRAY, LTD., have obtained a contract, from the London County Council, for the supply, installation and testing of a passenger lift at the Council's Central School of Arts and Crafts.

ROBERT DEMPSTER & SONS, LTD., Elland, Yorkshire, have obtained a contract from the Northern Gas Board, Newcastle-upon-Tyne, for the construction of a coal-carbonising plant having a capacity of $4\frac{1}{2}$ million cub. ft. of gas a day, at the Redheugh Works, Gateshead. The site has been cleared in readiness for the new plant.

THE BRITISH THOMSON-HOUSTON CO., LTD., Rugby, have now completed an order for a number of sets of mobile fire-control radar electronic equipment, Type A. A, No. 3, Mark 7, for the United States Army European headquarters command. With each equipment a 17·7 kVA mobile Diesel-engine driven alternator set is supplied.

AIRWORTHINESS OF AIRCRAFT IN OPERATION.

OWING to the complexity of modern transport aircraft, and their high take-off and landing speeds, they are becoming increasingly difficult to operate and to maintain in an airworthy condition. It is time that a consolidated effort was devoted to making the vehicle more reliable and less exacting on the men who fly and service it. That, in brief, is the conclusion to be drawn from the eighth British Commonwealth and Empire Lecture, entitled "Maintaining Airworthiness in Operation," given by Mr. R. E. Hardingham, O.B.E., F.R.Ae.S., Secretary of the Air Registration Board, to the Royal Aeronautical Society in London on Thursday, October 2. In order to keep pace with the development of aircraft, the trends in British airworthiness requirements, said the lecturer, were (i) to eliminate unnecessary safety margins, and to fit the requirements more closely to the operating conditions, (ii) to provide much more data for the crew and the operators, and (iii) to extend test procedures and maintenance methods to deal with the complex systems. The use of a modern certificate of airworthiness was contingent on the existence of a flight manual, with legal status, providing information on the performance and handling of the aeroplane and the conditions in which it might safely be operated; and on a service and instruction manual.

Before the second World War, Mr. Hardingham said, trans-oceanic flights were not routine operations, and most aeroplanes had a fair prospect of making safe forced landings. To-day, with the high wing loadings and take-off speeds resulting from the demand for high cruising speeds, this was not so. Unfortunately, engine failure rates had not decreased, and to ensure safe operation under all conditions the new performance standards required certain performance minima with an engine inoperative. From these, the maximum permissible weights, within the limits of structural strength, were established for varying altitudes and temperatures; these data were incorporated in the flight manual. Mr. Hardingham described how the performance data were used to adjust the weight of the aircraft flying over a particular route, to ensure that it could take off and land within the limits of the runways of the aerodromes concerned, and could clear obstacles in their vicinity and high ground encountered *en route*. Referring to other aspects of the flight manual, Mr. Hardingham then cited a recent example in which it was necessary to include more than three closely-printed pages on the sequence in which the fuel tanks should be used. It was not right, he thought, that safe air transport should depend on such an exact prescription of human action.

For many years aircraft maintenance had depended on daily and periodic inspections, according to the degree of knowledge and experience of the licensed aircraft engineers in charge. Much unnecessary inspection had been done, and there was a danger of some parts being overlooked. After the second World War, aircraft manufacturers were persuaded to produce more comprehensive maintenance handbooks, and the maintenance schedule was introduced, whereby the maintenance and overhaul of aircraft became related to the flying hours completed instead of to calendar time. An attempt was made to assess the lives of the various parts, instruments and accessories, which were replaced by new or reconditioned parts on the expiry of this period. Suitable rig tests were required before the aeroplane went into service in order to determine the reliable life. Later, operating experience might modify the lives initially established. The main purposes of assigning lives to components were to keep the defect rate to a low level, to avoid the need for unplanned replacements, and to allow complicated parts and equipment to be overhauled by specialists in properly equipped workshops.

Recently, a number of defect records, supplied by British European Airways, of instruments and equipment, other than engines and propellers, had been examined. The striking conclusion from most of these records was that the number of defects per 1,000 item-hours remained fairly constant over the whole life of the item. Thus, no improvement in safety, or reduction in the work of remedying defects, would have resulted from fixing shorter overhaul-life periods. Provided that an increase of life did not result in a sudden rise in the defect rate (associated, for example, with the onset of fatigue or wear), the overhaul life should be fixed as high as possible in order to avoid the work of frequently removing the items. If defect rates were to be lowered, it was necessary to improve design, construction and, possibly, overhaul methods.

With engines, the problem was usually more straightforward. Overhaul lives were based on test results, experience and local conditions, and were invariably low for new engines, but were extended as operating experience was gained. In deriving performance standards it was assumed that the failure of one engine would not increase the chances of a second failure at about the same time. When certifying a prototype aeroplane, great care was taken to ensure that the power units were mechanically and electrically independent. To ensure that this independence was not invalidated in service through mistakes in assembly or adjustment, it seemed desirable to stagger engine replacements. For the same reason, a careful check on the cleanliness and suitability of fuel, oil, etc., was essential to ensure against engines failing at, or about, the same time.

Owing to the inadequate reliability of much aircraft equipment, it was necessary to provide for a high failure rate by duplication or by providing emergency apparatus. This might introduce new airworthiness problems; power-operated flying controls were an example. Hydraulic, pneumatic or electric power-producers were not so reliable as the human being, nor were electric leads or hydraulic pipelines as dependable as the simple cable or rod. Hence, duplication of the power system was necessary, and it must be ensured that, in the event of one power system failing, there was sufficient time to change to the other before catastrophe occurred. As an illustration of the problems introduced by jet transport, the lecturer cited the question of structural reliability under a differential cabin pressure of 8 lb. per square inch, mainly associated with the reliability of transparent plastic windows. Detailed instructions on the care of plastic windows had been issued for the Comet air liner by the de Havilland Aircraft Company, Limited, after exhaustive tests.

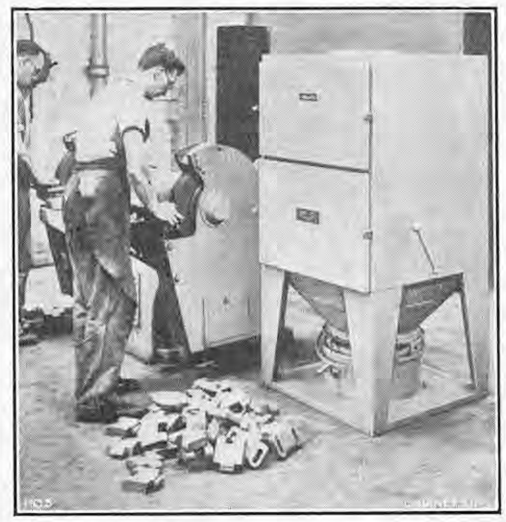
The safety of transport aircraft depended largely on maintaining their performance, and the lecturer suggested that periodic flight tests should be made on every aeroplane of a fleet. From time to time, the test results of the fleet could be collectively analysed. There was much to be learnt about the deterioration of performance: possible causes were falling-off of engine power resulting from excessive overhaul periods, repairs which increased the aircraft drag or reduced the thrust, and changes in the fuel specification. If satisfactory statistics for the fleet were available, it should be possible, after an aircraft type had been in operation for two or three years, to increase the scope of operation of the aircraft.

In conclusion, Mr. Hardingham suggested that the high percentage of accidents attributed to human error occurred largely because the modern aircraft was too complicated. He made a special plea for lower take-off and landing speeds; not only would this reduce the hazard, but it might render complex brakes and reversing propellers unnecessary. The economic gain from shorter runways would be considerable. He also suggested that the development of precise approach and navigation aids, readily interpretable by the pilot, would increase the safety of air transport.

"HOLOPHANE" BLENDED LIGHTING.—Holophane Ltd., Elverton-street, London, S.W.1, have designed a range of lighting units employing both mercury discharge and filament lamps. These are intended for industrial installations where high standards of illumination combined with good quality and economy in operation are required. Particular care has also been taken to obtain good colour uniformity in the blended light.

UNIT-CONSTRUCTION DUST COLLECTOR.

THE photograph reproduced in the accompanying illustration shows the Dustmaster, a unit dust collector with a wide range of industrial applications introduced recently by Messrs. Dallow, Lambert and Company, Limited, Spalding-street, Leicester. It comprises three units housed in a metal container: a fan and motor unit, available in five standard sizes, ranging from a fan capacity of 700 cub. ft. per minute to 2,000 cub. ft. per minute, the corresponding motors ranging from $\frac{3}{4}$ h.p. to $2\frac{1}{2}$ h.p.; a flameproof filter, available in



two types, one for normal applications and one for special dusts, both being equipped with a semi-automatic shaking mechanism; and the dust inlet and bin unit, the detachable bin being supplied in capacities of 1, 3 or 5 cub. ft. The bin is locked to the dust-collecting hopper by a quick-release lever mechanism. Suction inlets are provided on all four sides of the hopper. Any combination of these standard fan, filter and bin units may be selected, to suit the dust load. Thus, the Dustmaster is equally suitable for handling light bulky dusts or heavy concentrated dust.

FILM ON ALUMINIUM.—"Packaged Power" is the title of a highly-informative sound and colour film about aluminium which is shortly to be released for presentation to schools, colleges and public audiences. The film, which runs for 32 minutes, was made in Canada, and tells the story of the production of aluminium in a series of animated drawings and scenes photographed in the mines and works of Aluminium, Ltd. The story begins in British Guiana, where the bauxite ore is mined by open-cast methods and is later crushed, washed and dried before shipment to the smelting plant at Arvida, in northern Quebec. Near the latter place, the waters of the Saguenay river have been harnessed to provide a cheap source of power for the extraction processes. Two hydro-electric stations, situated on the river, supply a total of approximately 1,500 MW to the plant, which is the largest in the world. About 10 units of electricity are required to produce 1 lb. of metal, so that cheap power is essential. It is to the large amount of electricity consumed in making aluminium that the film owes its title. The various stages of the extraction process are illustrated: the treatment of the bauxite with hot caustic soda to dissolve the alumina and separate it from the unwanted impurities; the subsequent filtration, precipitation, washing and calcining; and the final electrolytic decomposition of the alumina, which yields the metal. The casting process and the dispatch of the ingots overseas to the company's rolling mills at Rogerstone, South Wales, are then illustrated, and the various rolling, cutting and finishing processes at the latter place, which yield the final product. After showing something of the research work undertaken by the company, the film gives an indication of new projects which will double the output of Canadian aluminium within a few years. A new smelting plant, which will treat alumina from Jamaica, is to be built in British Columbia, where the hydro-electric developments will ultimately suffice for an annual production of 500,000 metric tons of aluminium. "Packaged Power" won the award for the best industrially-sponsored film made in Canada in 1951. It is to be distributed in Britain by the Northern Aluminium Co., Ltd., Banbury.

BOOKS RECEIVED.

Danger Figures for Production Management. British Institute of Management, Management House, 8, Hill-street, London, W.1. [Price 3s. 6d.]

United Nations Economic and Social Council. Economic Commission for Europe. Committee on Electric Power. Report No. E/ECE/EP/126. *Transfers of Electric Power Across European Frontiers.* No. E/ECE/EP/127. *Prospects Opened Up by Technical Advances in Electric Power Production.* No. E/ECE/EP/128. *Some Technical Aspects of the Transmission of Electric Power.* United Nations Economic Commission for Europe, Geneva, Switzerland; and United Nations London Information Centre, Russell Square House, Russell-square, London, W.C.1.

Radreifen, Radscheiben und Vollräder. By DR.-ING. OTTO HEINZ LEHMANN, Verlag Stahleisen, Breite Strasse 27, Düsseldorf, Germany. [Price 14·50 D.M.]

The Institution of Mechanical Engineers and the American Society of Mechanical Engineers. Proceedings of the General Discussion on Heat Transfer, 11th-13th September, 1951. Offices of the Institution, Storey's Gate, St. James's Park, London, S.W.1. [Price 45s. net.]

Du Pont. The Autobiography of an American Enterprise. The Story of E.I. du Pont de Nemours and Company, published in Commemoration of the 150th Anniversary of the Founding of the Company on July 19, 1802. E.I. du Pont de Nemours and Company, Wilmington, Delaware, U.S.A.; and at Bush House, Aldwych, London, W.C.2. [For private circulation.]

Ministry of Housing and Local Government. Working Party on Requisitioned Properties in Use for Housing. Interim Report. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 4d. net.]

Aerodynamic Drag. By DR.-ING. SIGHARD F. HOERNER. Published by the author at 148, Busteed, Midland Park, New Jersey, U.S.A. [Price approximately 5 dols.]; and Bailey Brothers and Swinfen, Limited, 26-27, Hatton-garden, London, E.C.1. [Price 42s. 6d.]

Hose and Nozzle Charts for Fire Brigades. Merryweather and Sons, Limited, Greenwich High-road, London, S.E.10. [Price 10s. 6d. post free.]

Boiler-House Practice. By E. PULL. Third revised and enlarged edition. The Technical Press Limited, Gloucester-road, Kingston Hill, Surrey. [Price 12s. 6d. net.]

University of London. University College Calendar 1952-53. The Secretary, University College, London, Gower-street, London, W.C.1.

TRADE PUBLICATIONS.

Coal By-Products.—The Gas Council, 1, Grosvenor-place, London, S.W.1, have issued an illustrated booklet describing the valuable by-products obtained during the production of gas from coal.

Threading Dies.—A booklet entitled "The Identification of Threading Dies," which we noticed in this column some time ago, has now reached its third edition. It is published by W. H. A. Robertson & Co., Ltd., Small Part Division, Lynton Works, Bedford, who claim that no other firm in the world makes such a comprehensive range of dies and chasers to suit British, American and Continental die-heads, threading and thread-rolling machines and diestocks. The index refers to approximately 180 trade names of dies, and the main part of the booklet—which now covers thread-rolling dies—identifies some 300 chaser dies. It is illustrated, and gives details of 60 principal screw-thread systems.

Water-Cooling Plant.—The various types of water-cooling plant manufactured by them are described in a new edition of a well-illustrated pamphlet issued by the Visco Engineering Co. Ltd., Stafford-road, Croydon. It contains additional pages on which typical concrete and steel-shell coolers are illustrated, and some useful meteorological information is given.

Aircraft Wiring Cables.—British Insulated Callender's Cables Ltd., Norfolk House, Norfolk-street, London, W.C.2, have issued an illustrated leaflet giving particulars of their aircraft wiring cables. They have recently introduced cables with polytetrafluorethylene insulation (P.T.F.E.) which are suitable for use between temperatures of −75 deg. and +250 deg. C.

Spring Clips.—We have received two leaflets issued by Anderton Springs Ltd., Bingley, Yorkshire, giving respectively details of the ranges of Seeger Circlips and E-clips that they supply.

Automatic Dial Telephones.—Details of their automatic dial telephones, both of the desk and wall patterns, are given in a leaflet received from Communication Systems, Ltd., 8, Arundel-street, London, W.C.2.

Electrical Equipment for Trolley Buses.—The equipment manufactured by them for trolley buses is described in a well-illustrated pamphlet published by the General Electric Co., Ltd., Kingsway, London, W.C.2.

Loudspeakers.—Details of their Stantel cabinet loudspeakers are given in a leaflet published by Standard Telephones and Cables, Ltd., Aldwych, London, W.C.2.