THE TRACY PUMPING PLANT OF THE CENTRAL VALLEY PROJECT, CALIFORNIA.

As explained in the article describing the Central Valley Project, which appeared in our issues of July 4 and 11, the basic purpose of the whole scheme is to transfer surplus water from the northern part of the valley to the water-deficient areas in the south. The object is being attained by the construction of a complicated and extensive canal system, the main features of which were indicated in the map accompanying our previous article and appearing as Fig. 1, on page 4, *ante*. Owing to the configuration of the valley, water distribution cannot be wholly attained by controlled gravity flow and an interesting and important item in the whole scheme is formed by the Tracy Pumping Plant, which raises water flowing down the Sacramento from the north, a height of 197 ft., and delivers it to the Delta-Mendota Canal to flow some 117 miles southward to irrigate the San Joaquin Valley. The Tracy Pumping Plant is situated about 50 miles east of San Francisco. Its position, and the layout of the connecting canals, are indicated in the map already referred to.

The pumping plant was officially set in operation on July 9, 1951, and that date marked the inauguration of the integrated project under which water is transferred from the north of the Central Valley to the south. The equipment consists of six electrically-driven pumps, each of 767 cub. ft. per second normal output; the combined rating of the six driving motors is 135,000 h.p. The electricity supply is obtained from the Shasta and Keswick power plants, situated some 213 miles north of Tracy, through three separate 230-kV transmission lines. The Tracy plant incorporates a transformer and switch yard in which the current is stepped down to 13·8 kV to feed the motors. Water from the Sacramento River watershed gravitates to the Tracy inlet canal through the Delta Cross Channel, which is 2½ miles long and has a capacity of 4,600 cub. ft. per second. The pumps raise the water 197 ft., discharging through three 15-ft. diameter pipes, 5,000 ft. long, and laid on an upgrade, to the Delta-Mendota Canal.

An aerial view of the Tracy Pumping Plant is reproduced in Fig. 1, on this page, and a view showing the inlet side of the pumphouse in Fig. 2. A plan showing the layout of the inlet canal and discharge pipes is given in Fig. 5, on Plate XXXII. The 2½-mile long inlet canal has a bottom width of 100 ft. at the end remote from the plant, but at the pumphouse end the bottom width is 66 ft. The excavated width is 658 ft. and 4,193,000 cub. yards of material were removed during its construction. The canal bottom elevation is 17·75 ft. below sea level and the mean water-surface elevation 4 ft. above sea level. In the view reproduced in Fig. 2 the canal is almost empty. The gravity canal through which water reaches the inlet canal from the Sacramento River is 117 miles long; 99 miles are concrete-lined, the remaining 18 being of compacted-earth construction.

Fig. 1. Aerial View of Pumping Station.

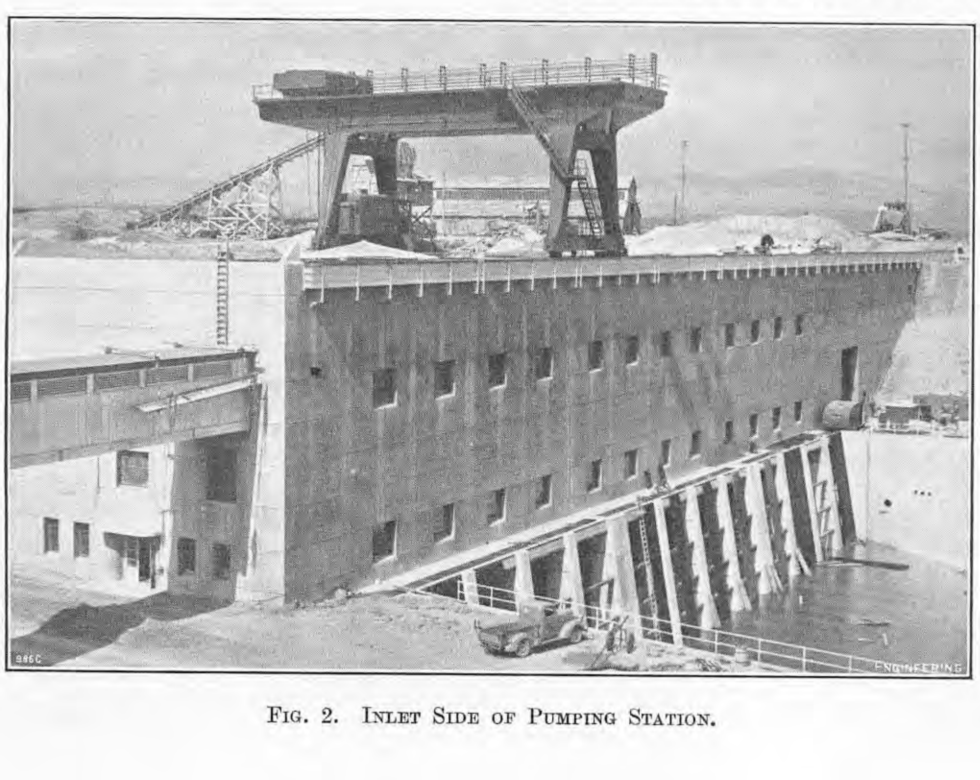


Fig. 2. Inlet Side of Pumping Station.

The pumphouse is a reinforced-concrete structure 362 ft. long, 60 ft. wide and 82 ft. from the foundation to the roof slab. Sectional drawings of the building are reproduced in Figs. 6 and 7, on Plate XXXII, Fig. 6 being a transverse section showing one of the pump units, and Fig. 7 a sectional plan at discharge-pipe level. As will be clear from Fig. 1, the building is almost below ground level, and from three sides only the 100-ton* travelling gantry crane on the roof is visible. The building is carried on 2,953 timber piles averaging 40 ft. in length; they were driven into silty, and partly clay, ground, after 450,000 cub. yards of material had been excavated. The amount of concrete required for the building was 33,690 cub. yards and the amount of steel 2,900 tons. Excavation for the intake canal at the plant, and for the building, had to be carried down to a depth of 80 ft.

The discharge pipes are buried, but there is a low-level roadway along the discharge, or rear side

* Short tons of 2,000 lb. and U.S. gallons are used throughout this article.

TRACY PUMPING PLANT: CENTRAL VALLEY PROJECT, CALIFORNIA.

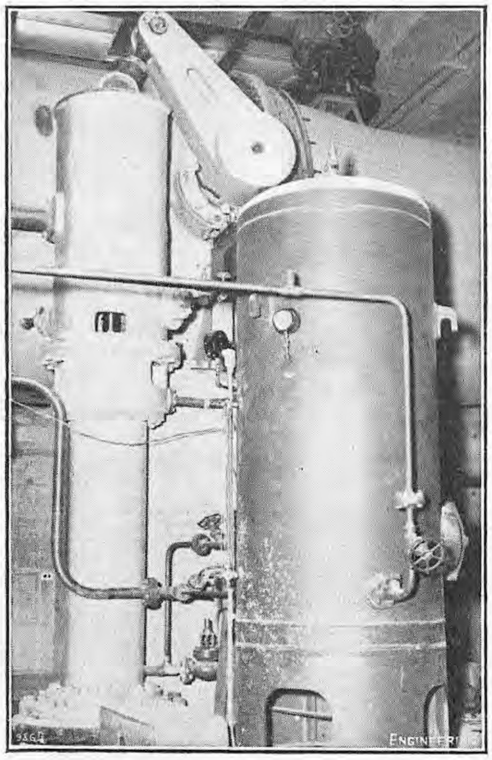


FIG. 3. 108-IN. BUTTERFLY VALVE.

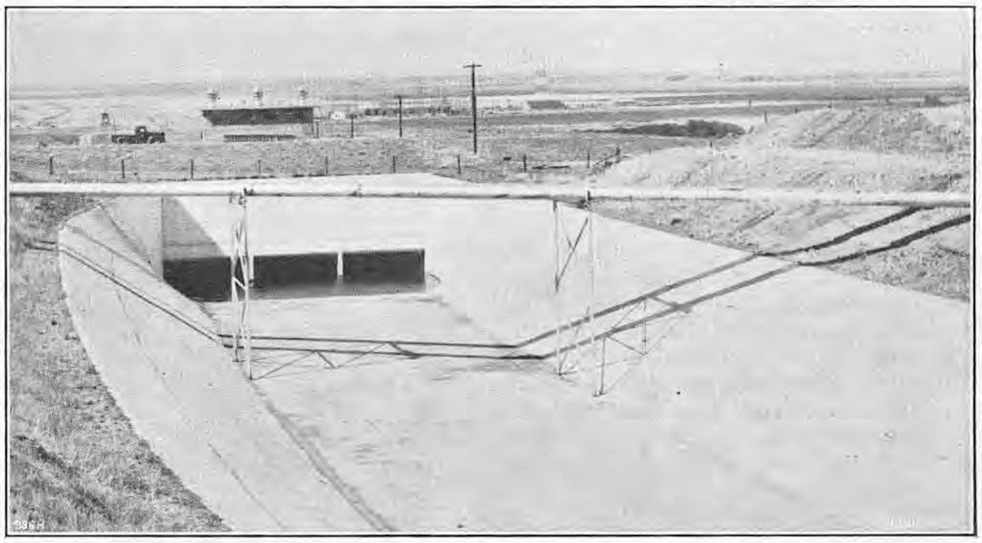


FIG. 4. OUTLET STRUCTURE FOR DISCHARGE PIPES.

of the building, giving access to the machine shop and to individual pumps. A 21-ton auxiliary gantry crane is available at this level for lifting the pump rotors or other parts and, if necessary, transferring them to the machine shop which, as shown in Fig. 7, is situated alongside the pump room. The auxiliary gantry crane is shown in Fig. 6; it is picked up and traversed along the building to any desired position by the 100-ton gantry crane on the roof. As shown in Figs. 2 and 6, the crane bridge has a cantilever section overhanging the auxiliary crane, on to which the lifting crab may be run. Extending from the pumphouse there is an enclosed bridge structure which can be seen at the left-hand side of Figs. 1 and 2. This leads to a tunnel which connects to the switchyard, the position of which is shown in Fig. 5. The tunnel and bridge accommodate eighteen main supply cables for the six pump motors. The machine shop is 119 ft. long and is provided with large vertical rising doors, both back and front.

Water from the intake canal passes through trash racks before entering the pumping plant, and behind the trash rack there are dual draft tubes for each of the six pumps. The tubes are formed in the concrete foundation of the building, as can be seen in Fig. 6, which shows a section through one of the tubes. The draft tubes are approximately square in cross-section, with rounded corners and they taper towards the suction elbow. At the inlet end, the bottom level of the tubes is at elevation $-17 \cdot 75$, which is the bottom level of the inlet canal. The slope is slightly downwards towards the pump elbow, the bottom level being at $-18 \cdot 10$. Special care was taken to obtain a smooth finish on the concrete surfaces of the tubes. Provision is made at the entrance end for vertical sliding gates which enable any individual intake to be closed. Each of the six pumping units is a centrifugal 84-in. vertical-shaft, bottom-suction, twin-volute pump, manufactured by the Worthington Pump and Machinery Corporation of Harrison, New Jersey. The designed capacity of each pump is approximately 360,000 gallons per minute at 197 ft. head.

As shown in Fig. 5, the pumps are connected in pairs to the three discharge pipe-lines. Between each pump casing and its short duct to the Y-connection there is a hydraulically-operated 108-in. butterfly valve manufactured by the Newport News Shipbuilding and Dry Dock Company. A view of one of the valves, with its accumulator tank, is given in Fig. 3, on this page. The short steel pipes between the valves and the Y-connections are 10 ft. in internal diameter. The three discharge pipes are each 15 ft. in internal diameter and 4,842 ft. long. For the first 2,939 ft. of its length, each pipe consists of sections of steel lining with a helically-wrapped steel reinforcement around which 15 in. of concrete were poured. The steel sections were fabricated at a point some 50 miles from the Tracy plant and after being transported to site were set in a vertical position and the 15-in. concrete encasement was poured, high-frequency vibration being used to compact the concrete, which was steam-cured after pouring. These prefabricated sections had an average length of 12 ft. and weighed from 60 to 62 tons, depending on the amount of reinforcement and the exact length. There was a total of 244 of these sections. After manufacture, they were transported by a double A-frame carrier and placed in an excavated trench.

For the remaining 1,903 ft. of each pipe, where the line rises from 77 ft. to 197 ft. above sea level and pressures are lower, a monolithic reinforced-concrete construction is used. This has a wall thickness varying from 15 in. to 18 in. For this section of the discharge pipes, 18,900 cub. yards of concrete and 2,600 tons of steel were used. The internal volume of each pipe-line is about 6,400,000 gallons. The total excavation required for the three lines was 112,000 cub. yards. A view of the outlet structure through which the pipes discharge to the Delta-Mendota Canal is given in Fig. 4, above. At the point where the pipes connect to the structure there is a transition section in which the cross-section changes from that of the 15 ft. diameter pipes to rectangular discharges 8 ft. 10 in. by 20 ft. The structure embodies a siphon on each pipe provided with a siphon-breaking valve. This valve is closed during normal discharge to the canal, but is open when the pumps are shut down, so preventing return flow from the canal.

(To be continued.)

GRANITE BLASTING AT BONAWE QUARRIES.—Preparations to blast an estimated 500,000 tons of granite from the face of the rock at Bonawe granite quarries, North Argyll, are expected to be completed soon. A main shaft has been driven more than 100 ft. into the granite, with side shafts 40 ft. long connecting with the powder chambers. Some 360 bags of explosive, each containing 56 lb., have been sealed in the chambers.

LITERATURE.

Architectural and Engineering Law.

By BERNARD TOMSON. Reinhold Publishing Corporation, 330, West 42nd-street, New York, 18, U.S.A. [Price 7 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 56s. net.]

BOTH the preface to this book and the introduction convey the impression, if they do not state the fact in actual terms, that it is the first in which the law relating to architects and building contractors in the United States has been collected together and systematised under one cover. If this is so, the author and his named collaborators are to be congratulated on a prodigious piece of research work, and a symmetrical and critical report on the results of their efforts. Law books in England are inevitably the result of evolutionary changes caused either by new enactments or re-enactments of old statutes, or by new decided cases. Thus many standard books extant to-day had their first edition a century ago and have been through a score of editions since. That, however, is in England; in this book the British reader must be instantly struck by the fact that the author has not to deal with a single body of law, but, to cover his subject-matter, he has to refer to as many laws as there are States in the Union. This, from the outset, makes his task formidable, because, for instance, he is necessarily called upon to cite literally dozens of cases decided on a single issue, each as determined by the judges in individual States. Further, if a case goes to appeal to the Supreme Court of the United States, that represents an added citation. These are difficulties which have been surmounted in a neat and logical way quite easy for the reader to follow.

For a building designer in California to print on his letter heading the caption "Not an Architect" because that State (and ten others) bans the use of the word "architect" is the key to the reason why nearly a quarter of the book is devoted to the licensing of architects and building contractors in individual States. Some 34 States do require either or both classes to be licensed, and woe betide the practitioner who neglects to register before he commences his professional or contractual undertaking. This pitfall applies not only to the newcomer, but to the established practitioner from another or "foreign" State, within the Union. He has to be licensed and may be required to submit to an examination before he is at liberty to practise. Failure to register may subject him to penalties and will certainly abrogate his right to sue for fees or for payment of work done. To the English

(To face page 426.)

THE TRACY PUMPING PLANT: CENTRAL VALLEY PROJECT, CALIFORNIA.

(For Description, see Page 425.)

Fig. 5. GENERAL PLAN.

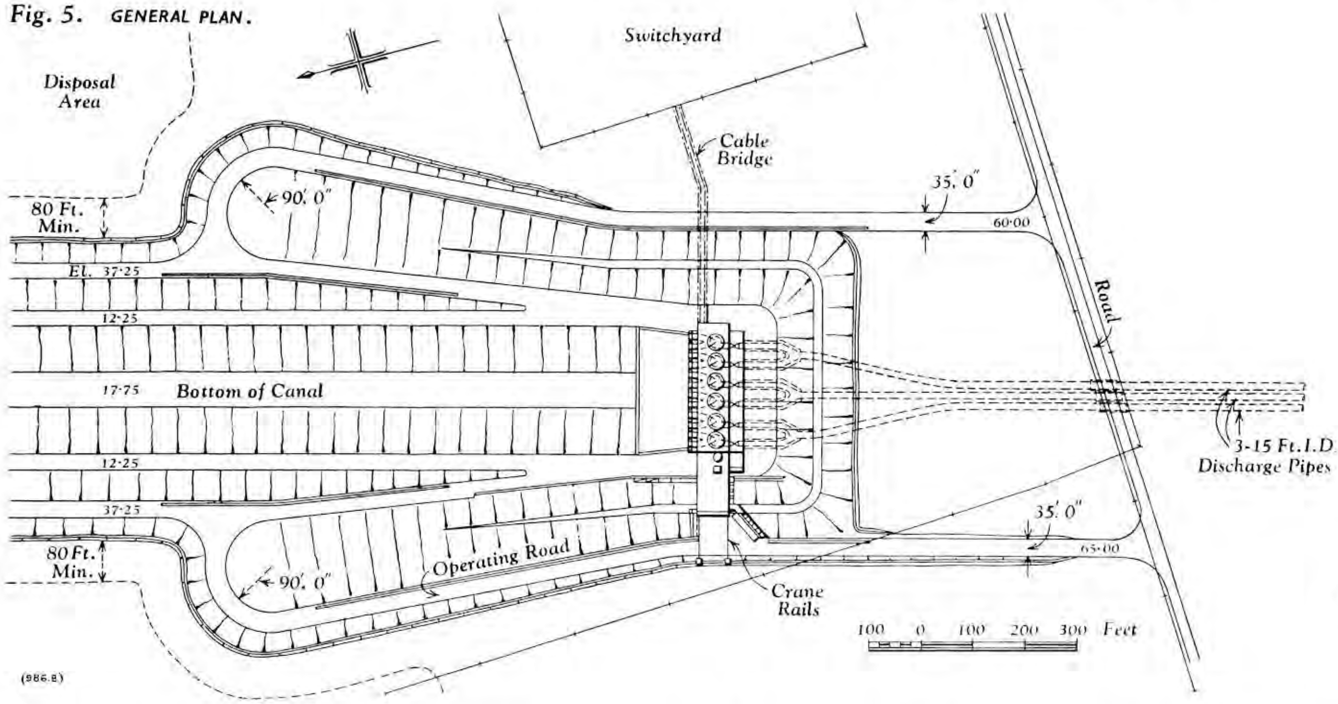


Fig. 6. CROSS SECTION THROUGH PLANT.

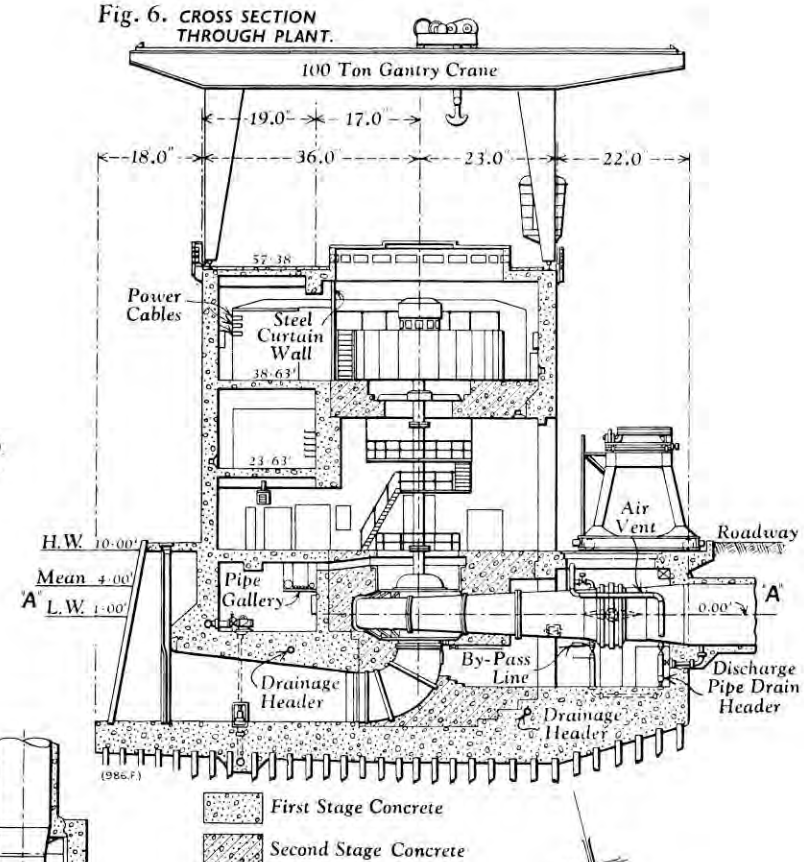
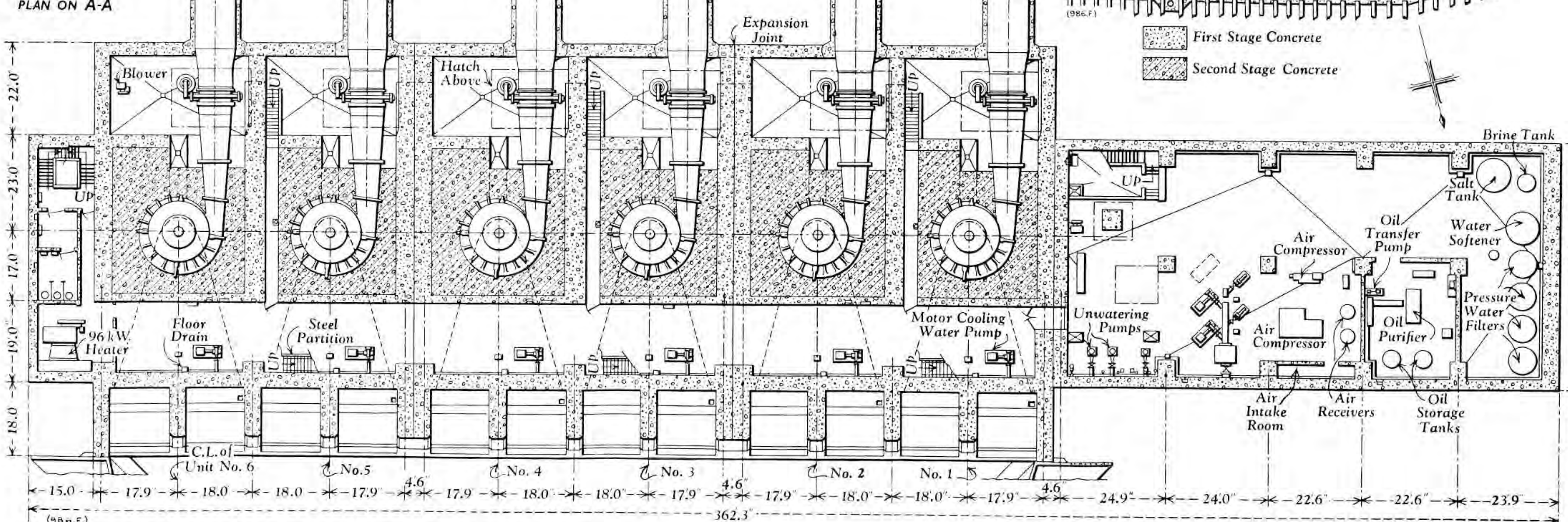


Fig. 7. PLAN ON A-A



reader, erroneously regarding the United States as a single entity so far as laws are concerned, such local discriminations might appear unnecessary and harsh, but nevertheless they represent an aspect of two centuries of evolution of the 11th Amendment to the Constitution: "The powers not delegated to the United States by the Constitution, nor prohibited by it to the States, are reserved to the States respectively, or to the people." To the British architect, commissioned to design buildings in the United States, or to the public works contractor who submits a successful tender, a study of the book, and especially its first quarter, would be of prime importance. The remainder of the book deals with conventional matters arising out of building contracts and their execution. It is clearly written and well arranged and, it may be said in conclusion, it is reassuring to note that the principles are identical with those set out in any recognised English book on the law of contract.

The New Electrical Encyclopædia.

Edited by S. G. BLAXLAND STUBBS. Four Volumes. The Waverley Book Company, Limited, 96/97, Farringdon-street, London, E.C.4. [Price 8*l*. 8*s*.]

ALTHOUGH technically a fourth edition of a work which first appeared nearly 20 years ago, the contents of these four volumes have been completely re-written, enlarged and re-set. Considering the advances that have taken place, even within that comparatively short period, especially in the field of electronics, such revision would have been desirable, if not necessary, if the value of the work was to be retained. Nevertheless, to produce some $1\frac{1}{4}$ million words, making 1,760 pages, and illustrated by nearly 3,000 drawings and photographs, was a commendable undertaking of which those who took part may justifiably be proud.

The field covered is wide and includes, besides all branches of heavy and light electrical engineering, information on the law affecting the engineer, craftsman and technician; on the relations and responsibilities of employers and employees; on the various professional bodies; and on the facilities available for training. With the exception of an introductory article on "Recent Progress in Electrical Engineering" by Dr. P. Dunsheath, the contents, which generally bear the name or initials of the author, are arranged alphabetically and not by subject. Any confusion arising from this cause should, however, be avoided by the system of cross-indexing that has been adopted. It is claimed, in fact, that the encyclopædic arrangement is not equalled either for ready reference or for solid reading. It certainly facilitates the discovery of information on a particular subject or sub-subject, but its chief danger is that the compression necessary in the compilation of the matter may lead to more or less important omissions. To some extent this has been overcome in the present work by the inclusion of a short bibliography at the end of each of the longer articles. It should be noted, however, that the term electrical engineering is interpreted very strictly. For instance, steam turbines and other prime movers are only cursorily mentioned as alternative means of driving electrical plant; and boilers only appear in connection with electrical heating. In pointing this out, the very complete index has been taken as the authority, and no criticism is implied since a principal task of the editor of any such work must be to decide what to leave out.

A drawback of the arrangement in the present instance is that certain entries are not complete in themselves. An example of this is to be found under the heading of switchgear, where only equipment suitable for voltages up to 33 kV is dealt with. For higher voltages, it is necessary to turn to the heading "Grid System," where the treatment can hardly be considered adequate; and finally, to that entitled "Circuit Breaker," which is only a little fuller, though it includes some excellent illustrations. It is, no doubt, a little difficult to see how this defect can be overcome; and the reader must therefore be careful to make exhaustive use of the index before abandoning his search.

These minor criticisms must not be, however, allowed to detract from the real value of this encyclopædia, which will be found most useful as a source book and as a means of checking other information. It can be recommended as an addition to both technical and lay libraries, especially in view of the clarity of its printing and the excellence of the illustrations.

Sound Recording and Reproduction.

By J. W. GODFREY and S. W. AMOS. Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 30*s*. net.]

THIS is one of the British Broadcasting Corporation's Engineering Training Manuals, written by members of the B.B.C. Engineering Division for the information of their own technical staff. Recorded material is now an indispensable auxiliary in the planning and production of broadcast programmes, and the B.B.C. has become one of the largest users of such material. Much of the equipment employed has been developed by their own engineers and it has always been notable for its high quality and advanced design. More than half the book is devoted to records made on discs coated with wax or lacquer, and to reproduction therefrom. Starting with an outline of the general principles of sound recording and reproduction, historical surveys are given of the development of the early acoustic machines and their electrical counterparts that enable the desired frequency range from 50 to 10,000 cycles per second to be covered, together with an analysis of the causes of distortion in electrical communication circuits. A thorough discussion of the technique of disc recording is followed by a detailed description of B.B.C. equipment from the earliest M.S.S. machine and the Presto equipment supplied during the war from the United States, to the type C portable outfit and the high-fidelity type D studio model introduced in 1943. The function of each component part is clearly explained, simplified circuit diagrams are provided, and illustrations of the actual machines appear as plates.

The chapter on reproduction from discs and pressings deals with various types of electrical reproducing heads, pick-up equaliser circuits, groove locating units and the causes of disc and needle wear. It is followed by an outline of disc processing methods. Beginning with a careful definition of terms, the chapter on magnetic recording and reproduction goes on to explain the theory of the method and to describe the Marconi-Stille, Magnetophon and E.M.I. systems, all of which have been used by the B.B.C. at different times. The final chapter is devoted to film recording and reproduction, and, after outlining the advantages and disadvantages of the two main photographic methods, describes more fully the Philips-Miller system, in which the sound track is cut on the film by a stylus. Nine appendixes contain useful reference data and interesting details on such matters as the manufacture of sapphire-tipped recording cutters and reproducing needles, induction and synchronous motors, the Buchmann-Meyer image, together with two papers reprinted from the *Proc. I.E.E.* and *Electronics* on frequency fluctuations in sound-recording and reproducing systems and tracking angle in phonograph pick-ups. Though the emphasis throughout is on B.B.C. equipment, no single book hitherto published in this country covers so comprehensively so many aspects of the high-quality recording and reproduction of sound.

INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING.

(*Continued from page* 298.)

WE continue our report of the working sessions of the 4th Congress of the International Association for Bridge and Structural Engineering with a review of some of the papers, which had been circulated in the *Preliminary Publication*, and of the discussions of the second of the three parts into which the technical business of the Congress was divided. Presented under the title of "Metal Structures," and concerned with both steel and light alloys, the subject was dealt with in the third and fourth working sessions. In the third session it was intended to deal with fundamental principles in the use of high-grade steels and light alloys together with the problems of welding; in the fourth, with the practical applications of the use of metals in structural engineering.

WELDED CONNECTIONS.

Despite the continued wide use of riveted connections with mild steel and the general interest being shown in the more extensive use for structural purposes of high-grade steels with a high elastic limit and of light alloys, no papers were submitted to the Congress on the fundamental principles involved in their use. Four papers were presented, however, dealing with the problems of welding and welded connections. In opening the session, the general reporter, Mr. H. Louis (Brussels), suggested that little progress had been made in welding techniques or in overcoming the problems incurred by welding since the 3rd Congress was held in 1948, although some attempts had been made to find better materials. On this latter point he was supported by Mr. G. N. Boyd (London), who observed, during the course of the open discussion, that engineers now had available a wide range of steels, with a high resistance in notch-bar tests, that could be obtained at economical prices.

The first paper, "Welding and Welded Connections," was a general review of current practices; the author, Ir. W. Genitsen (Bilthoven, Holland) began by drawing attention to the fact that many recent failures in welded bridge-work, shipbuilding and boilermaking were due to unsatisfactory design and construction rather than to the quality of the weld and the execution of the welding in the workshop. Although much attention was paid to the training of welders, the author complained of the widespread ignorance and lack of appreciation of the problems shown by many designers; as examples he mentioned the failure to make welds accessible to the welders, of designs containing inherent stress-raisers, and failure to specify the most satisfactory materials. The paper was illustrated by a considerable number of sketches illustrating both satisfactory and faulty welded connections. It ended with a graphic estimate of the high wastage of electrodes to be found in almost every workshop, caused by throwing away unnecessarily long stub-ends of electrodes, and of the economy that could be effected by paying attention to this point.

The second paper, by Ir. W. J. van der Eb (Delft, Holland), described an investigation into the static strength of end fillet welds under various conditions of stress. A large number of test specimens were subjected to either tensile or compressive stresses, in such a way that the direction of the action of the applied force was applied at a varying angle to the normal through the narrow part of the weld cross-section; this was achieved in a testing apparatus specially designed for the investigation. The author stated that the results of his tests, both in respect of breaking load as well as of angle of rupture, were most closely accounted for by the rupture hypothesis of Mariotte-Poncelet (the maximum strain theory), a theory which had been abandoned for so long by investigators. The author also examined the effect produced by varying weld heights and found that the average rupture strength fell as the height was increased, a result for which he was able to account theoretically.

The advantages to be gained from preliminary heating of the more important connections of the welded solid-web girders was discussed at considerable length in a paper (submitted in German) by Dr. J. Erega (Zagreb). The paper contained full descriptions of the methods used and the costs of preheating some bridge girders successfully welded in this manner. A mathematical estimation of the stresses induced by the procedure and some simple rules for use in the design office were also given by the author.

"The Fabrication and Erection of Large Welded Girders," by Mr. E. Ibbotson (Middlesbrough) was the fourth and last paper presented to the third working session. Mr. Ibbotson began his paper by pointing out that the post-war construction of new steel plants in Great Britain had given structural engineers the opportunity of applying modern design theories and forms of construction to structures of exceptional magnitude. Welding had been used extensively and the size of the projects had made it possible to install jigs and manipulators on a scale that could not be contemplated on normal constructional projects. When choosing sections for welding the limitations of rolling mills which had been equipped to deal with riveted construction had had to be considered, for few plants in this country were capable of levelling plates over $1\frac{1}{2}$ in. thick, and side-straightening (i.e., removing bends in the direction of the width of the plate) was restricted to much thinner plates. After levelling and straightening the correct handling of the sheet material became imperative and the use of stiff lifting beams with many grabs was advocated by the author. Steel manufactured in accordance with B.S. 15 : 1936 and having an ultimate tensile strength of 28 to 33 tons per square inch and a yield point of 16 tons per square inch was recommended as being suitable for large welding construction. The regular use of preliminary tests on specimen joints for newly-designed girders and tests on scale models of the girders had been found to give valuable information before finally proceeding with full-scale manufacture and construction.

Mr. Ibbotson continued his paper by describing in some detail the manipulators available for the manufacture of large all-welded girders. These manipulators, which consisted essentially of braced steel rings carried on rollers, were so designed that the individual plates of the girder to be fabricated could be placed within the manipulator, clamped into position and the whole work rotated so that each weld could be made efficiently and rapidly. The paper was concluded by some notes in regard to the problems of the final transport of the fabricated girders and their erection at site. The conversion of ancillary buildings close to the final site into temporary fabricating shops, and the use of Goliath cranes for erection were advocated by the author.

During the course of the discussion, Mr. W. H. Diamond (London) drew attention to the advantages of welding over riveting in regard to the final erection at site of such details as ventilation mains, escape ladders, etc. With riveted construction these items might all mean different detail drawings for the shops for each column or girder, due to the different drillings that were required. With site welding, however, the main members retained their standardisation and the position of ancillary equipment was determined by the fitter, at the site, with consequent saving in costs.

Metal Structures : Practical Applications.

Altogether, ten papers were submitted for discussion at the fourth working session, which proved to be the heaviest on the agenda of the Congress. The first paper, "Light-gauge (thin-walled) Steel Structures for Buildings in the United States of America," by Dr. George Winter (New York), gave a full description of this post-war development in structural engineering. Such structures, he said, consisted of members which were made of hot-rolled sheet or strip steel 0·03 to 0·15 in. thick, cold-formed in rolls or press-brakes and connected by spot or seam welds, screws, bolts or other special devices. It had become a standard method of construction under moderate loads, where long spans made the heavy hot-rolled members uneconomical, and where it was also desired that load-carrying members should provide useful surfaces such as in wall and floor panels and in roof decks. The use of such members offered considerable advantages for prefabrication and the lightness of the members made for rapid erection.

Various qualities of steel were in use, but whereas the A.I.S.C. specification for conventional steel construction was based upon a factor of safety of 1·65, the safety factor for light-gauge members had been necessarily increased to 1·85 due to the greater tolerances that had to be accepted in the thickness for sheet steel as compared with the heavier hot-rolled sections. The main design problems peculiar to thin-walled construction were due to the large width-to-thickness ratios of the component plate elements. If not properly designed, elements of this kind had low buckling resistance when subjected to compression, bending in their plane or to shear; the relatively low torsional resistance of thin-walled members meant that special attention had to be paid to bracing. A considerable part of the paper was devoted to consideration of these problems, and the advantages of using corrugated sheets, in contrast to plane sheets, to resist compression were mentioned. Extensive experimental work on the problem of shear lag in beams with wide flanges was also reported, it being noted, however, that this phenomenon was inconsequential for beams with reasonably uniformly distributed loads. During the session, Dr. Winter showed a number of slides illustrating examples of structures built by this method of construction, and he emphasised the opportunities available in composite construction where the main framing was of conventional steelwork and the walls, floor and roofs were made in light-gauge steel panels.

The buckling of thin webs of solid-web girders also formed the subject for the second paper, by Professor C. Massonnet (Liége) who, after referring briefly to the theoretical solutions of the problem of buckling, described recent tests he had made on a transversely loaded girder which was loaded until failure occurred. The tests showed that the buckling of the web was a progressive phenomenon which was much less dangerous than the buckling of struts. The girder was found to behave elastically far beyond the theoretical critical load and its final load was many times the latter, from which the author concluded that the factors of safety that should be adopted could be much smaller than those at present in use.

The use of light alloys was discussed in two papers; the first, by Mr. S. K. Ghaswala (Bombay and London), was concerned with the basic concepts of structural theory when applied to light alloys, and the second was a structural analysis of the Dome of Discovery by Messrs. M. A. and T. O. Lazarides (London), being a résumé of their recently published book. Mr. Ghaswala considered both the utility and limitations of light alloys and reached the conclusion that a new outlook in design was necessary when using aluminium alloys if many of the advantages were not to be lost. Referring to plastic design of structures, the author drew attention to the favourable form of the stress-strain characteristics of the light alloys, as compared with structural steels; the non-existence of the flat-yield characteristic in light alloys meant that relatively higher loads could be carried by redundant structures made from light alloys, due to the greater effects of continuity which contributed towards increasing the resisting moments. During the session, Professor Stüssi, the President, showed a number of slides of the Arvida Bridge, Canada, in illustration of Mr. Ghaswala's paper. In discussing the economics of light alloys, the President pointed out that the high initial costs could in part be offset where transport costs were high or if parts of the structure were movable. He ended his remarks by drawing attention to the need for the international standardisation of the alloys and their specifications.

Erection methods formed the basis of three papers: Mr. H. L. B. Huimink (The Hague) and Mr. A. H. Foest (Utrecht) described the methods used for erecting some bridges across main rivers in the Netherlands; some special methods for raising and erecting steel structures recently used in France were given by Mr. J. Cholous and Mr. A. Delcamp (Paris); and Mr. H. Shirley Smith, O.B.E. (London) presented a paper entitled "Influence of Erection Methods on the Design of Steel Bridges." Mr. Shirley Smith began his paper by pointing out that the proposed method of erecting the bridge must be considered during the early stages of the design, and the design modified as may be necessary in order to conform to the essential conditions of erection. Outlining the early history of large bridge construction during the Nineteenth Century, the author pointed out that the longest single spans were always of the suspension type, on account of the comparative ease of erecting the cables or chains as compared with the difficulties of erecting girder or arch bridges. The failure to provide adequate stiffening of suspension bridges against wind forces and the onset of the railway age, which brought with it the problems of heavier and more concentrated loads and of impact effects, increased the demand for bridges of sturdy design. So began the era of the great cantilever bridges.

The author then analysed the different methods of erection—by falsework or temporary staging, floating-out, service girder, cantilever construction, rolling-out or suspension type of bridge—for ways in which these methods might affect the design. Two considerations arose : the loading of members during erection when the bridge might be only partially complete and when members were held at points of temporary support, and the provision of suitable details that enabled the members to be quickly and accurately sited. The problems of prestressing members of trusses, i.e., the fabrication of the members to such a length and their intersections and connections at such angles that under dead and (if desired) live load, the trusses would assume their correct geometric shape, were also considered in terms of the method of erection to be adopted. The various types of crane available were briefly described :—the Scotch derrick or creeper crane mounted on the bridge itself, cranes independent of the bridge itself and, finally, the use of blondins, or cableways, for the erection of bridges across deep gorges or where other features dictated their use. In conclusion, Mr. Shirley Smith stated three reasons why the development of all-welded trusses of substantial size was being delayed. First was the difficulty of holding members securely in place during welding of site connections; secondly, was the lack of the knowledge which would permit a sufficiently-accurate estimate to be made of distortions, which must be allowed for if the truss was to be true to line and level after welding; and thirdly, the difficulty of carrying out prestressing during erection.

The session was completed by two French papers on details of design. The first, by Mr. J. R. Robinson (Paris) described a new light roadway system for bridges; the system consisted of arched plates to which the reinforcement rods of the overlying concrete surfacing were previously spot welded, so that steel panels and concrete together acted as a composite structure. In order to assess the capabilities of this particular form of construction, four such plates had been fabricated and tested to failure; on the basis of the experimental investigations the author proposed a method of calculation suitable for the design office. The final paper was submitted by Mr. J. Velitchkovitch and Mr. A. Schmid, who described in some detail the arrangement of the welded connections, the machining and erecting methods adopted during the reconstruction of the all-welded Corneille Bridge over the River Seine in the centre of Rouen. In elevation, the bridge had two principal spans with centre portions of 34 m. suspended between the cantilever arms of the shore spans : in cross-section, the superstructure consisted of nine solid-web box-shaped main girders. Welding had been reduced to a minimum, so as to avoid any accumulation or crossing of welds, and provision was made for the welded seams to contract as freely as possible. All the members were completed in the workshops, transported to the river bank and there erected with the assistance of a floating crane. Before final erection, the first structural elements to be completed were subjected to a full-load test.

During the course of the discussion, Mr. Shirley Smith showed a number of slides illustrating the replacement of railway bridges which had been demolished in Siam during the war. Both the original bridges and the new bridges were framed cantilever trusses, but, whereas in the old bridges

THE "PRINCESS" FLYING BOAT.

MESSRS. SAUNDERS-ROE, LIMITED, COWES.

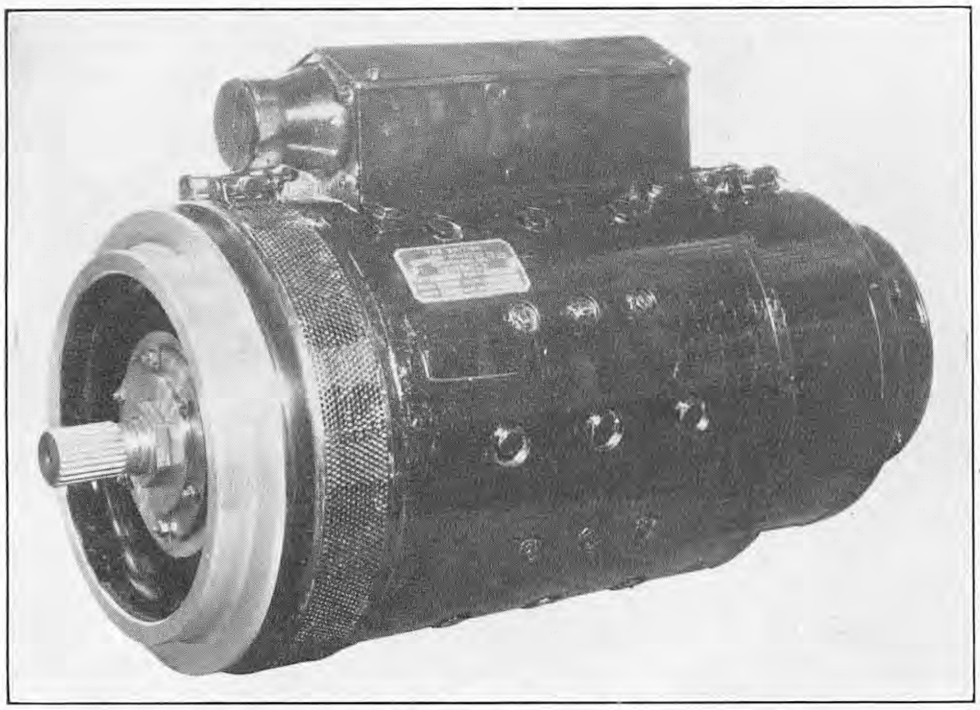
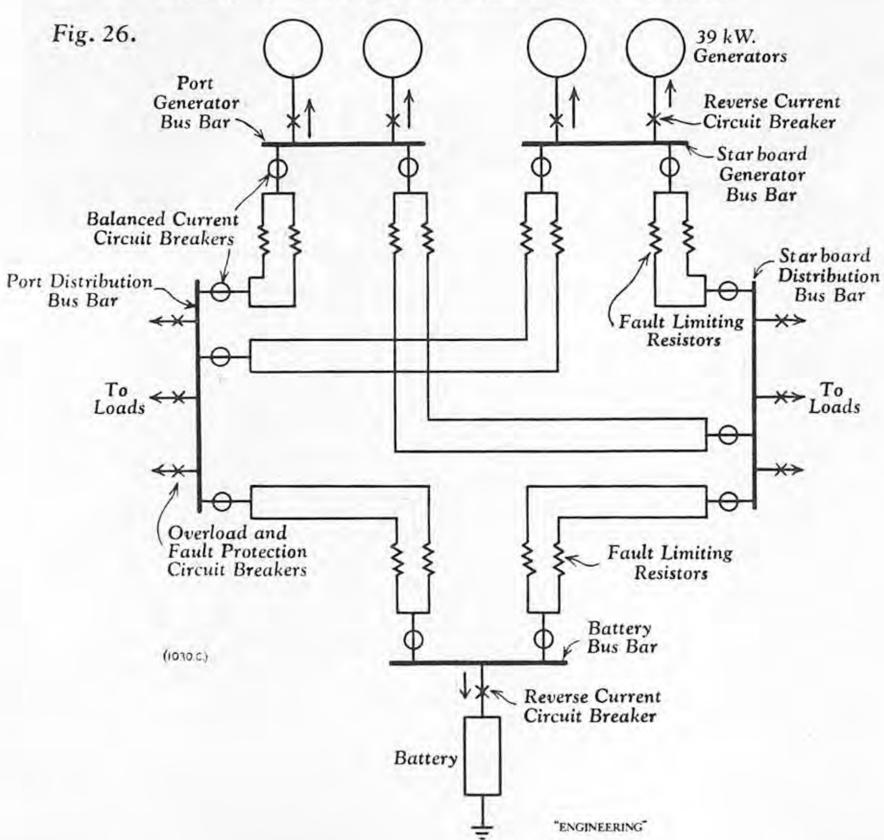


Fig. 25. B.T.H. 39-KW Direct-Current Generator.

Fig. 26.



built in mild steel it had been necessary to peak the trusses over the piers, in the new bridges, built in high-tensile steel, it had been possible to retain a straight horizontal top boom. He continued by stressing the flexibility of floating cranes for the erection of bridges wherever possible. In some recent bridgework, delays in erection had been experienced when using creeper cranes due to the late arrival of some intermediate girders (owing to the shortage of steel), so restricting the movement of the cranes; the use of floating cranes would have permitted the erection of all the girders available at site.

Mr. O. A. Kerensky (London), commenting on the large number of loose rivets so often found in large railway bridges, said that engineers were prone to blame faulty workmanship at the time of making the original rivets. This was not necessarily true. More often it was due to poor design, insufficient or improper allowances having been made for differential distortion between main girders, cross girders and stringers.

(To be continued.)

Journal of the Royal Society of Arts.—The first issue of the *Journal of the Society of Arts*, as it was then, was published on Friday, November 26, 1852, and the Society announces that the issue of the *Journal* to be published on November 28, 1952, which will be the first issue of volume 101, will contain a number of special centenary features. Information respecting the Society and its *Journal* may be obtained from the secretary, Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2.

THE "PRINCESS" FLYING BOAT.

(Continued from page 373.)

This article is concerned mainly with the electrical system of the "Princess," probably the most comprehensive and advanced installation of its kind. The services required during water operation—i.e., the floats, the bilging system, and the beaching gear—are also described. Previous articles on the Princess flying boat appeared on page 289 of our issue of September 5, in which the structural features were described, and on page 371 of our September 19 issue, which dealt with the powered flying controls.

Services for Water Operation.

Floats.—As already described on page 292, the float chassis retracts outwards into the space bounded by the front and rear-spars, and ribs 51 and 55, so that the float lies along the wing tip in flight. The floats are carried on two faired tubular float struts secured at their upper ends to a torque tube. The latter bears on stub-shafts attached to the front and rear spars, and has also two intermediate bearings in a bracket assembly attached to rib 51, in which is also mounted the operating jack. Each float has an independent retraction gear comprising an independent Dowty power pack, i.e., a hydraulic pump driven by an electric motor, together with Dowty emergency lowering gear, consisting of an air bottle and an electro-pneumatic valve. At the centre of the float-chassis torque shaft are two fork-ended actuating levers, to which is attached the jack ram.

The arrangement of the hydraulic and emergency pneumatic systems is orthodox, shuttle valves being provided at the up-locks, which are engaged mechanically and disengaged hydraulically, and the actuating jacks to cut off the hydraulic supply when the emergency air system is being used. A jettison valve is provided to release hydraulic pressure from the "up" side of the jack during emergency lowering. The electrical system comprises independent circuits for the port and starboard floats on the normal hydraulic system and separate circuits controlling the emergency system. In order to reduce the load on the electrical system, the propeller de-icing circuit is broken when "floats down" is selected.

Beaching Chassis.—The "Princess" is provided with a beaching chassis, capable of floating, for transferring the craft between the land and the water. It consists of two main chassis units, and a bow unit. Each main unit weighs $4\frac{1}{2}$ tons, and comprises two hollow watertight struts, forming a "V" braced at the top by an adjustable tube, and mounted at its lower end on a four-wheel chassis. The struts engage in sockets under the wing and a side-bracing member engages in a socket on the side of the hull. A hand-operated winch is mounted on each chassis leg, and pulleys are provided in the top attachment fittings to facilitate attaching the chassis to the aircraft when the latter is afloat. The bow chassis is a tripod structure, provided with two steerable wheels with a limiting radius of turn of 50 ft. The forward strut is secured at its upper end to a bow attachment fitting and the side struts engage in sockets on the planing bottom. One of the bow-chassis buoyancy units can be adjusted vertically to regulate the floating attitude of the aircraft during beaching operations. Jacking points are provided on the underside of all the chassis axles; the front of the aircraft can be raised by an 8-ton jack, and two 25-ton jacks, carrying a lifting beam which is arranged fore-and-aft under the main chassis axle, provide for lifting each main chassis unit.

Bilging System.—The 15 watertight compartments of the hull planing bottom, aft of the mooring compartment, are provided with a power-operated bilging system. A vertical suction pipe in each compartment is connected, through a manually-operated valve and a filter element, with a longitudinal gallery pipe running below the floor of the lower deck. The gallery is connected to the suction inlet of a rotary vane pump, with a capacity of 1,650 gallons per hour, installed in the well of the forward staircase. A hand pump can also be connected, by flexible pipes, to the system so that bilging can be carried out if, for any reason, the power-driven pump is not working.

Electrical System

Since the control of the "Princess" in the air depends entirely on the electrical system, particular care has been devoted by Messrs. Saunders-Roe, in consultation with the British Thomson-Houston Company, Limited, Rugby, to the development of a reliable system which automatically isolates any faulty conductor or component without interrupting the supply to the essential services. Some of the B.T.H. equipment specially designed for the "Princess" is illustrated in Figs. 25, 27 and 28. Every component has been extensively tested on a ground rig simulating the aircraft installation. There are two direct-current earth-return systems—a 120-volt (nominal) supply for the heavier services, i.e., the flying controls, the wing flaps, float-retraction, engine-starting, air-conditioning fans, bilge pumps, propeller feathering, propeller de-icing, galley services, fluorescent lighting, and motor-generator sets supplying alternating current for the fuel booster-pump motors, radar, and certain instruments. A 24-volt (nominal) system provides for the radio, most of the aircraft instruments, the powered engine controls and services, the fuel cocks, air-conditioning plant, emergency lighting and the control coils for the contactors of the high-voltage system.

The main 120-volt supply is furnished by four B.T.H. direct-current 39-kW generators driven from the auxiliary gearboxes of the four coupled power units. Each generator, which has a built-in radio-frequency suppressor, weighs only 204 lb., and operates over the range 3,200 to 4,000 r.p.m. The generators feed a ring main through port and starboard-generator 'bus-bars; a diagram of the ring-main distribution system is reproduced in Fig. 26, on page 429. The aircraft loads are divided between the port and starboard distribution 'bus-bars, so that the essential services, e.g., the flying-control power packs, may be supplied from either 'bus-bar, and it will be seen that, in the event of failure of any generator or conductor, there is always an alternative path between the working generators, the distribution 'bus-bars, and the battery 'bus-bar. There are nine 12-volt 63-ampere hour batteries connected in series, located in the top deck under the wing, which serve for starting the engines when a ground supply is not available, and which also form a reserve of electrical power which is sufficient to allow the aircraft to be brought down safely from a height of 40,000 ft. in the unlikely event of all four generators failing. The battery is protected by a reverse-current circuit-breaker which, when it trips, opens the battery contactor and isolates the battery from the services. When operating the aircraft services from a ground supply (a connector being provided on the port side of the hull below the wing) it is possible to charge the battery *in situ* simultaneously.

Each generator is connected to the 'bus-bar through a differential cut-out incorporating the main contactor, a reverse-current circuit-breaker with a rupturing capacity of 8,000 amperes., which operates only under fault conditions, and an over-voltage protection unit. No forward protection against faults in the distribution circuits is provided for the generators, as it is essential that the supplies to the flying controls and to other vital services shall be maintained. The differential cut-out incorporates a polarised pick-up relay which disconnects the generator from the 'bus-bar in the event of the generator polarity becoming reversed—an unlikely contingency. The main function of the differential cut-out, however, is to cut in the generator automatically as the engine speed runs up and to cut it out when the speed falls below that at which it will generate power. This is accomplished by a polarised differential relay with three windings arranged so that, when the generator voltage exceeds the 'bus-bar voltage by 2 to 3 volts, the relay closes and energises the coil of the main contactor, thus connecting the generator with the 'bus-bar. If the generator voltage drops so that the current flowing back from the 'bus-bar, in the reverse direction, exceeds 35 amperes, the differential relay opens and breaks the main contactor.

THE "PRINCESS" FLYING BOAT.

MESSRS. SAUNDERS-ROE, LIMITED, COWES.

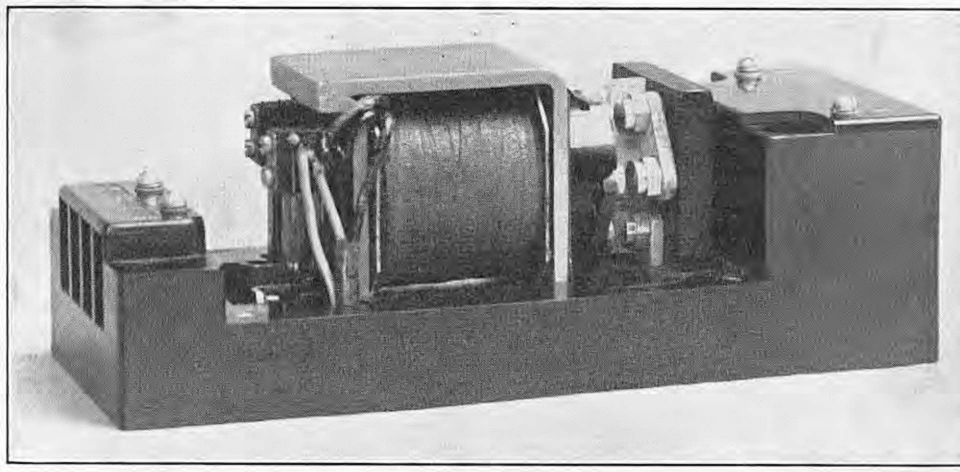


Fig. 27. B.T.H. 120-Volt 150-Ampere Contactor with Cover Removed.

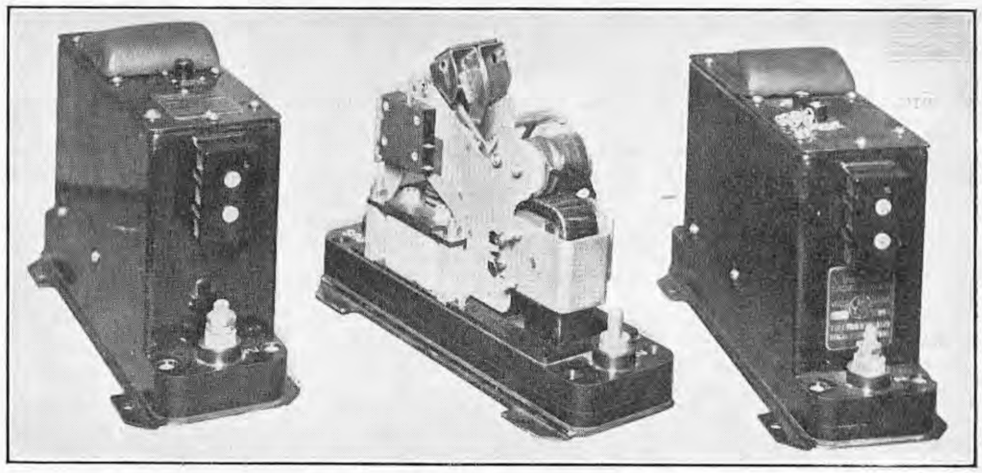


Fig. 28. Typical B.T.H. 120-Volt Direct-Current Circuit-Breakers.

The generator field current is regulated by a carbon-pile regulator fitted with a stabilising transformer to damp out oscillations; a thermal field-overload relay is provided on the negative side of the regulator which breaks the reverse-current breaker in the event of excessive field current, and isolates the generator. To ensure that the load is shared equally to within 10 per cent. by all four generators, a load-sharing circuit is employed: in each generator negative line is a calibrated resistance, the four resistances being grouped together with a common earthing point. The voltage drop in each resistance is applied to an equalising coil in the carbon-pile regulator. The four equalising coils are connected in parallel in such a way that a correcting current is applied to the field winding of any generator taking a greater or a smaller load than the others. If, however, one generator is switched off, it is automatically disconnected from the load-sharing circuit. If, for any reason, the voltage regulation breaks down and one generator produces excessive voltage, an over-voltage protection relay closes and energises the reverse-current breaker, thus isolating the generator. The carbon-pile regulator incorporates an additional resistance arranged to give a higher generator voltage before the main contactor closes. As soon as the generator is cut in, however, this resistance is short-circuited so that the generator voltage regains its normal value. The purpose of this arrangement is to avoid a condition which might arise with one generator cut in, when starting up a second generator, whereby the close voltage regulation might prevent the second generator from developing sufficient voltage to operate the differential cut-out.

The reverse-current breaker in the generator circuit is mechanically locked in the closed position. It is broken electrically when a high reverse current, greater than 300 amperes, flows in the main generator line, or by the over-voltage relay, or by the field overload relay. To prevent the reverse-current breaker from opening under surge currents, a time delay is built in. Under heavy currents, however, it functions within 15 milliseconds. Similar reverse-current breakers protect the battery circuit.

All the principal cables in the ring-main distribution system are duplicated to form identical parallel current lines, with out-of-balance circuit-breakers at each end which, in the event of a fault occurring in any line, break that line automatically,

EXHIBITS AT THE INTERNATIONAL MACHINE TOOL EXHIBITION.

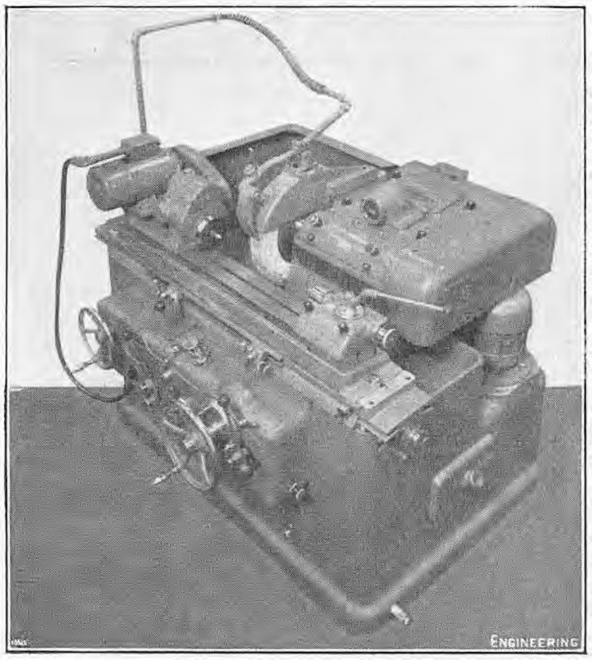


FIG. 84. PLAIN CYLINDRICAL GRINDING MACHINE; JOHN LUND, LTD.

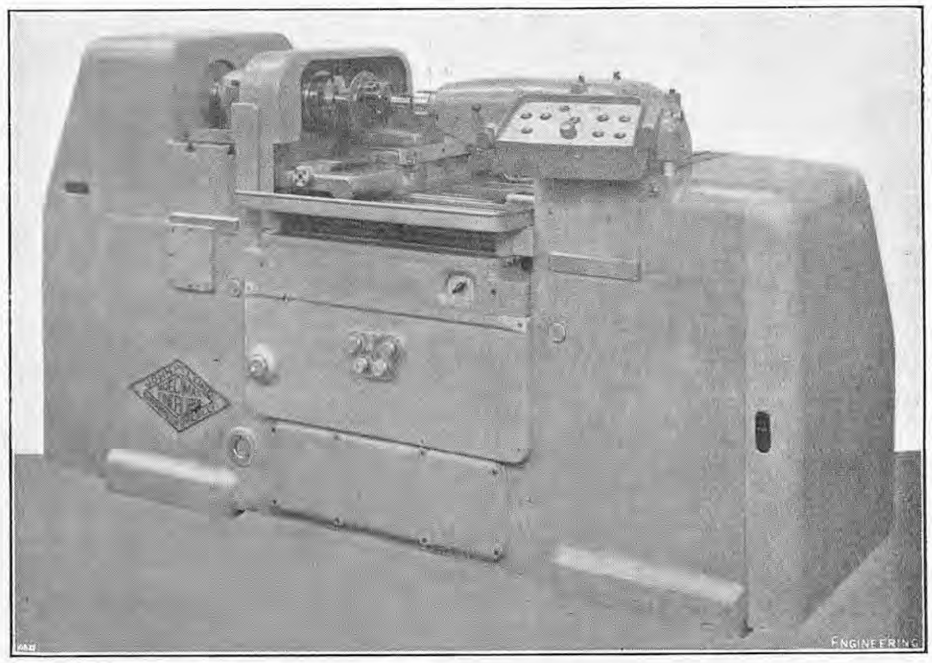


FIG. 85. DOUBLE-ENDED FINE-BORING MACHINE; JOHN LUND, LTD.

the parallel path being still available. To prevent an excessive current building up in the distribution lines in the event of a short circuit, fault-current limiting resistors are connected in each conductor which limit the current to 8,000 amperes.

The circuit-breakers, typical examples of which can be seen in Fig. 28, on page 430, protecting the service lines connected to the distribution 'bus-bars are in series with the service contactor switches, the control coils of which are supplied from the 24-volt system. Mechanically-latched contactors are employed so that, should the 24-volt system fail, switches are held in the closed position and essential services are not lost. The protective circuit-breakers are of the thermal and magnetic type; if a fault current of over 2,500 amperes passes, the magnetic relay trips within 15 milliseconds and thus prevents thermal distortions of the bimetal element.

The 'bus-bars and their circuit-breakers are enclosed in a metal box which is insulated from earth—i.e., the air frame—but is connected with it through a high rupturing-capacity fuse. If, therefore, a fault develops in the 'bus-bar, and the fuse ruptures, the system continues to function, but the 'bus-bar box is live. All the 'bus-bar boxes and main circuit-breakers are in an electrical compartment. The 24-volt direct-current system is basically similar to the 120-volt system. Power is supplied by two 28-volt generators driven from the auxiliary gearboxes of the two centre power units; the operating speed range is 6,400 to 8,000 r.p.m. The two generators feed a common 'bus-bar, to which is connected a 126-ampere-hour battery.

Three types of motor-generator sets are employed in the "Princess." From the 120-volt system, two 400-cycle and 1,600-cycle machines supply alternating current at 115 volts for the high-frequency instruments and cloud-and-collision radar. Both motor generators are in continuous use, the essential loads being connected to one machine and non-essential loads to the other, with provision for transferring the load. The 120-volt system also supplies three 400-cycle three-phase motor generators for driving the fuel-system booster-pump motors which are immersed in the fuel tanks; one of the sets forms a standby. From the 24-volt system, two inverters provide alternating current for the low-voltage aircraft instruments.

(*To be continued.*)

THE INTERNATIONAL MACHINE TOOL EXHIBITION AT OLYMPIA.

(*Continued from page* 400.)

DESCRIPTIONS of a further selection of exhibits at the International Machine Tool Exhibition are given in this, the fourth, article in the series. The exhibition closes at Olympia tomorrow (Saturday, October 4).

PLAIN CYLINDRICAL GRINDING MACHINE.

Grinding machines and fine-boring machines are exhibited by Messrs. John Lund, Limited, Cross Hills, near Keighley. One of each is described and illustrated here, but in addition, the machines displayed include a plain cylindrical grinding machine, type MPA 12-14/40; a universal grinding machine with a Thyratron valve control for a variable-speed work-head motor; a single-ended fine-boring machine; and a bridge unit for the latter.

The Precimax plain cylindrical grinding machine shown in Fig. 84, on this page, is the type MPO 5/18, which will grind, on a production basis, components of small diameter, e.g., micrometer spindles, and will admit 18 in. in length. The maximum workpiece diameter is 5 in., though for efficient repetitive grinding of workpieces over $2\frac{1}{2}$-in. diameter the makers recommend one of their larger machines. The principal features of all Precimax machines, including that illustrated, are as follows. Hydraulic operation and control for the various linear motions of slides and units ensure speed, smoothness, flexibility and reliability. The grinding-wheel and tailstock spindles are of Nitralloy and the former runs in Oilwedge spindle bearings. There are independent motor drives to the wheel-head, work-head, hydraulic pump, and coolant pump. By designing the wheel-spindle alternating-current motor so that it fits in the wheel-head casing, well-proportioned precision bearings can be provided, ensuring precise mounting and balancing. An alternating-current variable-speed motor, specially developed for Precimax machines, gives stepless variation of the work-head speed by an induction regulator, starting at any pre-set speed and also quick stopping. The electrical equipment of the machine, including the starting gear and the regulator, together with most of the hydraulic fittings, are enclosed within the machine body, thereby affording protection against damage.

Rapid approach and retraction of the wheel-head to and from the grinding position are provided by means of the hydraulic system. A plunge-feed system applied to the wheel-head gives a continuous in-feed at infinitely-variable rates. The table-traverse speed is also infinitely variable, and owing to the high rates of traverse available a wide grinding wheel may be used to full advantage. The handwheel operating the table traverse is automatically disengaged hydraulically whenever the power traverse is engaged; this automatic action also takes place in the reverse order. Precimax machines are equipped for the use of a Tymcizer automatic-sizing device and, when specially requested, a Stop-cote automatic sizing device, both of which adapt the machines for an automatic cycle of movements. The operator's duty is then limited—apart from an occasional check for size—to loading and unloading the workpieces. Semi-skilled labour can thus be used. The Stop-cote device was first marketed in France in 1948, and the excellent results which were obtained with it were registered at the Courbevoie Machine Tool Test Laboratory. It has a Wheatstone bridge, energised by a high-frequency generator, which is connected to the controlling mechanism in such a way that the bridge is perfectly symmetrical when the workpiece has been ground to the exact size.

DOUBLE-ENDED FINE-BORING MACHINE.

The Precimax FB2 double-ended fine-boring machine, illustrated in Fig. 85, on this page, carries a reciprocating table on long accurate guides in the bed. At each end of the bed a bridge is mounted to provide the bases for independent spindle units. The workpiece, or workpieces, may be carried either non-rotary on a table unit, or rotary in chucks or fixtures on flange or rotating spindles. Table movement is derived from hydraulic pressure supplied by a motor-driven pump in the base of the machine. The spindles are independently belt-driven by electric motors (1·5 to 4·5 h.p.). Table rapid traverse, boring and slow-facing feeds are selected by hydraulic valves, each actuated by one pair of solenoids. These are energised by means of adjustable table dogs depressing snap-action switches acting directly or through relays. Spindles are started and stop-braked by appropriate switches. Cycle-selector switches provide for slow or fast start; slow, fast or no automatic reverse at the end of the stroke; delay of the spindle stop at the end of the table movement; and a setting cycle. In the latter, push-button and hand-lever switch control supersedes automatic functions. The above functions are interlocked with one another and with the table positions, thus adding to the versatility and effi-

EXHIBITS AT THE INTERNATIONAL MACHINE TOOL EXHIBITION.

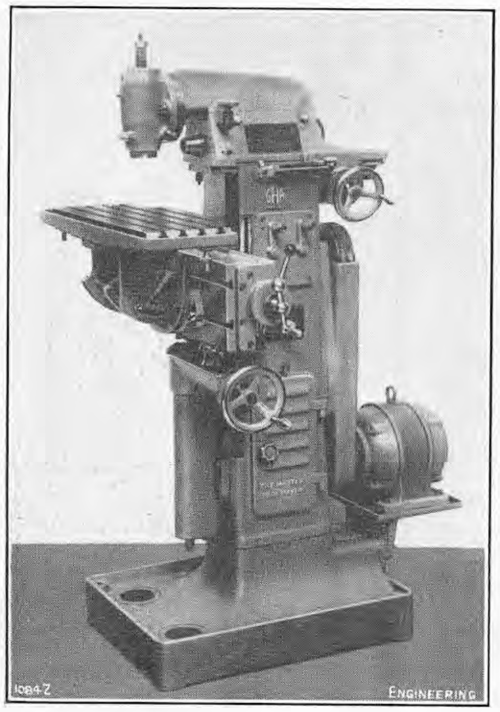


FIG. 86. UNIVERSAL MILLING MACHINE; GEORGE H. ALEXANDER MACHINERY, LTD.

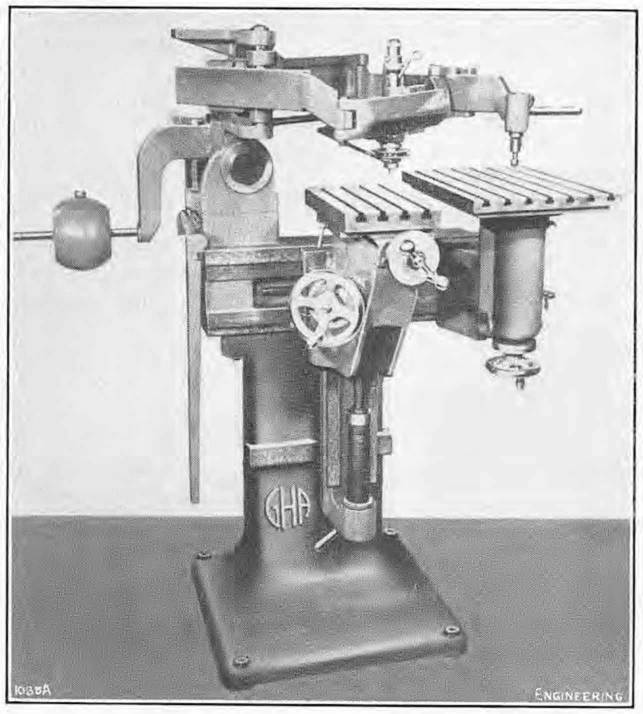


FIG. 87. DIE-SINKING MACHINE; GEORGE H. ALEXANDER MACHINERY, LTD.

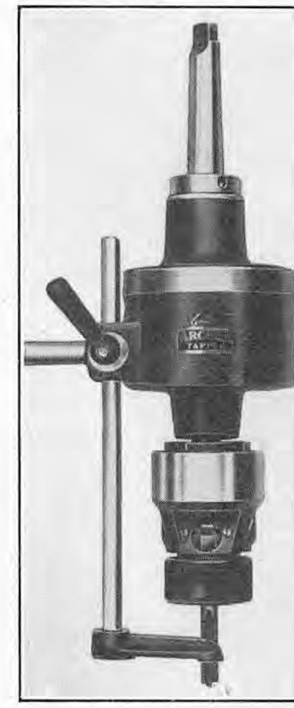


FIG. 88. "ARCHER" TAPPING ATTACHMENT; FRANK GUYLEE & SON, LTD.

ciency of the machine, producing round holes, and true surfaces accurate for size, position and finish. Another machine, the Precimax fine-boring machine type FB1, is similar except that it is single-ended, i.e., the bridge and boring heads are mounted only on the left-hand end of the machine bed.

UNIVERSAL DIE-SINKING MACHINE.

The exhibits on the stand of Messrs. George H. Alexander Machinery, Limited, 82-84, Coleshill-street, Birmingham, include several three-dimensional die-sinking machines and a small universal milling machine of their own manufacture, and a selection from the range of machine tools made by Ludw. Loewe and Company, Berlin. One of the die-sinking machines, namely, their model 2, is illustrated in Fig. 87, herewith, it is particularly suitable for the production of moulds and dies where irregular forms are of paramount importance. The cutter spindle runs in ball bearings and is held in the cutter head by means of a bayonet lock so that it can be removed easily. It is driven by a ½-h.p. electric motor and 12 speeds are available ranging from 550 r.p.m. to 9,125 r.p.m. On flat work and lettering the depth of cut is regulated by a combination coarse and fine adjustment mechanism located on the cutter head, but this feed can be supplemented by moving the work-table vertically. The cutter-spindle feed mechanism is provided with a positive stop which can be adjusted to give the exact depth of work required, this adjustment being simplified by a scale calibrated to 0·002 in. Both the work and copy tables can be adjusted vertically and the latter can be unclamped and swung freely about its axis. The work-table, however, moves in two directions only, that is, longitudinally and laterally, both movements being accomplished through the manipulation of hand-wheels in the normal manner. To eliminate springiness and vibration, the various members forming the pantograph are of exceptionally heavy cross-section. A simple design of pantograph is used, the arrangement of the arms and pivots being such that a reduction can be obtained in three planes, the complete unit being suspended from a horizontal bearing which permits it to swivel and thus control the depth of the work. All bearings in the linkage are fitted with roller bearings, and the pantograph, as a result, is extremely sensitive and easily guided by hand. It is adjusted for the various ratios by moving guide castings along the arms to coincide with engraved graduations, the range available being from 1 : 1·5 to 1 : 10. A spacing piece is available which, when inserted, restricts the movement of the pantograph to the horizontal plane. Other attachments available include a cam-forming arm, a routing attachment, a rotary engraving attachment and dividing heads.

UNIVERSAL MILLING MACHINE.

The universal milling machine being shown by George H. Alexander Machinery, Limited, is illustrated in Fig. 86, herewith. This machine, which is known as the Master Toolmaker, has a vertical table measuring 21⅝ in. by 7⅞ in. with a horizontal motion of 9⅞ in. and a vertical motion of 11⅝ in. An automatic table-feeding mechanism is incorporated which can be used to move the table horizontally to either side or vertically both up and down. The machine is driven either by a standard 2-h.p. motor or by a two-speed pole-changing motor of the same rating, the speed of the former being 1,420 r.p.m. and of the latter 1,420 r.p.m. and 700 r.p.m. When fitted with a standard motor, the spindle has six speeds ranging from 120 r.p.m. to 1,200 r.p.m. and the table six feeds ranging from ⅜ in. per minute to 6¼ in. per minute. With the two-speed motor, there are 12 speeds for the spindle and 12 feeds for the table. The range of the former being from 60 r.p.m. to 1,200 r.p.m. and the latter from ⅜ in. per minute to 6¼ in. per minute. The headstock is adjustable in the direction of the spindle up to 5⅞ in. and the cutter arbor support permits the use of cutters up to 5⅛ in. in diameter. Additional equipment available with the machine includes a vertical milling attachment, a universal tilting table and a slotter, the machine illustrated being fitted with the two former items of equipment. The head of the vertical-milling attachment swivels to each side and has a longitudinal motion of 5⅞ in. Six speeds are available, ranging from 185 r.p.m. to 1,840 r.p.m. with the standard motor, and 12 speeds with the two-speed motor, the range in the latter case extending from 95 r.p.m. to 1,840 r.p.m. The universal tilting table, as its name suggests, swivels in three directions and has a clamping area of 10¼ in. by 23⅝ in. For the slotting attachment, the height of stroke can be adjusted to a maximum of 3 in. and the longitudinal motion of the slotting head is 5⅞ in. The device can be tilted to both sides and the number of strokes per minute varies from 47 to 475 with the standard motor and from 24 to 475 with the two-speed motor, six variations being available with the standard motor and twelve with the two-speed motor. The overall height of the machine is 55 in., and with the vertical milling head, 61 in.; the space required for its installation is 47 in. by 43½ in.

TAPPING ATTACHMENT.

A comprehensive selection from their extensive range of small tools is shown by Messrs. Frank Guylee and Son, Limited, Archer Tool Works, Millhouses, Sheffield, 8. The selection includes keyless drill chucks, grinding-wheel dressers, revolving lathe centres, drill sleeves, sockets and drifts and tapping attachments. One of the several tapping attachments on view, namely, the Archer automatic-reversing unit, is illustrated in Fig. 88, above. This is made in three sizes, namely, Nos. 1/1A, 2 and 3, which are capable of tapping up to ¼-in. Whitworth, ½-in. Whitworth and ¾-in. Whitworth, respectively. They can be fitted to any drilling-machine spindle by means of the taper shank, but for larger sizes, the makers recommend the use of a cotter or set screw to prevent the shank loosening when reversing. The upper outer casing of the unit containing the forward and reversing gears is held stationary by an arrestor rod placed against the body of the machine or a suitably-mounted stay. A friction device is incorporated in the drive so that when hard spots are encountered, or the tap is overfed, slipping occurs, thus preventing the tap from being damaged. When the spindle is raised, the tap automatically reverses and runs at twice the speed, and where deep holes are being tapped the tap can be removed and fed into the work repeatedly so that it can be adequately lubricated. An adjustable depth gauge is fitted for use when tapping blind holes or to a limited depth. The length of the No. 1 machine is 6⅝ in., the No. 2 machine, 8¼ in., and the No. 3 machine, 9 in., and the diameter of the outer casing is 2¾ in., 3⅜ in., and 3⅝ in., respectively. The lengths quoted, however, do not include the shank.

TOOL-ROOM LATHE WITH HYDRAULIC COPIER.

THE extensive range of Continental machine tools being shown by the Elgar Machine Tool Company, Limited, Hampton-road, Hanworth, Feltham, Middlesex, includes the tool-room lathe illustrated in Fig. 89, on Plate XXXIII. Known as the type TUV 220, this machine is manufactured by the Morando Company, Turin, Italy, and can be used either as a straightforward lathe or fitted with a hydraulic-copying attachment as shown in the illustration.

EXHIBITS AT THE INTERNATIONAL MACHINE TOOL EXHIBITION.

(*For Description, see Page* 432.)

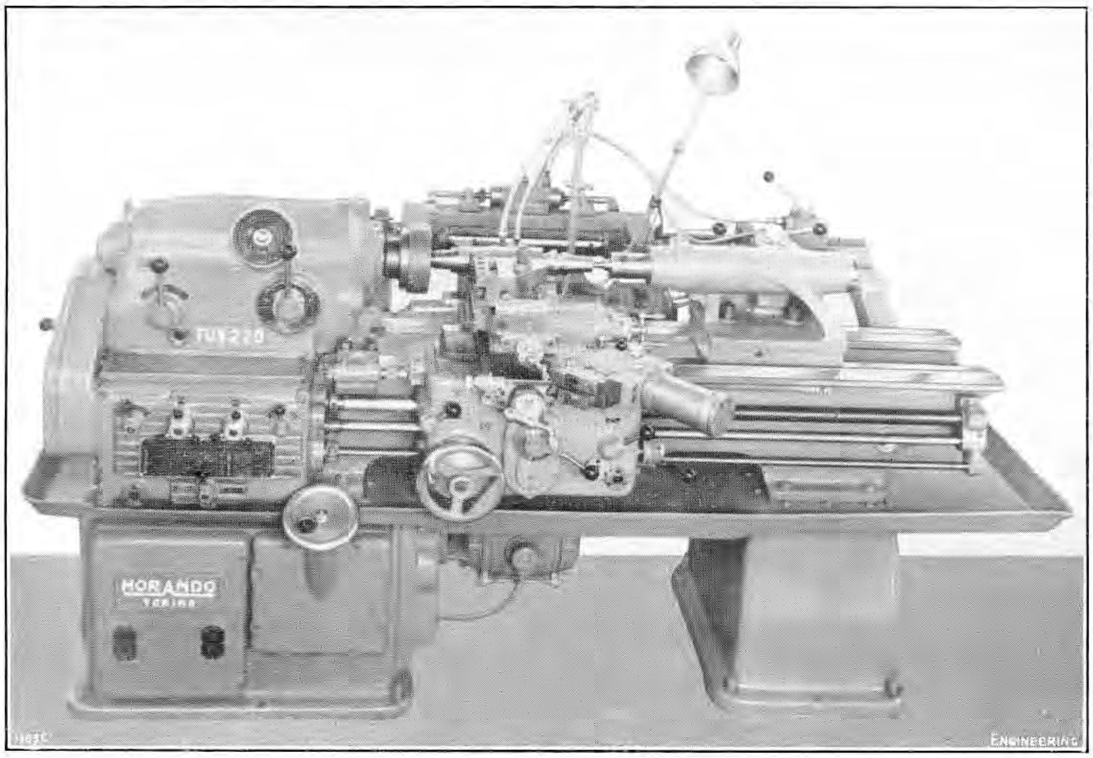


Fig. 89. Toolroom Lathe with Hydraulic Copier; Elgar Machine Tool Co., Ltd.

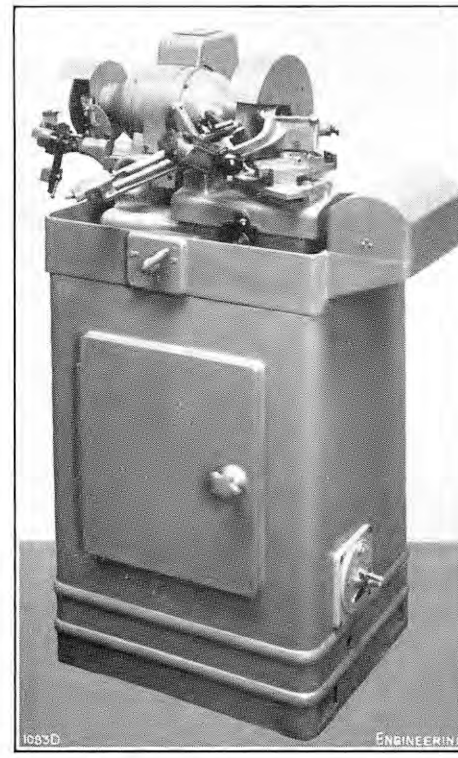


Fig. 90. Twist-Drill Grinding Machine; Motor Gear & Engineering Co. Ltd.

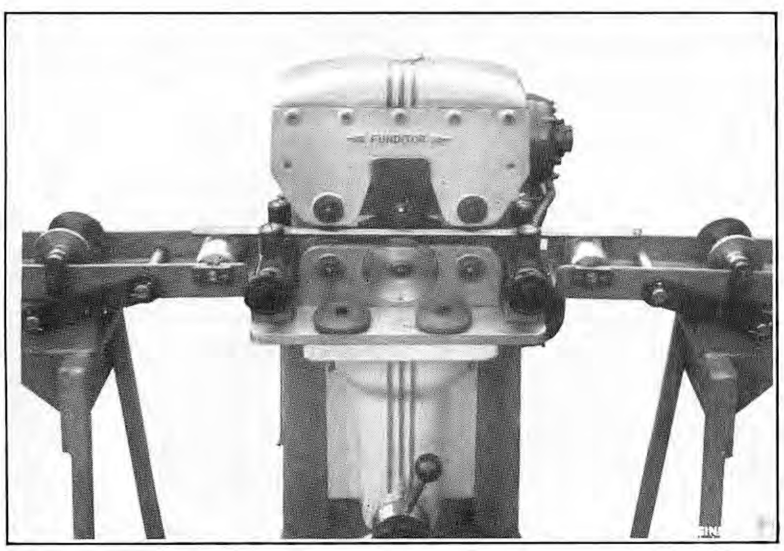


Fig. 91. Pneumatic Bar-Marking Machine; Funditor, Ltd.

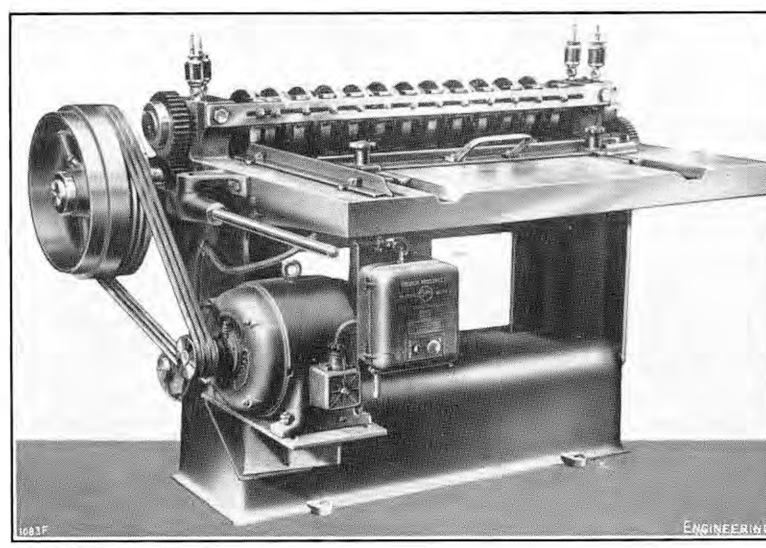


Fig. 92. Gang-Slitting Machine; E. W. Bliss (England), Ltd.

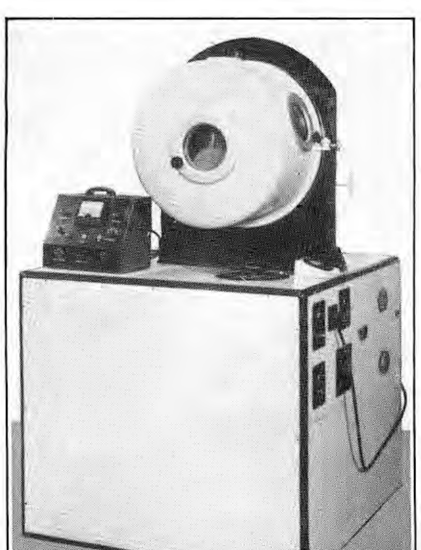


Fig. 93. Vacuum Furnace; Birlec, Ltd.

Fig. 94. "Olsen" Ductility-Testing Machine; Edward G. Herbert, Ltd.

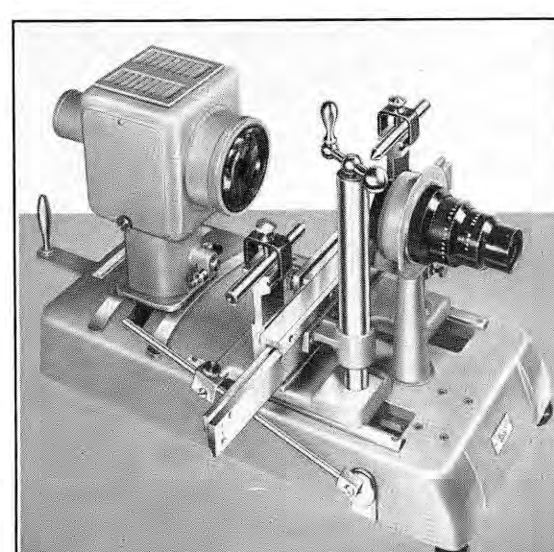


Fig. 95. Optical Projector; J. E. Baty & Co., Ltd.

EXHIBITS AT THE INTERNATIONAL MACHINE TOOL EXHIBITION.

(*For Description, see Page* 433.)

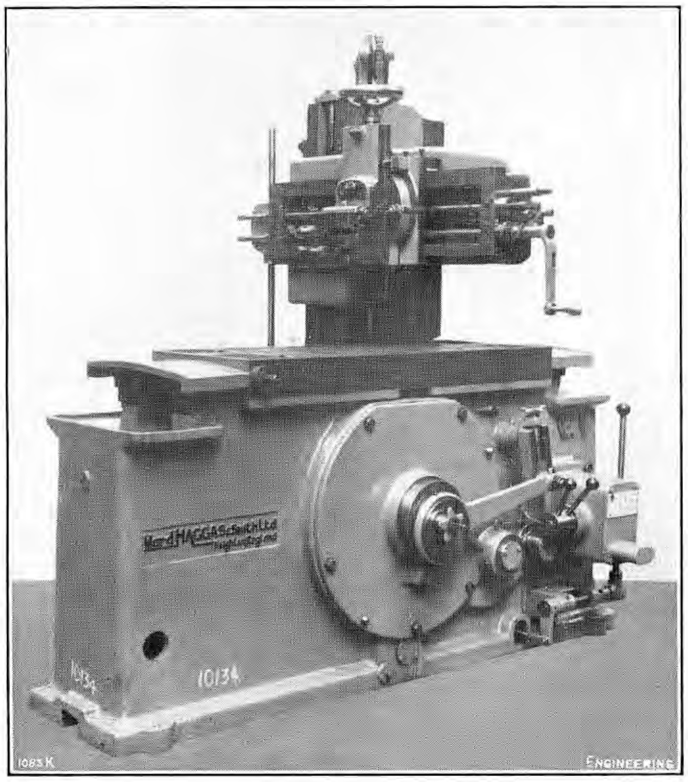


FIG. 96. 24-IN. OPEN-SIDE PLANER-SHAPER; WARD, HAGGAS & SMITH, LTD.

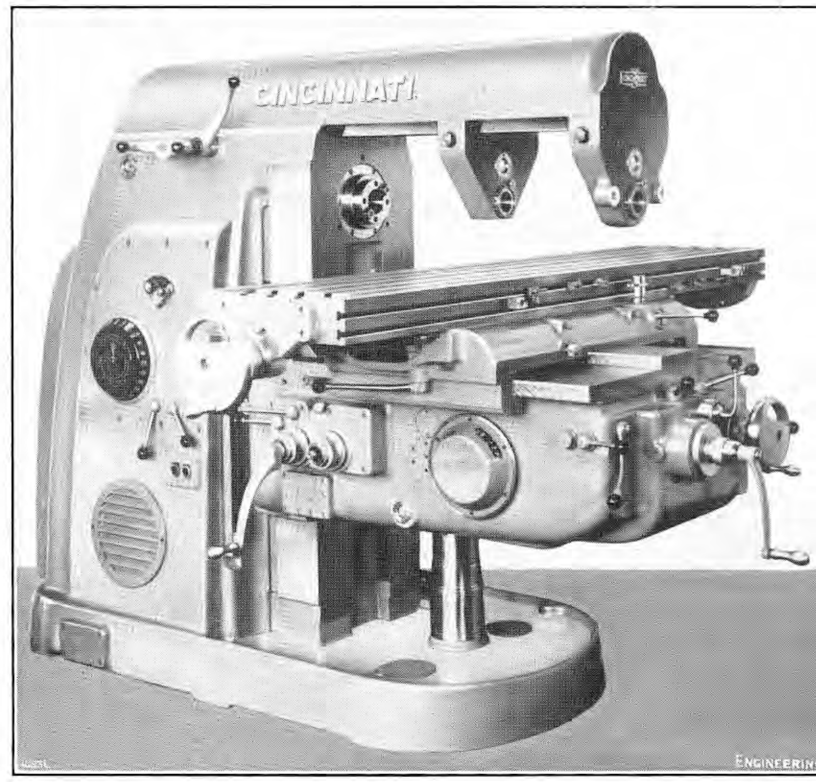


FIG. 97. DUAL-POWER MILLING MACHINE; CINCINNATI MILLING MACHINES, LTD.

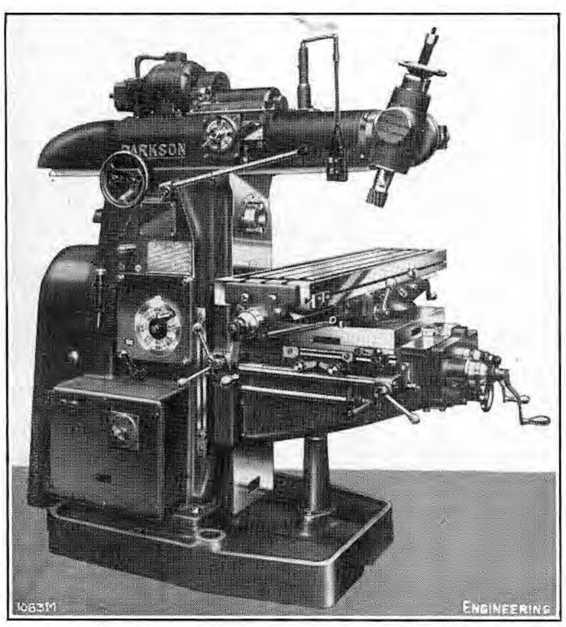


FIG. 98. UNIVERSAL MILLER; J. PARKINSON & SON (SHIPLEY), LTD.

FIG. 99. STAMPING TRIMMER; OLIVER MACHINERY CO., LTD.

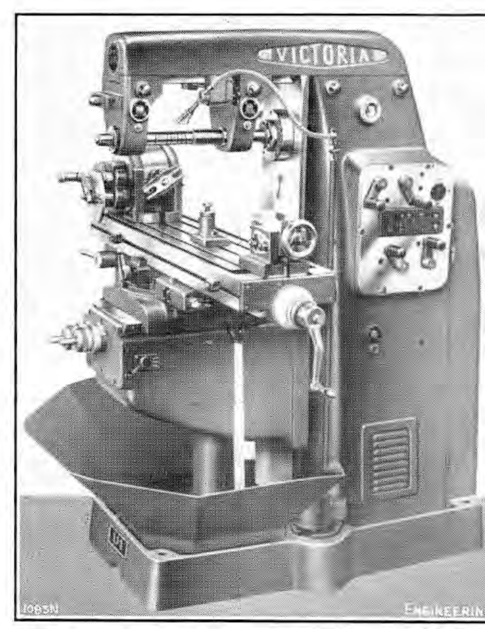


FIG. 100. UNIVERSAL MILLING MACHINE; B ELLIOTT & CO., LTD.

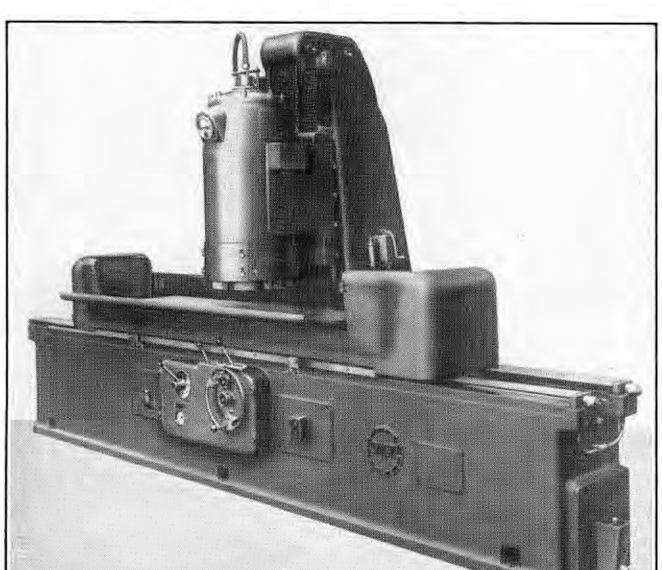


FIG. 101. VERTICAL SURFACE GRINDER; SNOW & CO., LTD.

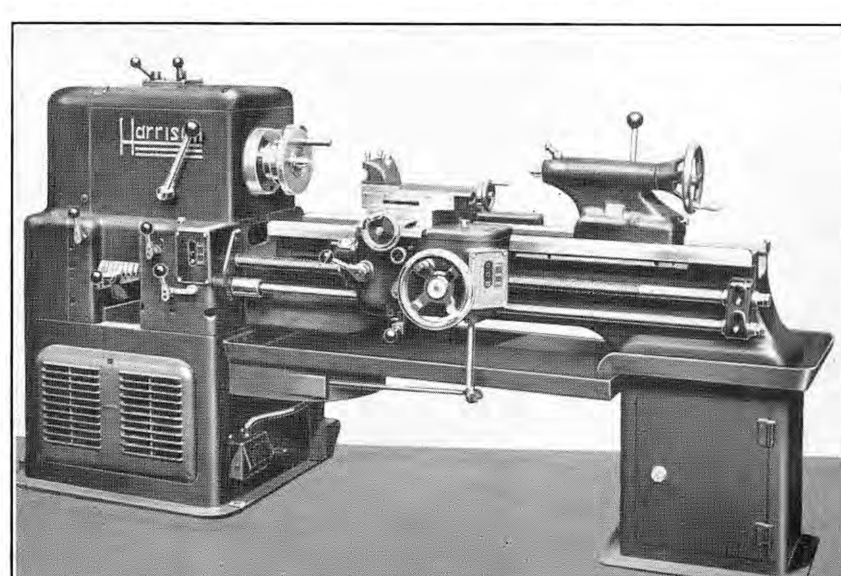


FIG. 102. 14-IN.-SWING CENTRE LATHE; T. S. HARRISON & SONS, LTD.

EXHIBITS AT THE INTERNATIONAL MACHINE TOOL EXHIBITION.

(*For Description, see Page* 433.)

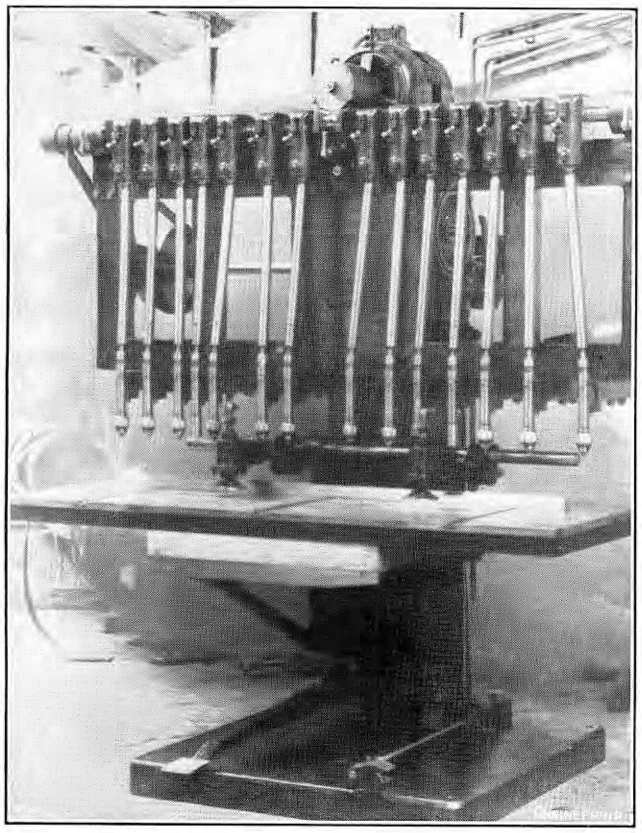


Fig. 103. Multi-Spindle Drilling Machine; W. A. Fell, Ltd.

Fig. 104. 30-kW Induction Heater; Radio Heaters Ltd.

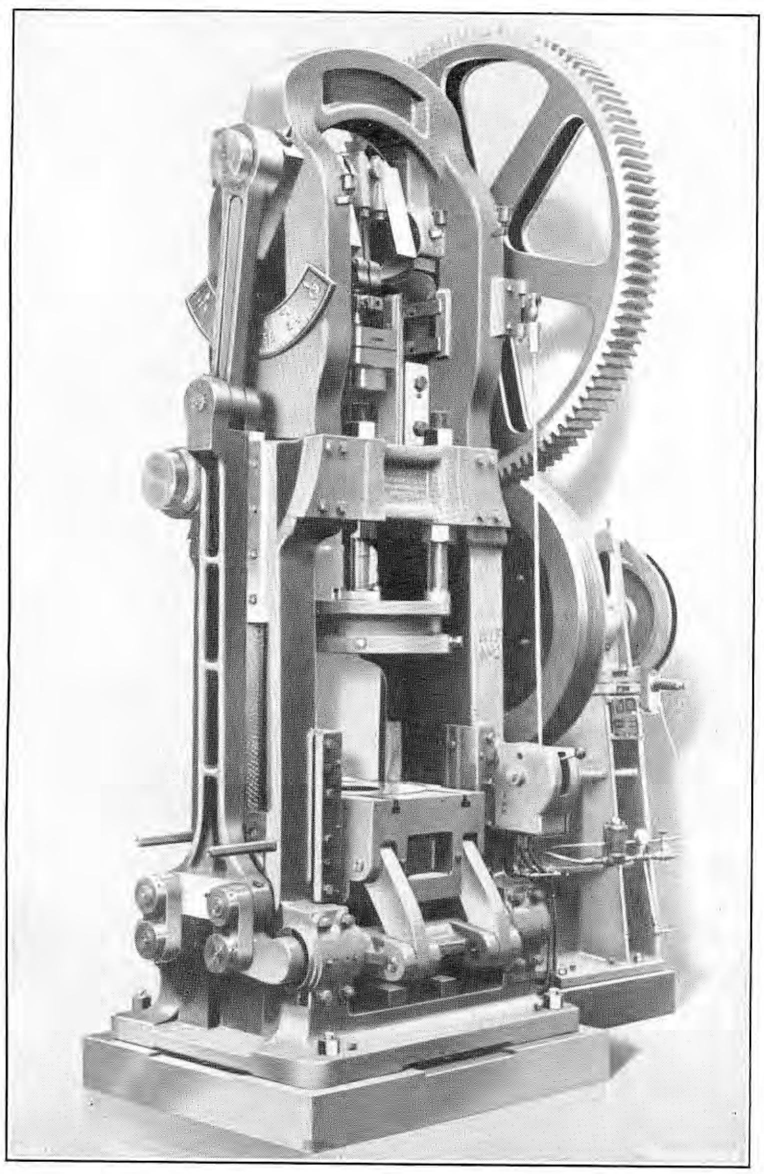


Fig. 105. Rising-Table Press; Hordern, Mason & Edwards, Ltd.

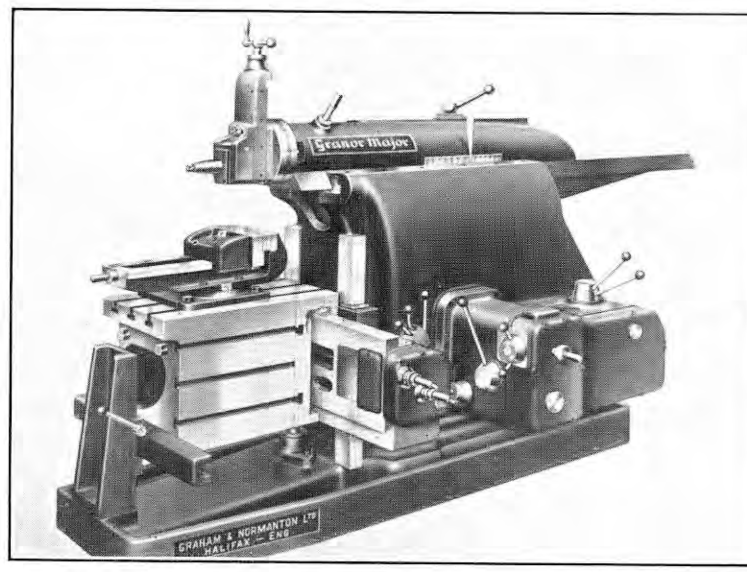


Fig. 106. "Granor" Shaping Machine; Morrison, Marshall & Hill, Ltd.

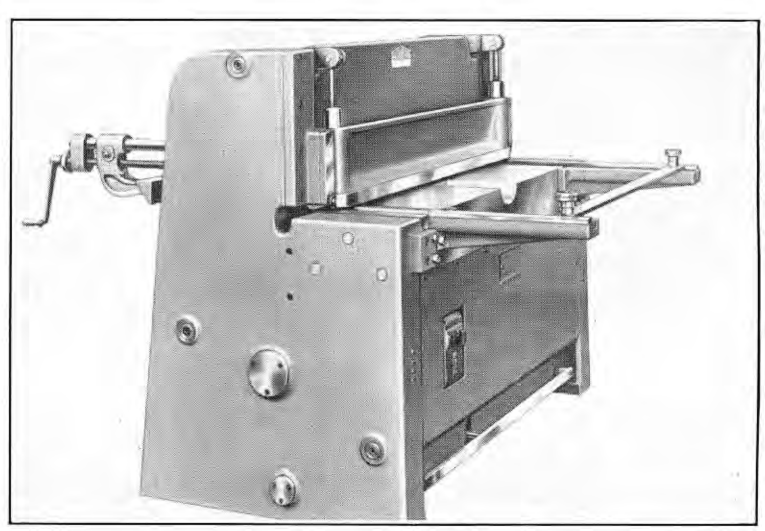


Fig. 107. "Rushworth" Precision Guillotine; Morrison, Marshall & Hill, Ltd.

EXHIBITS AT THE INTERNATIONAL MACHINE TOOL EXHIBITION.

(For Description, see Page 433.)

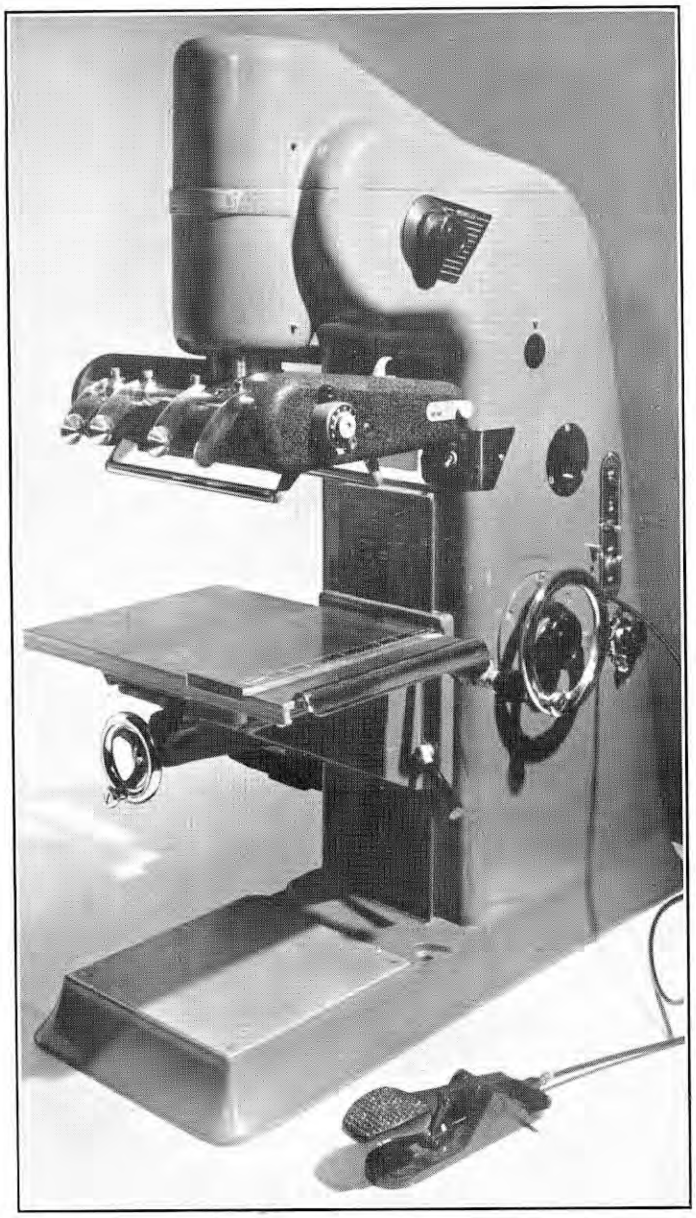


Fig. 108. "Masseeley" Marking Machine; Masson Seeley & Co., Ltd.

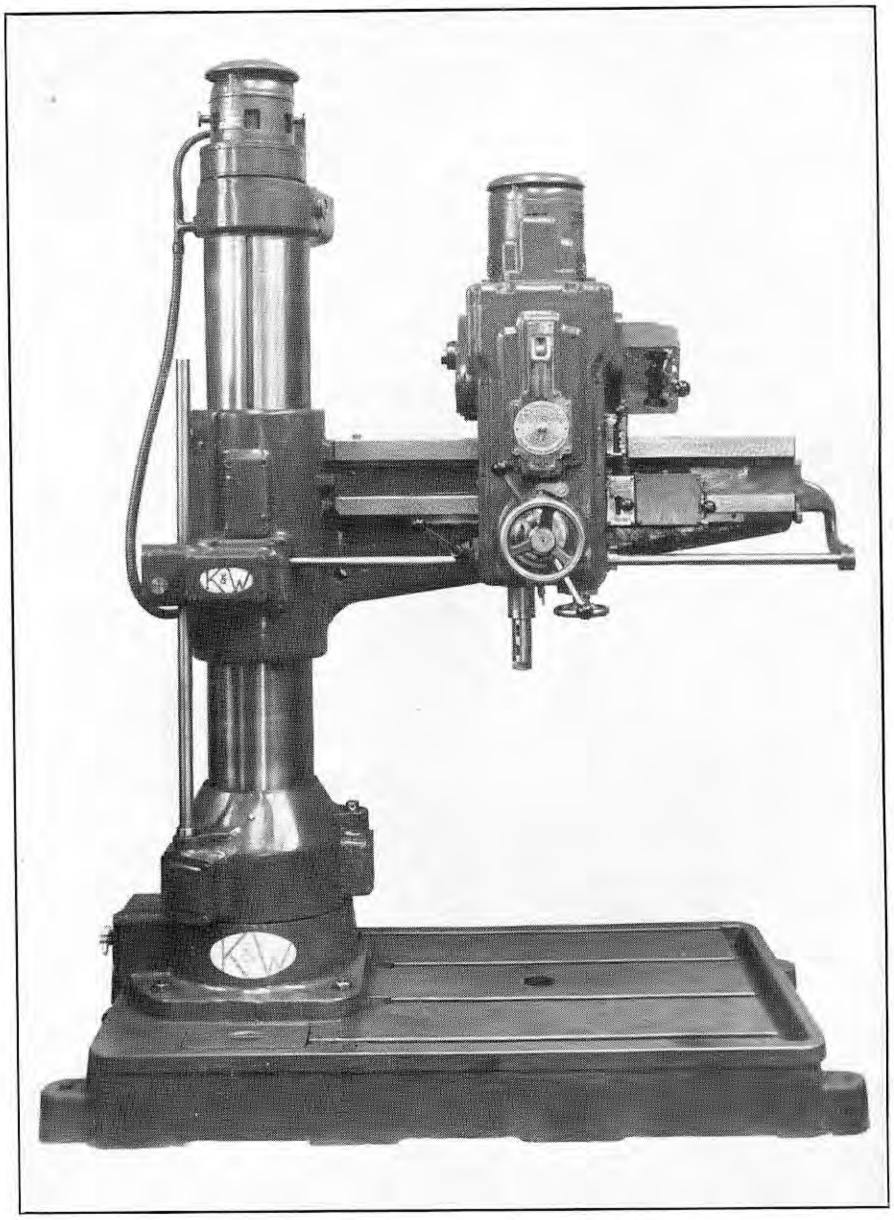


Fig. 109. 3 ft. 6 in. Radial Drilling Machine; Kitchen & Wade, Ltd.

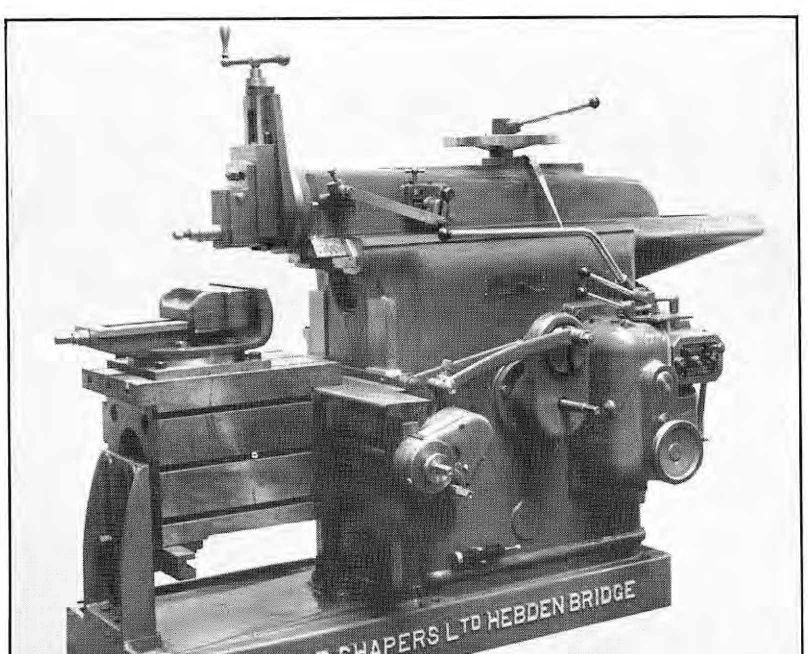


Fig. 110. 12-in. Ormerod Shaper; Kitchen & Wade, Ltd.

Fig. 111. Continuous Plan Printer; E. N. Mason & Sons, Ltd.

(To face page 433.)

When so fitted, it can be used for machining automatically tapers, right-angle and tapered shoulders and multiple diameters on such components as motor shafts, gearbox shafts, etc. It can also be employed for copying operations in the transverse as well as the longitudinal direction, but it is necessary for additional equipment to be fitted before it can be used for the former type of work. The hydraulic copying device can easily be rendered inoperative and the machine used as a normal lathe it being possible to machine the template and subsequently use it for the production of the batch on the same machine. The machine is also useful for producing comparatively small quantities of different components as the template holder is provided with nine stations thus enabling nine different parts to be machined without re-setting.

In general, the design of the lathe follows standard practice. The headstock casing is machined from a high-grade iron casting and the work spindle is supported at the front and rear by special alloy bearings, the latter incorporating means for taking the thrust. The spindle is driven by multiple V belts, the driven pulley being situated at the centre of the shaft and supported by bearings located in the head casting. This pulley, in turn, drives the shaft when in direct drive through an internally-toothed coupling or, when the reduction gearing is in use, through the gears; the spindle, therefore, is not subjected to bending stresses at any time. Sixteen spindle speeds are available ranging from 27 r.p.m. to 1,600 r.p.m. and there are 31 longitudinal and transverse feeds, the longitudinal feeds extending from 0·03 in. to 1·31 in. per revolution and the transverse feeds from 0·02 to 1·11 in. per revolution. The apron is an iron casting and the transmission consists of a worm and worm wheel, the latter being arranged to drive the pinion through spur reduction gearing. There is a special safety device which automatically disengages both the longitudinal and transverse motions at the end of the permissible cutting stroke or when an obstruction is encountered. This safety device can be adjusted according to the type of work in progress and is engaged automatically with both the longitudinal and transverse motions. The height of the centres is $8\frac{11}{16}$ in., the turning diameter over the bed $17\frac{7}{16}$ in. and over the cross slide, $8\frac{1}{2}$ in.

PNEUMATIC BAR-MARKING MACHINE.

A new bar-marking machine capable of marking continuously hexagonal stock up to $1\frac{3}{4}$ in. across the flats or the equivalent in other sections is being shown by Funditor Limited, Woodbridge House, 3, Woodbridge-street, London, E.C.1. This machine, which is shown in Fig. 91, on Plate XXXIII, is intended for the marking of new bar stock along its complete length so as to overcome the problem of identifying parted stock where the ends only are marked. Users receiving bulk supplies from various sources can mark the complete length not only with their symbols, order numbers, etc., but with their analysis symbols. Stock is fed to the machine longitudinally from a feed table the height and length of which can be adjusted to suit requirements. A knurled die, 3 in. in diameter, is situated in the head of the machine and this is driven through a speed-reduction unit by an electric motor, bevel gearing transmitting the drive to the lower knurl. Both the upper and lower dies are easily changed and the stock may be marked either simultaneously on both sides or on one side only. Initial table adjustment is effected by a small handwheel at the front of the machine and it is raised to the operating position pneumatically on depression of a pedal. The stock is drawn from the feed table and directed through the guides by rollers geared to the marking knurls, the design of the guides being such that the stock, whatever the length, is ejected squarely.

TWIST-DRILL GRINDING MACHINE.

The Motor Gear and Engineering Company, Limited, Chadwell Heath, Essex, are showing several tapping machines, a new centreless grinding machine, a tool-room band sawing machine, a selection of gears and universal joints, and the No. 2 twist-drill grinding machine illustrated in Fig. 90, on Plate XXXIII. This machine allows the relief angle of the drill to be ground to the most appropriate angle for the material to be drilled. It is also equipped with a point-thinning attachment, which results in a reduction in the torque and thrust required when drilling. The capacity of the machine is $\frac{1}{4}$-in. to $\frac{3}{4}$-in. diameter, with relief angles up to 20 deg. The design of the machine is based on the conical method of drill-grinding, which has been accepted as the best method of obtaining a relief angle which increases towards the point of the centre of the drill. The machine consists of two parts, the actual drill grinder and the point-thinning attachment. The two grinding wheels are mounted on the spindle of a double-ended motor, the motor being fixed to a V-slide for advancing to the dressing diamond. The sliding table, which carries the drill-grinding assembly, is carried on ball bearings and allows the drill to pass fully across the wheel. On this table is mounted the rocker-arm bracket, which is also capable of being moved angularly to vary the point angle of the drill. Two slides with vernier scales provide for alterations to the relief angle. Attached to the vernier slides are caliper blocks which provide instant setting of the scales when a standard relief angle of 10 deg. is required. The drill is inserted between the blocks, and the slides clamped. This provides for rapid setting when batches of varying-diameter drills have to be ground with standard relief angles. For all other relief angles, the scales must be set visually. The drill is held in position by V-blocks and is fed into the wheel by micrometer feed. The point-thinning attachment is mounted on the left of the machine, and the drill automatically brought into the correct position by means of a patented setting block, the amount of thinning being governed by a fixed stop. A simple nomograph is supplied, and from it various relief-angle settings can be obtained. If a standard relief angle of 10 deg. is required, then the setting becomes identical to the diameter of the drill, and there is no need to consult the graph.

GANG SLITTING MACHINE.

Representative examples from their range of inclinable power presses, high-production presses and gang-slitting machines are being shown by E. W. Bliss (England), Limited, City-road, Derby. One of the gang-slitting machines, namely, their model 225A, is illustrated in Fig. 92, on Plate XXXIII. This machine is designed to slit tinplate sheets up to a maximum thickness of 0·025 in. into narrow strips, and is used extensively by tin-box manufacturers. It may also be used for precision cutting of lithographed tin-plate sheets and, if necessary, for trimming the edges only. It is easily reset to cut different widths and, as a consequence, is particularly suitable for use where batches of different size strips are required. The frame of the machine is constructed from fabricated-steel and the cast-iron hubs and hardened-steel cutters are mounted on shafts having fixed centres. Large-diameter shafts are used to minimise deflection and to ensure accuracy of cutting, they are provided with thrust bearings. Normally, these machines are equipped with a hand-operated friction clutch and can be provided with a plain driving pulley for flat-belt drives from line shafting, but they can be arranged for direct drive from an electric motor, as shown in the illustration. The material is fed to the cutters by hand or by a hand-operated back gauge sliding in V-grooves on the main table, a fixed side gauge, adjustable within limits, permitting the operator to offer successive sheets in constant relation to the cutters. Automatic operation of the back gauge can be arranged, however, by equipping it with a reciprocating motion to start the sheets of tinplate into the cutters and feed-out rolls. For long sheets, the machine can be furnished with extension arms and a side gauge which extends the full length of the arms; the clutch is then controlled by an extension handle. A flexing attachment can be installed which cold-works the blanks as they emerge from the feed-out rolls, this action causing the blanks to be strain hardened slightly so that, when they are formed into cylindrical bodies, they will not bend too easily and thus form flats. The machine illustrated will trim sheets up to 36 in. in width, the minimum distance between cuts varying according to the type of cutter used and the finish required. With adjustable cutters having standard hubs, for example, and the burrs pointing in the same direction, the minimum cut is 3 in., but with burrs up and down, this figure can be reduced to $2\frac{1}{2}$ in.

VACUUM FURNACE.

Industrial furnaces are playing an increasingly important part in the machine-tool industry, a fact well emphasised by the display on the stand of Birlec Limited, Tyburn-road, Erdington, Birmingham, 24, who are showing a 20-kW shaker-hearth-furnace, a high-frequency induction gear-hardening machine, a Lectrodryer, a spark-gap converter and an endothermic atmosphere generator. They, are also showing, in co-operation with British American Research, Limited, the vacuum melting unit illustrated in Fig. 93, on Plate XXXIII, which is on view for the first time. It is a laboratory type vacuum furnace for heat treatment and melting applications and temperatures up to 2,000 deg. C., and vacua down to 1 micron, or less, can be obtained. It has been designed for universal work such as melting, degassing metals, heat treatment and sintering and in all probability will be used mainly in fundamental and applied research work. The equipment is contained in a metal cabinet which accommodates the vacuum-pumping system and gauges on top of which is the furnace contained in a vacuum enclosure. The furnace is heated by a molybdenum or tungsten element wound round the crucible, the whole being surrounded by a stainless-steel sleeve. Crucibles up to a capacity of 19 cub. in., that is, 6 in. by 2 in. in diameter, can be accommodated and if half filled, this size of crucible contains between 3 and 4 lb. of steel, well within the melting capacity of the unit. The vacuum system consists of a new Bar-type H4P oil-diffusion pump aided by a Kinney mechanical roughing pump, suitable gauges being provided to determine the exceptionally high degree of vacua obtained. Heat treatment and melting operations are controlled from the outside of the unit and when melting, for example, it is possible to add to the melt, stir it and pour it under a vacuum or controlled-atmosphere conditions.

"OLSEN" DUCTILITY-TESTING MACHINE.

Messrs. Edward G. Herbert, Limited, Atlas Works, Levenshulme, Manchester, 19, are exhibiting several sawing machines, a jig sawing and filing machine, and an automatic saw-blade sharpening machine, all of their own manufacture, as well as some machines which they make under licence from the Tinius Olsen Testing Machine Company, U.S.A. The latter include two Brinell hardness-testing machines, a 60,000-lb. hydraulic universal testing machine, a torsion-testing machine, an impact-testing machine, and the ductility-testing machine shown in Fig. 94, on Plate XXXIII.

This machine is one of a range of motor-driven ductility-testing machines with capacities from 12,000 lb. to 60,000 lb. Hand-operated machines range from 2,000 lb. to 12,000 lb. They are used for testing sheet metal. The sheet is clamped between a set of dies and a steel ball is forced through the dies to form a cup. The depth of the cup, up to the point of rupture, is a measure of the ductility of the material. A load-indicating mechanism on the machine allows the operator to observe the point at which the load falls off, i.e., at, or slightly before, the point of rupture. The depth of cup is then read by means of a dial indicator which is graduated in 0·001 in.

OPTICAL PROJECTOR.

A selection from their new range of dial gauges is included in the exhibits on the stand of J. E. Baty and Company, Limited, 39, Victoria-street, London. These instruments have unit movements to give easier assembly and overhaul procedures and the pinions, racks and all other steel parts are made from stainless steel. All types and styles are available from $1\frac{1}{8}$ in. diameter to $4\frac{7}{16}$ in. diameter and there is a wide choice of readings and graduations. This firm are also showing a range of small-bore and cylinder gauges, dial micrometers and dial comparators and two sizes of their Westminster projectors. One of the projectors, namely, the Westminster No. 2, is illustrated in Fig. 95, on Plate XXXIII. This projector can be supplied with a choice of lenses and magnifications of up to 100 ×

can be obtained. It is provided with a remote-control focusing device consisting of a small reversible electric motor arranged to move the focusing slide through suitable reduction gearing. The motor is incorporated in the base of the projector and is controlled remotely by a turn-button switch connected to sufficient length of cable to permit operation at the maximum distance from the projector to the screen. By this means it is possible for the operator to obtain accurate focusing without moving from the screen. A laminated-wooden screen is used and this supported from the wall by brackets, the fixing being designed so that the screen can be moved transversely and through a small angle. The cross slide of the projector is mounted on balls to give a sensitive movement and a micrometer head is available for fitting to the cross slide so that, when required, the transverse movement can be measured accurately.

24-In. Open-Side Planer-Shaper.

Messrs. Ward, Haggas and Smith, Limited, Eastwood Works, Keighley, are showing a 6½-in. centre lathe, an 8½-in. centre lathe, a 5-ft. swing surfacing and boring lathe, and two open-sided planer-shapers, a 36-in. model and a 24-in. model, of which the latter is illustrated in Fig. 96, on Plate XXXIV.

This machine has a table stroke of 24 in., a horizontal tool travel of 22 in., a table 46 in. by 18 in., and a maximum distance, between the table and the cross-rail, of 17 in. The table strokes per minute are 8, 12, 20, 28, 44 and 70. The machine is designed to incorporate the most valuable features of both a planing machine and a shaping machine. The table is carefully fitted to the V-ways in the bed, and any tendency to lift is obviated by gibs underneath. The crank motion is of heavy design and gives a quick return to the table. Cut and return strokes can be set to a mark. The head is of the standard swivelling type, with accurately-scraped bearing surfaces. It is graduated and provided with adjustable gibs. Hand and power cross and vertical feed are provided in each direction. All feed screws have micrometer dials mounted on them.

Dual-Power Milling Machine.

The machinery being shown by Cincinnati Milling Machines, Limited, Woodlands Farm-road, Tyburn, Birmingham, comprises four toolroom and general purpose millers, three profiling and die-sinking machines, a broaching machine, two cutter sharpeners, a universal grinder and a centreless grinder. One of the milling machines, namely, their No. 5 dual-power machine, is illustrated in Fig. 97, on Plate XXXIV. This unit, which is being shown for the first time in this country, is of the knee and column type and is designed for taking exceptionally-heavy cuts on large components. It is fitted with a 50-h.p. motor, the full power being used when the spindle operates at high speeds. The power, however, is automatically reduced to approximately a half for the six lowest machine speeds. There are 24 spindle speeds and 32 feeds, the spindle speeds ranging from 14 r.p.m. to 1,400 r.p.m. and the feeds in geometrical progression from ½ in. per minute to 60 in. per minute. Synchromesh mechanisms are incorporated in the gearbox and the speed changes are made hydraulically. The over-arm is of heavy rectangular construction and a built-in vibration damper enables high feed rates to be used and, at the same time, reduces the need for braces. The vertical and cross screws and all rotating shafts are completely enclosed to protect them from damage, and at the same time to give added safety to the operator. The vertical screw is automatically lubricated from a bath of oil. The table has a working surface of 94½ in. by 20 in. and a longitudinal travel of 50 in.; the cross travel is 14 in. and the rise and fall 20 in. There are rapid-traverse speeds for all three movements of the table, the longitudinal and traverse movements operating at 150 in. per minute and the vertical movement at 37½ in. per minute. The distance between the underside of the over-arm and the centre line of the arbor is 8⅛ in. and the maximum distance from the spindle to the top of the table, 20 in.

Universal Miller.

Messrs. J. Parkinson and Son (Shipley), Limited, Shipley, are showing a number of milling machines and attachments, Sunderland gear-planers, and a Parkson gear tester for spur, bevel and worm gears. The milling machines include that illustrated in Fig. 98, on Plate XXXIV, which is a No. 3 NU machine with an independently motor-driven universal milling head on a special over-arm.

This attachment swivels through 360 deg. on two axes at right-angles, so that the spindle may be presented at any angle. It provides 16 spindle speeds ranging from 44 to 1,800 r.p.m. The over-arm can be used in the usual way if required. The spindle runs on taper-roller bearings and has a 3-in. axial movement which provides for fine adjustment and for drilling at any angle.

Stamping Trimmer.

The machines shown by the Oliver Machinery Company, Limited, 196, Deansgate, Manchester, 3, include several on view for the first time, in particular the stamping trimmer illustrated in Fig. 99, on Plate XXXIV, a high-speed flanging machine, a universal box and pan bending brake, and a ring-bending machine. The stamping trimmer is used for trimming flash from pressings and stampings and avoids the need for expensive trimming dies. Two vertical spindles project above the table top, one holding a stamping over the inside cutter, while the other, movable, spindle carries the outside cutter. A pedal valve opens and closes the spindles pneumatically. When the spindles are brought together, the cutters trim the pressings smoothly, quickly and to precision limits. The standard diameter of spindle is 1⅞ in., giving the minimum corner radius handled, though special spindles can be provided for corner radii down to ⅜ in. The machine can also be used for beading and forming the pressings.

Universal Milling Machine

An exceptionally wide range of machine tools, including milling machines, drilling machines, grinders, filing and sawing machines, shapers and sheet-metal machinery, is being shown by B. Elliott and Company, Limited, Victoria Works, Willesden, London, N.W.10. One of the milling machines on view is illustrated in Fig. 100, on Plate XXXIV; this is known as the Victoria Model U1 universal machine and is manufactured by the Victoria Machine Tool Company, Limited, of whom B. Elliott and Company, Limited, are the proprietors and act as world distributors. The U1 machine has a table measuring 40 in. by 11 in. with a longitudinal traverse of 25 in., a transverse feed of 8½ in. and a vertical feed of 16 in. A power feed is provided for the longitudinal movement, the number of feeds available being 18 and the feed range from ½ in. to 16½ in. Twelve spindle speeds are available ranging from 30 r.p.m. to 1,010 r.p.m. The spindle is supported in twin Timken taper-roller bearings at the front and a parallel-roller bearing at the rear. The over-arm is of box section heavily ribbed and has a ground slide on which are located two arbor supports, additional support being provided by a double-brace strut. Feed stops are provided and in addition to the power feed there are two rates of hand feed. The machine is driven by a self-contained electric motor mounted in the base, the drive being transmitted to the gearbox through multiple V belts. Stepped pulleys acting in conjunction with a six-speed gearbox give the twelve different spindle speeds. The gears are cut from nickel-chrome-molybdenum steel, sliding gears are fitted to hardened and ground shafts and all shafts are supported by ball or roller bearings.

Vertical Surface Grinder.

A precision tool-room surface grinder, a heavy-duty precision surface grinder and the VB 18 vertical surface grinder illustrated in Fig. 101, on Plate XXXIV, are being exhibited by Messrs. Snow and Company, Limited, Stanley-street, Sheffield, 3.

The vertical surface grinder shown in the illustration has a working capacity of 72 in. by 15 in. The bed is of such a length as to eliminate overhang of the work-table at extreme positions of travel. The slideways are protected by stationary belts running the full length of the bed and passing through the shears of the work-table. The hydraulic valve control unit, motor-driven vane pump, oil tank and slideway lubricating tank are mounted in the bed. The table speeds are steplessly variable from 5 ft. to 80 ft. per minute and any predetermined slow speed for finish grinding is instantly obtained by the vernier adjustments on the table control lever. There is also a "load" position on the table control lever to enable the table to be run out to the limit of travel, clear of the wheel-head, for loading and unloading the work. The column carrying the wheel-head is adjustable in all directions for correcting alignment with the work-table. A 30-h.p. motor is incorporated in the wheel-head. The grinding wheel, of the "outside" segment type, is 18 in. in diameter, so the whole of the table surface is covered at each traverse. The segments are secured by bronze wedges and the wheel is enclosed by a heavy forged steel hood.

The vertical feed is applied automatically or by hand. A micrometer dial device enables settings to be made rapidly to 0·0005 in. The maximum height from table to grinding wheel is 18 in. Power elevation is also provided to the wheel-head. This range of surface grinders is available with capacities from 32 in. by 10 in. by 12 in. to 72 in. by 15 in. by 18 in.

14-In. Swing Centre Lathe.

The centre lathes being shown by T. S. Harrison and Sons, Limited, Union-street, Heckmondwike, Yorkshire, include the 7-in. centre, 14-in. swing machine illustrated in Fig. 102, on Plate XXXIV. An interesting point in the design of this lathe is the absence of a clutch, the motor being stopped and started by push-buttons on the headstock and saddle. The standard machine is fitted with a 3-h.p. motor operating at 1,000 r.p.m., but a 2-h.p. motor running at 750 r.p.m. or a 5-h.p. motor running at 1,500 r.p.m. can be supplied as alternatives. There are 12 spindle speeds, the actual speeds available depending on the size of motor fitted. With the standard 3-h.p. motor the range extends from 20 r.p.m. to 400 r.p.m., with the 2-h.p. motor, from 15 r.p.m. to 300 r.p.m., and with the 5-h.p. motor, from 30 r.p.m. to 600 r.p.m. A two-speed motor is also available, and when this is installed the number of spindle speeds is, of course, increased to 24 and the actual speeds available extended to a maximum of 1,000 r.p.m. The bed of the machine is of the double inverted-V type and it is assembled with a removable gap piece for accommodating work with a larger swing, the actual swing available with the gap in use being 24 in. with a width in front of the faceplate of 8¾ in. Normally, the swing over the bed is 14 in. and over the saddle, 9⅝ in. The bed is machined from an iron casting and alternative lengths capable of admitting 3 ft., 4 ft., 5 ft. and 6 ft. between centres are available. The spindle is supported by Timken opposed taper-roller bearings and is bored to pass bar stock up to a maximum diameter of 2 in. An electrically-operated brake is fitted to the spindle and this operates in conjunction with the contactor gear, automatically bringing the spindle to rest when the contactors are opened. Screwcutting and surfacing motions are obtained through a Norton-type gearbox; this is designed to give 32 different threads with pitches of from 4 to 56 threads per inch, sliding feeds from 0·05 in. to 0·0035 in. per revolution and surfacing feeds of from 0·0385 in. to 0·0025 in. per revolution.

Multiple-Spindle Drilling Machine.

The woodworking machinery being shown by W. A. Fell, Limited, Bridge Iron Works, Windermere, includes a 6-ft. multiple drilling machine, a 24-in. variety turning machine, a hand-turner's lathe and a small automatic dowel-turning machine. The 6-ft. multiple drilling machine is illustrated in Fig. 103, on Plate XXXV; it has been designed for drilling holes in wood where exact duplicates are required but where the layout is constantly changing. It will bore holes from ¼ in. diameter to 1 in. diameter and although 14 spindles are shown in the illustration, more can be fitted if required, the limiting factor being the length of the machine. Each spindle consists of an upper driving head, a lower boring head which carries the drill and a telescopic shaft with two universal joints. The standard size of universal joint is 1 in.; thus the minimum distance between the holes is limited to $1\frac{1}{16}$ in. but other sizes of joint, namely, $\frac{3}{4}$ in., $\frac{7}{8}$ in., 1 in., $1\frac{1}{4}$ in. and $1\frac{1}{2}$ in. are available, the closest distance between the spindles in each case being the diameter plus $\frac{1}{16}$ in. Where closer centres are required the makers are able to supply single heads with clusters of two, three or more spindles. The work table is advanced to the drills automatically by a worm and worm-wheel assembly and two rates of feed are available, namely, 20 in. and 40 in. per minute. The feed is put into action by depressing a pedal and it is automatically tripped at the required height, the table returning to the starting position under its own weight. The machine is built in four lengths, namely, 3 ft., 4 ft., 5 ft., and 6 ft. and the maximum number of spindles is 10, 14, 17 and 21, respectively. When in the lowest position, the distance from the spindle nose to the table is 14 in. while the distance from the centre line of the boring area to the side of the table is 15 in.

30-KW INDUCTION HEATER.

Messrs. Radio Heaters, Limited, Eastheath-avenue, Wokingham, Berkshire, are displaying induction heating equipment, including a 1-kW unit and the new 30-kW Radyne unit shown in Fig. 104, on Plate XXXV. This equipment has many interesting features. By employing a single air-blast cooled oscillator valve, the need for a costly water re-circulation unit is avoided. The high-frequency output from the equipment is continuously variable from low to full power by means of a control wheel on the front panel. As the variable output is obtained by varying the coupling between the primary and secondary of the high-frequency output transformer, correct matching between the oscillator valve and the load being heated is obtained under all conditions. Moreover, as an isolated and earthed high-frequency output circuit is employed, the equipment can be coupled directly to the majority of industrial loads. The unit is provided with an unusually large tank condenser (over 2,000 kVA) which ensures that it is possible satisfactorily to load the equipment under all conditions. The equipment is provided with two process timers, one of which controls the duration of the heating cycle, while the other controls the duration of the water quench cycle, if one is being employed. Provision is made for switching the process timers out of circuit if required. The unit is constructed on a heavy steel base frame, and the whole of the upper frame and panelling are made from hard aluminium. The construction of the upper frame from light alloy was essential in view of the unusually high circulating current around the tank coil inside the equipment.

DOUBLE-ACTION DRAWING PRESS.

The press illustrated in Fig. 105, on Plate XXXV, which is being shown by the manufacturers, Messrs. Hordern, Mason and Edwards, Limited, Pype Hayes, Birmingham, is capable of producing drawn articles in most materials up to a depth of 10 in.; it is particularly suitable, therefore, for use in the motor, electrical and hollow-ware industries. The diameter of the maximum circular blank admitted is 26 in., and when working to this maximum the press will deal with steel plate up to a thickness of 16 s.w.g. To facilitate extraction and reloading, the table descends clear of the pressed article, ejection of the work being effected by the downward movement of the table. The ejector is readily removed, however, when drawing through the die is necessary. The table is raised by steel toggles which take the vertical thrust while the blank is being drawn, end play in the toggle mechanism being taken up by the weight of the table and die. The blank holder remains stationary while the punch and table move in opposite directions, thus giving a balanced motion, but by removing the blank holder the machine can be used as a single-action press in which case full advantage can be taken of the combined movement of table and slide to give a stroke of $23\frac{3}{4}$ in. An electric motor of 17·5 h.p. operating at 1,350 r.p.m., is used to drive the press. The motor is mounted on an adjustable bracket pivoted to the outside pedestal and transmits the drive by roller-bearing flywheel through a pneumatic clutch, the operator controlling the machine by means of a light lever installed on the right-hand frame member. The maximum pressure developed at bottom of the stroke is 115 tons and the pressure available 4 in. from bottom of the stroke is 40 tons. The total stroke of the ram is $14\frac{3}{4}$ in. and its adjustment $3\frac{1}{2}$ in., while the total stroke of the table is $10\frac{13}{16}$ in. With the table up and the ram down, the distance between them is $18\frac{3}{4}$ in., and the distance between the table and ram slideways, $26\frac{1}{2}$ in.

"GRANOR" SHAPING MACHINE.

Messrs. Morrison, Marshall and Hill, Limited, 44-45, Tower-hill, London, E.C.3, are exhibiting on a stand which they share with their other principals—Messrs. D. Mitchell and Company, Limited, Keighley; Messrs. Rushworth and Company (Sowerby Bridge), Limited, Sowerby Bridge; and Messrs. Graham and Normanton, Limited, Halifax. The exhibits include the two illustrated in Figs. 106 and 107, on Plate XXXV, and described below, as well as a Rushworth guillotine and press brake, and several Mitchell lathes.

The 26-in. Granor Major shaping machine is an up-to-date machine. The drive is by a 10-h.p. motor, through V-belts and a multi-disc friction clutch. The machine has a table of box section, with T-slots in the top and both vertical faces; it is detachable from its apron, which also has T-slots provided to allow large or bulky castings to be bolted to the apron face. The table is traversed vertically and horizontally mechanically, giving eight variations of feed per ram stroke—horizontally from 0·010 in. to 0·160 in. and vertically from 0·004 in. to 0·063 in. The feeds are adjustable while the machine is in motion. The tool-head is of solid design and is arranged to swivel through an arc of 45 deg. each side of zero. The tool-head can be raised or lowered either by automatic mechanical feed or by hand feed as required. Rapid power traverse is provided and lubrication is either forced or by the single shot method. The swivel and tilting table is arranged to swivel through 90 deg. each side of the vertical, and is arranged to tilt at any angle from 0 deg. to 15 deg., and can be locked at any angle or position.

"RUSHWORTH" PRECISION GUILLOTINE.

The other machine described here which is being shown by Messrs. Morrison, Marshall and Hill, Limited, is the Rushworth precision guillotine, illustrated in Fig. 107, on Plate XXXV. These worm-geared guillotines are the latest addition to the Rushworth range of sheet-metal machinery. They have been designed to meet modern needs and great care has been taken to include the fundamental points which are most called for, i.e., performance, safety and appearance. The machines are capable of giving continuous service even under the most arduous conditions. The rigidity of the frame, coupled with low shearing angle, permits the precision shearing of strips, a matter of great importance to most users. Worm-geared guillotines are silent in operation and without any vibration—a great help to the operator to maintain output. The safety factors on these worm-geared guillotines are exceptionally high for machines of this type. All rotating parts are housed in the body of the machine. External springs for balancing the ram, and for cramping pressure, work in totally-enclosed housings. The treadle bar is situated in a recess under the bed and cannot be operated by any falling body. The guillotine is fitted with a non-repeat device which is foolproof, and on no account will the ram make two strokes unless the operator depresses the treadle twice at the exact timing of the stroke sequence. The capacities available are 4 ft. by $\frac{1}{8}$ in., 6 ft. by $\frac{1}{8}$ in. and 8 ft. by $\frac{1}{8}$ in. in mild steel.

"MASSEELEY" MARKING MACHINE.

Messrs. Masson Seeley and Company, Limited, 14, Howick-place, London, S.W.1, are showing a range of marking machines. The latest, the Model 41, has been specially designed for high production speeds, and is recommended for marking metal or plastic articles, nameplates, instruction plates, instrument dials and other calibrated gauges, textile products such as hosiery, ribbon or tape for clothing labels, cardboard boxes, transfers, wood, leather, rubber, etc.

In fact, articles of practically any material, varying from paper thickness to 17 in. in height, may be marked, and the marking may be single or multi-colour. The machine is shown in Fig. 108, on Plate XXXVI. The marking operation is a simple one of controlled heat and pressure, the machine functioning through the medium of an electrically-heated top platen and/or dies, and dry pigmented foil. It is controlled by pedal for individual markings, and by the twist of a knob becomes fully automatic and capable of producing up to 5,000 impressions per hour. Heating is thermostatically controlled, and pressure is readily adjustable to fine limits over a wide range. Where variation of lettering or part marking is required during a run, automatically interchangeable dies are supplied, to obviate the handling of type for each change. Where the job requires movable jigs and fixtures, these can be pneumatically controlled.

3-FT. 6-IN. RADIAL DRILLING MACHINE.

Messrs. Kitchen and Wade, Limited, Arundel-street, Halifax, are showing four radial drilling machines, though they make a large range of drilling, boring, tapping machines, multi-spindle machines, etc. The 3-ft. 6-in. radial drilling machine shown in Fig. 109, on Plate XXXVI, is described below. The firm's associate company, Messrs. Ormerod Shapers, Limited, Hebden Bridge, are displaying a 12-in. shaping machine and an 8-in. slotter, the former of which is also described below. A new universal attachment for tapping, drilling, studding, etc., made by the Caledonian Tractor and Equipment Company, Limited, 1, Rigby-street, Glasgow, E.1, is being demonstrated on Messrs. Kitchen and Wade's stand. The reduction of unproductive handling time with this attachment is stated to be at least 50 per cent.

The 3-ft. 6-in. radial drilling machine has a $10\frac{1}{2}$-in. length of feed and provides eight spindle speeds, from 1,500 to 80 r.p.m., from 1,000 to 53 r.p.m., or from 750 to 40 r.p.m. The four rates of power feed are from 77 to 220 cuts per inch. The machine is fitted with a combined locking motion to the saddle and arm, and power elevation of the arm is provided by a separate motor. The saddle has centralised control, and has nickel-chromium change gears. An automatic tapping reverse can be provided.

12-IN SHAPER.

The 12-in. Ormerod shaper mentioned above is illustrated in Fig. 110, on Plate XXXVI. It is one of a range of such machines with strokes from 10 in. to 32 in. A universal table and a swivelling table are among the extra equipment that can be provided. The drive from the motor is transmitted through an expanding-ring clutch housed in the column, and a brake is provided for stopping or inching the ram. The gearbox provides nine speeds to the ram, from 13 to 130 strokes per minute. The main driving gear has generated helical teeth.

CONTINUOUS PLAN PRINTER.

The mercury reproduction unit illustrated in Fig. 111, on Plate XXXVI, is one of a number of equipments being shown by Messrs. E. N. Mason and Sons, Limited, Colchester. It is a new combined photo-printing and developing machine for producing dyeline prints in one continuous operation. The choice of light source consists of nine mercury-vapour lamps or one 3,200 quartz tube and, also, the machine is available with automatic or manually-controlled speeds. The developing unit is totally enclosed but is easily removable for occasional maintenance. The tank holds 10 pints of liquid developer and is fitted with a special device which gives warning to the operator when the tank is becoming empty. Prints, fully developed, are delivered dry into the back tray and tracings fall into the front tray. Sensitised material may be used in roll form or in pre-cut sheets. The light-tight compartment under the feed table holds one large roll of sensitised material. For small prints, cut sheets of material can be stacked in the top tray ready for use and well within the reach of the operator. The machine is designed for fast, large-scale output of dyeline prints.

(*To be continued.*)

EXHIBITS AT THE COMMERCIAL MOTOR SHOW.

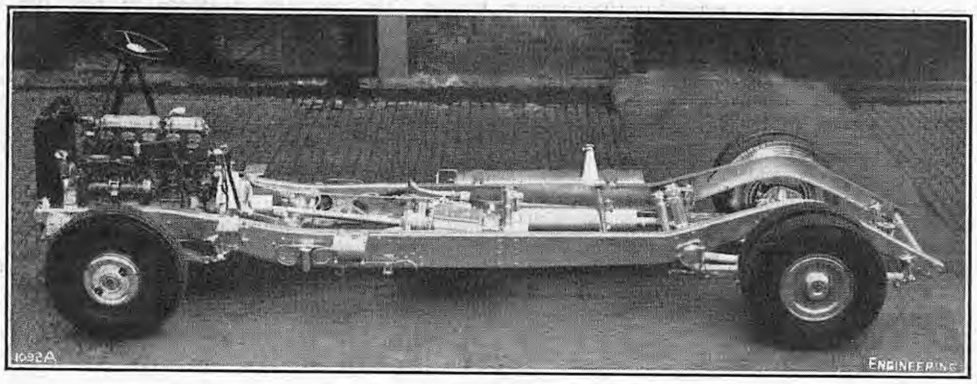


FIG. 5. LIGHTWEIGHT CHASSIS; TRANSPORT VEHICLES (DAIMLER), LTD.

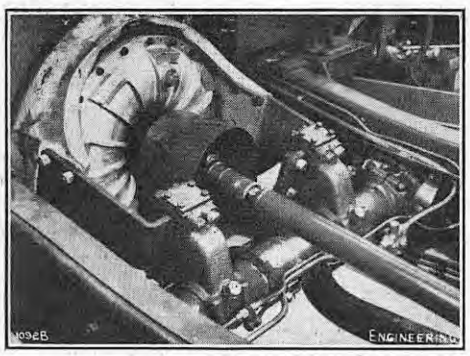


FIG. 6. ENGINE BEARERS; DAIMLER LIGHTWEIGHT CHASSIS.

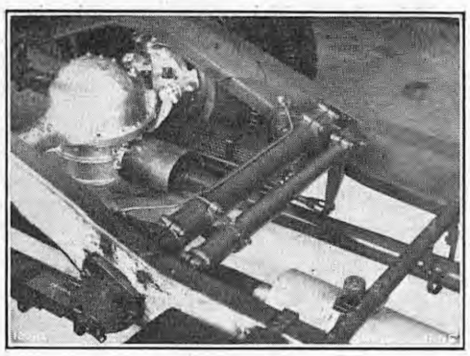


FIG. 7. REAR AXLE; DAIMLER LIGHTWEIGHT CHASSIS.

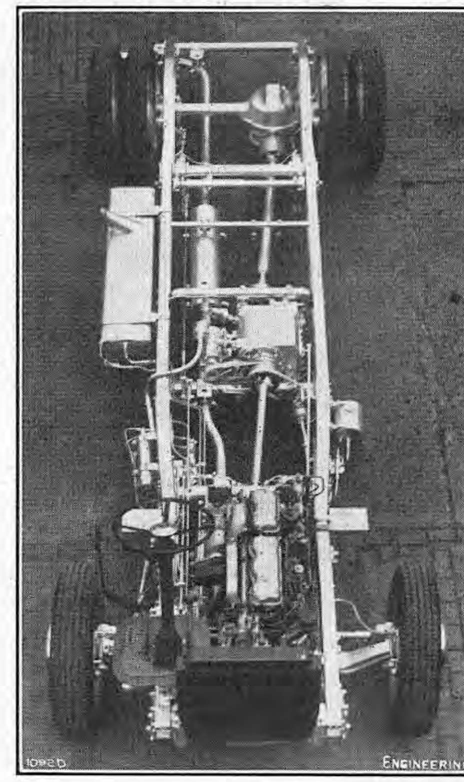


FIG. 8. LIGHTWEIGHT CHASSIS; TRANSPORT VEHICLES (DAIMLER), LTD.

INTERNATIONAL COMMERCIAL MOTOR SHOW.

(*Continued from page* 413.)

THE 16th International Commercial Motor Show, which closes to-morrow evening after having been open since the morning of Friday, September 26, is outstanding not only because of its size and the wide scope of the exhibits but owing to the remarkably high standard of the vehicles on show and the surprising number of new models. Many new types of an advanced design were introduced both at the 1948 and 1950 shows, and in view of this the manufacturers would have been more than justified in consolidating their designs and concentrating on production. They have, however, shown a healthy appreciation of the need to keep in front of their overseas competitors, and judging from the vehicles on view, there is little doubt that the lead so well established after the war has been adequately maintained. It is all the more remarkable that this lead has been kept despite shortages of labour and material, restrictions on home models and crippling taxation. Upwards of 20 new models are on show, the word "new" being used advisedly as they are not old patterns decked out in a fresh guise but completely new designs evolved for specific purposes. Some of these were described on page 412 of our issue for September 26 and we continue below our account of the exhibition.

LIGHTWEIGHT DOUBLE-DECK 'BUS CHASSIS.

Every endeavour is being made by the various manufacturers to reduce, so far as possible, chassis weights. Transport Vehicles (Daimler), Limited, Radford, Coventry, for example, are showing a new double-deck passenger chassis designed as a result of investigations into weight-saving carried out by the Daimler Company in conjunction with several municipal operators, notably the Birmingham Corporation Transport Department for whom one of the first chassis of the new type has been built. Others who have co-operated in this project include the Aluminium Development Association, whose advice and assistance was sought regarding the use of light alloys in the various parts of the chassis. The aim has been to produce a double-deck vehicle with a normal seating capacity of 54 to 56 passengers and a gross weight of 10 tons 10 cwt. as against the average present-day weight of 11 tons 10 cwt. for commensurate vehicles. It was decided that the total required saving of weight should be divided equally between the chassis and body, this decision entailing a saving of 10 cwt. in each case or, for the chassis, a reduction from 4 tons 15 cwt. to 4 tons 5 cwt.

The resulting chassis, which is known as the CLG Lightweight, is illustrated in Figs. 5 and 8, on this page. It has a wheelbase of 16 ft. 4 in. and is designed for a 56-seat body 7 ft. 6 in. wide and 27 ft. long. To render it suitable for all operational requirements, the chassis is designed to accommodate any of three power units, namely, the Gardner five-cylinder 7-litre and six-cylinder 8·4-litre oil engines or the Daimler CVD six-cylinder 8·6-litre oil engine. The engine in each case is secured to the chassis through four Metalastik mountings, the difference in the lengths of the various engines being accommodated by altering the length of two mounting arms bolted to the flywheel housing at the rear of the engine. This arrangement will be clear from an examination of Fig. 6, herewith, and it will be appreciated that adoption of this design avoids the necessity for varying the position of the supporting cross member. When fitted with the Daimler engine, the chassis will be known as the CLD Lightweight.

The chassis side members are similar to those used on the firm's CD650 chassis, a double-deck passenger vehicle fitted with a 10·6-litre oil engine. These side members, however, are $1\frac{1}{2}$ in. closer together than on the CD650 model and the tubular cross-shafts are correspondingly shorter; their weight is further reduced by employing integral flanges in place of the heavier welded brackets used hitherto. Light alloys have been used wherever possible, and although the individual savings are, in some applications, small the total weight saved by this means is quite appreciable. Parts made from light alloys include the spring brackets, the mountings for engine and gearbox, steering box, the radiator in which aluminium replaces gunmetal, and all water connections. The gearbox casing is in Elektron and the final-drive casing in aluminium. Considerable savings in weight have been achieved however, by means other than the use of light alloys. Two of these are of interest in that they are made possible as a consequence of the total weight reduction which has permitted the use of lighter springs and a smaller fuel tank. Although a width of $3\frac{1}{2}$ in. has been maintained for the springs, they are of lighter construction with fewer leaves, while the fuel tank, in view of the reduced consumption brought about by the overall reduction in weight, has been reduced to a capacity of 30 gallons, as against the more usual 35 gallons.

The braking system employs the same lightweight hydraulic equipment as used on the makers' Freeline underfloor-engined chassis, which is fitted with the Lockheed continuous-flow system. The system also operates the gear-change, a small hydraulic cylinder being fitted to the gear-engaging lever on the side of the gearbox. The hydraulic pump is mounted on the inside of one of the chassis side members and is driven through twin V-belts from a pulley integral with that installed at the front of the gearbox for driving the dynamo. The transmission system comprises the usual open-circuit fluid flywheel and four-speed pre-selective epicyclic gearbox. The gearbox is placed farther back in the chassis than usual; this has been done so that either four-window or five-window body construction can be used without the gearbox interfering with the position of the body cross-members and pillars. Final drive is through the makers' fully-floating, underslung-worm rear axle (Fig. 7) with the worm drive offset to the left.

UNDERFLOOR-ENGINED PASSENGER CHASSIS.

Messrs. Dennis Brothers, Limited, Guildford, are also showing a new passenger chassis in which every endeavour has been made to reduce weight to a minimum with a view to obtaining a better fuel consumption. In this case, however, it is an underfloor-engined chassis designed to accept single-deck bodies for public-service or coaching duties. The new chassis, which is known as the Lancet UF, is illustrated in Fig. 9, opposite, from which it will be seen that front and rear dropped chassis extensions give exceptionally low platforms for the passenger entrances and exits. The main channel-section frame members are made from an alloy steel and have the same section for the full length, being 9 in. deep, 3 in. wide and 0·212 in. thick. The right-hand side-member top and bottom flanges are reinforced by welded strips, and though the illustration shows a dropped rear extension, a

EXHIBITS AT THE COMMERCIAL MOTOR SHOW.

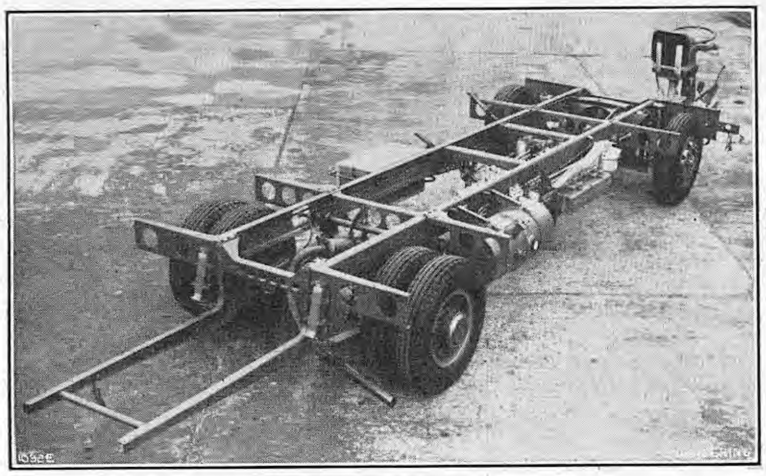


FIG. 9. "LANCET" PASSENGER CHASSIS; DENNIS BROTHERS, LTD.

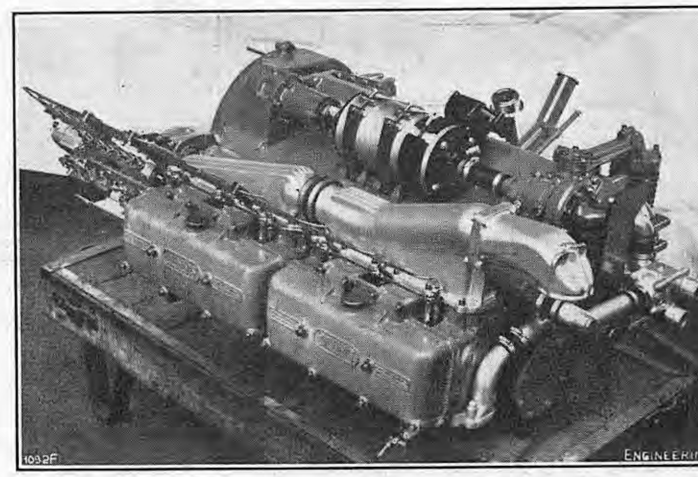


FIG. 10. UNDERFLOOR OIL ENGINE; DENNIS BROTHERS, LTD.

FIG. 11. TURNTABLE FIRE ENGINE; DENNIS BROTHERS, LTD.

straight extension can be fitted if required. The wheelbase is 16 ft. 4 in. and the overall length 29 ft. 3 in., with a length of frame behind the driver's seat of 25 ft. $6\frac{3}{4}$ in. The width of the frame is 3 ft. $3\frac{1}{4}$ in. and the overall width of the complete vehicle 8 ft. Without fuel, lubricants, or water and without tools and spare wheel, the weight is approximately 3 tons 17 cwt.

The engine for the Lancet chassis is illustrated in Fig. 10, above, from which it will be seen that it is a horizontal six-cylinder unit of exceptionally compact design. The bore and stroke are 105 mm. and 146 mm., respectively, with a cubic capacity of 7·585 litres, and the output at the maximum governed speed of 2,000 r.p.m. is 110 h.p. Unit construction is employed for the crankcase and cylinder block, the latter being fitted with cast-iron wet-type liners which are surrounded by coolant for their full depth. There are two cylinder heads, one for each set of three bores, and the heads are fitted with the overhead valve gear, there being four valves per cylinder operated by short push rods and rocking levers in the usual manner. Anodised silicon-aluminium alloy pistons are fitted, each piston being provided with four compression rings and two oil-scraper rings, the top scraper ring being of the slotted type. In accordance with modern practice, open-type combustion chambers incorporating toroidal recesses are formed in the piston crowns. The crankshaft is machined from a chromium-molybdenum alloy-steel stamping and is supported by seven bearings of the steel-backed copper-lined type, the diameter of the journals being $3\frac{3}{8}$ in. Similar bearings are used for the big ends of the connecting rods which, to enable the piston and connecting-rod assembly to be withdrawn through the cylinder bores, are split diagonally. The timing gears are situated at the rear of the unit adjacent to the flywheel and, as will be seen from the illustration, are arranged to drive the dynamo and water pump which are mounted in tandem on top of the engine. A gear-type pump supplies oil under pressure to the main bearings, big-end bearings, the camshaft bearings, the gudgeon pins and the valve-rocker bearings, the lubricating system incorporating a fuel-flow filter with emergency by-pass.

In general, the layout of the transmission follows conventional lines. A hydraulically-operated dry two-plate clutch with a friction area of 429 sq. in. transmits the drive to a five-speed gearbox, the fifth gear of which is a pre-selective overdrive. All gears are made from nickel-chromium-molybdenum steel and the addendum tooth form is used to give silence allied with strength. The ratios of the various speeds are: first, 4·54 to 1; second, 2·74 to 1; third, 1·66 to 1; fourth, 1 to 1; and fifth, or overdrive, 0·69 to 1. A one-piece propeller shaft fitted with Hardy-Spicer universal joints is used to transmit the drive to the rear axle, the latter being of the double-reduction type with spiral-bevel reduction gears at the centre and epicyclic reduction gears in the hubs, giving a standard overall axle ratio of 6·06 to 1. A special section designed to give torsional rigidity for resisting brake loads is used for the front axle beam, which, like the rear axle, is connected to the chassis through semi-elliptical leaf-type springs, those at the front being $46\frac{5}{8}$ in. long and those at the rear 60 in. long. A worm-and-nut type of steering of Dennis design is fitted, the steering column, together with other controls, being located at the front of the forward extension. The brake-shoe mechanism also is of Dennis design and manufacture, the front shoes measuring 17 in. by 3 in. and the rear shoes 17 in. by $6\frac{3}{8}$ in.; they are applied by means of hydraulic cylinders and camshafts. A 24-volt lighting and starting system is provided, the output of the dynamo, which is of C.A.V. manufacture, being 900 watts.

TURNTABLE FIRE ESCAPE.

Probably the most impressive exhibit on the Dennis stand, however, is the turntable fire escape illustrated in Fig. 11, on this page; this is being shown with the escape extended. This appliance is based on the Dennis F14 chassis and is fitted with a Metz 100-ft. turntable escape. The motive unit is a Rolls-Royce eight-cylinder in-line petrol engine having a bore and stroke of $3\frac{1}{2}$ in. and $4\frac{1}{2}$ in., respectively, and developing a maximum service power of 150 brake horse-power. An unusual feature of this engine is the disposition of the valves, overhead inlet valves and side exhaust valves being employed.

The transmission group comprises a twin-plate Borg and Beck 11-in. diameter dry-type clutch and a four-speed and reverse gearbox, the ratios of which are arranged to suit the characteristics of the engine. The frame is of pressed-steel construction with deep side-members and channel-section cross-members, the overall width of the appliance being 7 ft. 6 in. and the wheelbase 13 ft. 6 in. Two-leading-shoe hydraulic brakes are fitted to all four wheels and these are applied by means of a vacuum-servo unit. A Dennis No. 2 pump is fitted centrally in the chassis and is driven from a power take-off fitted to the top of the gearbox, the drive being transmitted through a propeller shaft fitted with needle-bearing universal joints. The output of the pump is 550 gallons per minute at a pressure of 140 lb. per square inch when operating with a suction lift of 3 ft. 9 in. Four 7-ft. lengths of 4-in. suction hose are provided and these are complete with couplings and a 4-in. metal strainer.

The ladder is made from steel and is of welded construction throughout. It is elevated by two chains arranged so that there is a constant leverage throughout the arc of travel, each chain being capable of taking the total maximum load with a factor of safety of six. Extension is by cable and winch drum, the ladder automatically being supported by pawls when at rest. Two speeds are available for this movement but second speed is selected automatically when the extension exceeds 64 ft. Training is accomplished by a geared drive to the main turntable, which is mounted on a double-ball ring guide. Plumbing is entirely automatic and the ladder is brought into a vertical position when the chassis is on a transverse slope such as the camber of a road. All movements are protected by self-acting limiting stops with the addition of impact control for elevation, extension and training, the controls being returned to neutral and the movements stopped when the safety devices operate. Jacking of the appliance is automatic, the controls being interlocked so that no movement of the ladder can take place until the jacking procedure is completed. The engine throttle is in the form of a ring which encompasses the base of the ladder and it can be operated from any position. The 100-ft. ladder is in four sections and the time required to carry out erection, 90 deg. rotation and full extension is from 25 to 30 seconds.

(To be continued.)

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

The Late Mr. R. Hudson.—Mr. Robert Hudson, who was actively associated with the Lion Foundry Co., Ltd., Kirkintilloch, near Glasgow, for the greater part of his life, died at his home in Kilmarnock on September 24. He was a director of the firm for about 20 years, from which office he retired only a few months ago.

Relighting of Steel Furnaces.—As a result of increased pig-iron outputs from local blast furnaces coupled with imports from the Continent and the maintenance of scrap supplies from both home and overseas sources, Messrs. Colvilles Ltd. have relit two of the six furnaces comprising No. 1 melting shop at their Clydebridge Steelworks, Glasgow. These had been laid off since the end of 1950. The furnaces are producing at the rate of 2,000 tons a week. This will materially help in the drive to increase the output of plates, the shortage of which has affected shipbuilding programmes.

Steelworks Working Week.—On Sunday, September 28, Scottish steelworks employees commenced the operation of a five-and-a-half day, 44-hour week. This was delayed from September 7 on account of a disagreement on certain details between some of the men and the employers.

Edinburgh Tramway System to be Abolished.—Edinburgh Town Council decided, on September 25 to abolish the City tramway system "within a period of three years or as soon thereafter as possible." One of the principal spokesmen in favour of the proposal said that it was a question of either spending 1,250,000*l.* on the tramway track, 800,000*l.* on tramway cars, and 200,000*l.* on new equipment, and at the end still have an ageing tramway system serving about half of the population of the City, or to spend 1,200,000*l.* on 300 new omnibuses and have a single unified system of transport.

Spey-Valley Survey.—Mr. W. M. Snadden, Under-Secretary of State for Scotland, said in Inverness, on September 19, that the Spey-Valley survey was nearing completion; it was necessary before a big land-reclamation scheme was put in hand at Loch Insh, Badenoch. When the drainage scheme was undertaken, it was hoped to recover between 7,000 and 9,000 acres of flooded land. The Government, however, would first have to be in a position to say what protection would be necessary against further flooding and that was one of the main purposes of the survey.

"Nullmatic" Process Control Instruments.—A demonstration of "Nullmatic" process control instruments, which have recently been introduced by Sunvic Controls, Ltd., 10, Essex-street, London W.C.2, will be given at the Engineering Centre, Glasgow, on Tuesday and Wednesday, October 14 and 15. Tickets of admission may be obtained by applying to the company.

North of Scotland Sub-Centre of the Institution of Electrical Engineers.—The North of Scotland Sub-Centre of the Institution of Electrical Engineers has been re-constituted and the inaugural meeting will be held at the Caledonian Hotel, Aberdeen, on Wednesday, October 8. The meeting, at which the chairman (Mr. L. B. Perkins) will be installed, will be preceded by an informal dinner.

132-KV Cables for Braehead Power Station.—The output from the new Braehead power station of the British Electricity Authority near Glasgow, two of the four 50-MW sets in which are now in operation, is being transmitted by 132-kV underground cable to Govan, a distance of about 5,500 yards. These cables, which were manufactured by Enfield Cables, Ltd., Southampton-row, London, W.C.1, are of the pipe-line compression type, the 0·5 sq. in cores being contained in a 6⅝ in. diameter steel pipe, which is filled with nitrogen at a working pressure of 200 lb. per square inch. Towards the end of the pipe line the cable trifurcates to three single-core compression cables, which terminate in sealing bells of the stabilised glaze type. The same firm is also laying 4,500 yards of 132-kV 0·3-sq. in. compression cable from Govan to Pollokshaws, which will carry some of the load on Dalmarnock when a section of that station is shut down for renewal.

CLEVELAND AND THE NORTHERN COUNTIES.

The Late Mr. E. Cameron, M.B.E.—The death has occurred at South Shields, at the age of 81, of Mr. Edmund Cameron, former dry docks manager to John Readhead and Sons, South Shields. He was with the firm for 57 years and retired seven years ago. In 1942 he was awarded the M.B.E.

The Late Mr. J. G. Kirkup.—We note also the death at Sunderland, at the age of 82, of Mr. John George Kirkup, formerly managing director of Philip Kirkup and Co. Ltd., Portobello oil and grease works, Monkwearmouth, County Durham. The firm was started by his father and Mr. J. G. Kirkup took over the management when he was 18 years old. He retired two years ago.

Tyne Launches.—One launch on the Tyne in October will bring the River's shipbuilding output for the first ten months of the present year to 139,000 gross tons, compared with nearly 184,000 tons last year. In October, 1951, five vessels, aggregating over 48,000 tons, entered the water.

Howdon Gas Plant.—Viscount Allendale, Lord Lieutenant of Northumberland, has officially opened the new 1,500,000*l.* gas-making plant erected at Howdon-on-Tyne by the Northern Gas Board. The plant, which employs 250 men, will produce 12,000,000 cub. ft. of gas daily. The old works at Howdon employed 240 men and produced some 3,000,000 cub. ft. daily. The plant consumes 540 tons of coal daily. In addition to gas, the works produce, each day, 1,500 gallons of benzol, 5,000 gallons of tar and six tons of sulphate of ammonia.

Centenary of North of England Institute.—Speaking at a dinner at Newcastle-on-Tyne, given by the Northumberland and Durham Coalowners' Associations to mark the centenary celebrations of the North of England Institute of Mining and Mechanical Engineers, Major S. Walton-Brown, vice-chairman of the Northumberland Owners' Association, expressed the opinion that mine managers were "grossly overworked." It was unfortunate, he continued, that the centenary celebrations of the Institute, which had worked so long in the interests of mine safety, should coincide with the publication of the Easington-Colliery explosion report. The manager of a large colliery should have two qualified mining engineers as his subordinates. It was not possible for the manager of a large pit to inspect the mine thoroughly, and these technicians should be there to help him. This method would improve safety in mines. Professor Granville Poole, President of the Institute, said that mines inspectors would agree that from 40 to 50 per cent. of all mining accidents could be avoided with proper care. Mr. N. C. Anthony, President of Durham Coalowners' Association, said that it was probably the last time the Associations would meet the Institute, as their usefulness was drawing to a close.

LANCASHIRE AND SOUTH YORKSHIRE.

Position in Steelworks-Plant Manufacture.—Mr. D. F. Campbell, chairman of Davy and United Engineering Co., Ltd., Sheffield, has stated that it is now more than two years since any major rolling-mill installation has been ordered by the British steel industry, which has concentrated its capital expenditure on coke-ovens and blast-furnaces to relieve the shortage of scrap steel. As a result, he continued, the firm's home contracts were rapidly approaching completion although the new British programme to increase steel production should improve the home demand for rolling-mill equipment during the next few years. The bulk of the work now in hand was for export.

Sheffield College of Commerce and Technology.—The controllers of the Sheffield College of Commerce and Technology have been gratified by the fact that enrolments for classes have reached an all-time record. Last year's total of 7,500 has been exceeded and many of the building, commerce and management, engineering, and science and metallurgy courses have been extended. There are also new post-graduate courses for industrial specialists in machine design, tool and welding design, metals and X-ray techniques.

Benefits of a Buyers' Market.—At the revived annual dinner of the Sheffield Chamber of Commerce, the Master Cutler, Mr. G. M. Flather, welcomed the return of a buyers' market with its stimulus to competition, and hoped that it would be accompanied by the abolition of many import cuts and other restrictions. In remarking that practically everything at present depended, at some stage, on Sheffield steels, he pleaded that the quality of these products should be maintained at a high level.

Short Course on Iron and Steelmaking.—At the invitation of the United Steel Companies Ltd., 36 students of pure science, engineering and metallurgy from the Universities of London, Sheffield, Leeds, Southampton, Cambridge, Bristol and Birmingham, spent last week in Sheffield as guests of the company. The aim of the course was to give an insight into the scientific foundation of iron and steelmaking and of certain derivative chemical-manufacturing processes, and the scope of engineering and research in the industry. Some idea, too, was given of the economic structure of the industry.

The Late Mr. E. Hall.—Mr. Edley Hall died suddenly at his home in Rotherham on September 19. He was the son of the founder of Thos. Hall & Son, Ltd., refrigerator engineers, Hillsborough, Sheffield, and was a co-partner in the firm. Mr. Hall was 68.

THE MIDLANDS.

Illuminated Town Plan.—Wolverhampton Junior Chamber of Commerce have erected a plan of the town near the entrance to the two principal railway stations. The plan, which is 5 ft. square, has panels at each side on which are listed the names of more than 120 Wolverhampton firms. Push-buttons are provided adjacent to each name and, when the appropriate button is pressed, the situation of a particular firm is indicated by a light on the plan. Details are also given of the public-transport routes serving each firm, and the approximate time to reach the premises is stated.

British Industries Fair Preparations.—About 1,000,000 sq. ft. of exhibition space will be available at the Birmingham section of the British Industries Fair, which is to be held between April 27 and May 8 next year. Many applications for space have been received, and the organisers expect that all the available space will be occupied. The recent improvement in supplies of raw materials, especially steel and non-ferrous metals will, if it continues as anticipated, provide welcome new features at the Fair. For the first time for some years, manufacturers expect to be able to offer improved deliveries for export orders.

Centenary of West Bromwich Firm.—J. B. and S. Lees, Ltd., Albion Strip Mills, West Bromwich, Staffordshire, celebrated the 100th anniversary of the founding of the company on September 20. The firm began as manufacturers of wrought iron in 1852, and originally made rolled bars, sheets and plates. For many years they have specialised in the production of steel strip.

SOUTH-WEST ENGLAND AND SOUTH WALES.

Llandarcy Refinery.—The fifth and last of the new jetties serving the Anglo-Iranian Oil Company's Llandarcy refinery has now been completed. All five jetties which are at the Queen's Dock, Swansea, have been made of spun concrete, and tankers of up to 28,000 tons deadweight capacity can now be accommodated; five of them can be discharged simultaneously. The improvements have been made necessary as a result of the large-scale post-war developments at the Llandarcy refinery, which has now a throughput of 4,000,000 tons a year compared with 360,000 tons before the war. The present output of motor spirit is 500,000 gallons a day and this will be raised by 50 per cent. before the end of the year.

South Wales Ports Traffic.—The expansion in the oil trade at Swansea has been one of the features of the latest returns issued by the Docks and Inland Waterways Executive relating to the South Wales ports. These show that imports of oil and spirits into South Wales, but chiefly through Swansea, amounted to 3,046,477 tons in the first eight months of the present year, compared with 2,465,439 tons in the corresponding period a year ago. The returns show that the total import and export trade of the South Wales group of ports was 15,498,424 tons, against 13,623,442 tons a year ago. Exports were 8,661,678 tons, against 7,314,504 tons. The inward trade totalled 6,836,746 tons, against 6,308,938 tons. Coal exports this year, at more than 500,000 tons above the level reached in 1951, totalled 2,442,763 tons. Imports of iron ore, at 1,503,635 tons, compared with 1,310,069 tons a year ago while arrivals of partly-manufactured iron and steel goods rose from last year's level of 354,552 to 471,000 tons. Exports of iron and steel products fell, however, from 194,024 to 157,656 tons, but tin-plate shipments rose from 143,649 to 172,900 tons.

Bristol Channel Ferry.—Application has been made to the Treasury for sanction to raise, by public subscription, the sum of 56,000*l.* to put into operation a Bristol-Channel ferry from Uphill, Somerset, to Penarth, near Cardiff. It is expected that, by next summer, two ferry vessels will be in service.

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.

SOCIETY OF ENGINEERS.—Monday, October 6, 5.30 p.m., Geological Society, Burlington House, Piccadilly, W.1. "Refuse-Sewage Composting: Engineering Aspects," by Mr. Hal Gutteridge.

INSTITUTION OF ELECTRICAL ENGINEERS.—*South Midland Centre:* Monday, October 6, 6 p.m., Grand Hotel, Birmingham. Annual Meeting and Conversazione. Chairman's Address by Dr. K. R. Sturley. *Merseyside and North Wales Centre:* Monday, October 6, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. Chairman's Address by Mr. W. A. Hatch. *East Midland Centre:* Tuesday, October 7, 6.30 p.m., Loughborough College, Loughborough. Chairman's Address by Mr. H. E. Knight. Thursday, October 9, 7.30 p.m. Corn Exchange, Spalding. "Review of Overhead Lines," by Mr. N. G. Simpson. *North-Western Centre:* Tuesday, October 7, 6.30 p.m., Engineers' Club, Manchester. Chairman's Address by Mr. J. Prince. *Southern Centre:* Wednesday, October 8, 6.30 p.m., Dorset Technical College, Weymouth. "Illumination," by Mr. S. S. Beggs. *District Meeting:* Wednesday, October 8, 7 p.m., Offices of the Southern Electricity Board, 37, George-street, Oxford. "Short-Circuit Testing Technique," by Mr. J. Anderson. *Institution:* Thursday, October 9, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Presidential Address by Colonel B. H. Leeson. *North Midland Centre:* Friday, October 10, 6.30 p.m., Offices of the Yorkshire Electricity Board, 1, Whitehall-road, Leeds, 1. Chairman's Address by Mr. H. S. Moody.

INSTITUTION OF PRODUCTION ENGINEERS.—*Halifax Section:* Monday, October 6, 7.15 p.m., White Swan Hotel, Halifax. "Increased Productivity by Workshop Practice," by Mr. A. Cameron. *Western Graduate Section:* Monday, October 6, 7.30 p.m., Grand Hotel, Bristol. "Some Trends in Production Engineering Education and Training," by Mr. T. B. Worth. *Birmingham Section:* Wednesday, October 8, 7 p.m., Cadena Café, Worcester. "Interesting Set-Ups on Modern Machine Tools," by Mr. R. C. Fenton. *Nottingham Section:* Wednesday, October 8, 7 p.m., Victoria Station Hotel, Nottingham. "Photo-Elasticity for Production Engineers," by Dr. J. Ward. *Preston Section:* Wednesday, October 8, 7.15 p.m., Crown Hotel, Market-place, Blackburn. "Substitute Materials and Their Application," by Mr. E. R. Gadd. *Coventry Graduate Section:* Wednesday, October 8, 7.30 p.m., Geisha Café, Hertford-street, Coventry. (i) Discussion on "Factory Lay-Out and Batch Production," (ii) "Flow Production," by Mr. R. Gore. *Liverpool Section:* Wednesday, October 8, 7.30 p.m., Radiant House, Bold-street, Liverpool. "Steel: Engineers' Clay," by Mr. F. Westall. *Rochester Section:* Thursday, October 9, 7.30 p.m., Sun Hotel, Chatham. "Jet Engines," by Mr. E. Storm. *Eastern Counties Section:* Friday, October 10, 7.30 p.m., Britannia Works, Colchester. "The Corby Iron and Steel Works of Stewarts and Lloyds, Ltd.," by Mr. E. A. Taylor.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*Scottish Centre:* Monday, October 6, 7.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. Discussion on "Welding Methods." *Eastern Centre:* Tuesday, October 7, 7 p.m., Albert Hall, Cowdray-avenue, Colchester. "The Running and Maintenance of Fuel-Injection Equipment," by Mr. R. W. Preece. *South Wales Group:* Friday, October 10, 7 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Dieselisation," by Mr. H. Parrish.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Sheffield Branch:* Monday, October 6, 7.30 p.m., Sheffield College of Commerce and Technology, Pond-street, Sheffield, 1. (i) Branch President's Address on "Men and Moulds," by Mr. F. A. Martin. (ii) Film Display. *Scottish Branch:* Saturday, October 11, 3 p.m., Royal Technical College, Glasgow. (i) Branch President's Address, by Mr. A. J. D. Black. (ii) "Present Developments and Future Trends in Cast-Iron Industry," by Mr. John McGrandle. *Bristol and West of England Branch:* Saturday, October 11, 3 p.m., at works of Newman, Hender & Co., Ltd., Woodchester Stroud, Gloucestershire. "Production of Aluminium Patterns Using Plaster Mould," by Mr. D. H. Potts. *Newcastle Branch:* Saturday, October 11, 6 p.m., Neville Hall, Newcastle-upon-Tyne. "Modern Core Binders and Synthetic Resins," by Mr. A. Tipper. *East Midlands Branch:* Saturday, October 11, 6 p.m., All Saints Buildings, Northampton. "Some Comparisons of British and American Foundry Practice," by Mr. P. A. Russell and Mr. F. G. Butters. *West Riding of Yorkshire Branch:* Saturday, October 11, 6.30 p.m., Technical College, Bradford. Brains Trust Meeting. *Lincolnshire Branch:* Saturday, October 11, 7.15 p.m., Technical College, Lincoln. Branch President's Address by Mr. E. Clipson.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Leeds Branch:* Monday, October 6, 7.30 p.m., Great Northern Hotel, Leeds. "Electrification in the Dales," by Mr. A. Browell. *Nottingham Branch:* Tuesday, October 7, 7.30 p.m., Offices of the East Midland Electricity Board, Smithy-row, Nottingham. "The Permanent Way to Earth," by Mr. F. Porter.

IRON AND STEEL INSTITUTE.—Tuesday, Wednesday and Thursday, October 7, 8 and 9. Special Meeting in Swansea. Various visits and excursions. For programme, see page 247, *ante*.

INSTITUTION OF MECHANICAL ENGINEERS.—*Automobile Division:* Tuesday, October 7, 5.30 p.m., Storey's-gate, St. James's Park, Westminster, S.W.1. Annual Meeting. Address by the chairman of the Division, Mr. Maurice Platt, on "The Changing Practice of Automobile Engineering." *London Graduates' Section:* Wednesday, October 8, 6.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Surface Finish Measurement," by Mr. J. Halling. *Luton Graduates' Section:* Wednesday, October 8, 7.30 p.m., Town Hall, Luton. "Some Problems of Gas Turbines," by Professor W. R. Hawthorne. *Institution:* Friday, October 17, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Presidential Address on "The Art of the Practical Engineer," by Sir David Pye.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—*North-East Coast Branch:* Tuesday, October 7, 6.30 p.m., Neville Hall, Newcastle-upon-Tyne, 1. Annual Meeting. "Heating and Hot-Water Service for Moderate Rental Flats," by Mr. A. F. Myers.

INSTITUTION OF CHEMICAL ENGINEERS.—*South Wales Graduates' and Students' Section:* Tuesday, October 7, 7 p.m., University College of South Wales and Monmouthshire, Museum-avenue, Cardiff. "Non-Metallic Corrosion-Resistant Materials," by Mr. N. Monks.

SHEFFIELD METALLURGICAL ASSOCIATION.—Tuesday, October 7, 7 p.m., Grand Hotel, Sheffield. "Metallurgy: A Partner in the Administration of an Integrated Steelworks," by Mr. H. Humphries.

INCORPORATED PLANT ENGINEERS.—Tuesday, October 7, 7 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. "Fire Protection in Factories and Works," by Mr. G. W. Underdown. *South Wales Branch:* Tuesday, October 7, 7.15 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Discussion on "Plant Inspection as an Aid to Maintenance." *East Midlands Branch:* Wednesday, October 8, 7 p.m., Welbeck Hotel, Nottingham. "Protecting Your Plant from Fire," by Mr. J. C. Elliott. *Newcastle-on-Tyne Branch:* Thursday, October 9, 7.30 p.m., Roadway House, Oxford-street, Newcastle-upon-Tyne. "The Manufacture of Glass and Some Aspects of Toughened Glass," by Mr. D. Curran.

INSTITUTION OF WORKS MANAGERS.—*Sheffield Branch:* Tuesday, October 7, 7.30 p.m., Grand Hotel, Sheffield. "Magnetism in Industry," by Mr. T. G. Hawker.

INSTITUTION OF ENGINEERING INSPECTION.—*Coventry Branch:* Tuesday, October 7, 7.30 p.m., Technical College, Coventry. "Jet Propulsion from the Pilot's Viewpoint," by Group Captain L. R. Stokes.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, October 7, 7.30 p.m., The Lorne, Greenock. "Air Conditioning of Ships," by Mr. J. K. W. MacVicar.

INSTITUTE OF PETROLEUM.—Wednesday, October 8, 5.30 p.m., 26, Portland-place, W.1. "Methods of Atomising Liquid Fuels," by Mr. J. R. Joyce.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*North-Eastern Section:* Wednesday, October 8, 6 p.m., Neville Hall, Newcastle-upon-Tyne. "Germanium Crystal Valves: Their Characteristics and Application," by Mr. B. R. Bettridge. *London Section:* Wednesday, October 8, 6.30 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Annual Meeting. Presidential Address, by Mr. W. E. Miller.

INSTITUTE OF WELDING.—Wednesday, October 8, 6.30 p.m., Institution of Civil Engineers, Great George-street, S.W.1. Presidential Address, by Mr. A. R. Jenkins.

INSTITUTION OF ENGINEERS-IN-CHARGE.—Wednesday, October 8, 6.30 p.m., St. Bride Institute, Fleet-street, E.C.4. "Use of Unusual Fuels," by Mr. C. E. Newman.

INSTITUTE OF FUEL.—*Yorkshire Section:* Wednesday, October 8, 6.30 p.m., The University, Leeds. Chairman's Address, by Mr. F. A. Gray.

SOCIETY OF CHEMICAL INDUSTRY.—*Corrosion Group:* Wednesday, October 8, 6.30 p.m., Chemical Society's Apartments, Burlington House, Piccadilly, W.1. Discussion on "Filiform Corrosion and Related Phenomena."

ILLUMINATING ENGINEERING SOCIETY.—*Manchester Centre:* Thursday, October 9, 6 p.m., Town Hall Extension, Manchester. "Home Lighting," by Miss M. D. Wardlaw.

INSTITUTION OF SANITARY ENGINEERS.—Thursday, October 9, 6 p.m., Caxton Hall, Victoria-street, S.W.1. "Sanitary Engineering Services for Pit-Head Baths," by Mr. J. H. Walton.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 10, 7 p.m., Townsend House, Greycoat-place, S.W.1. "Electricity and Productivity," by Mr. H. J. Gibson.

PERSONAL.

MR. HARRY BULL, managing director of Brown Bayley Steels Ltd., Leeds-road, Attercliffe, Sheffield, 9, and chairman of Welding Rods Ltd., Sheffield, has been appointed a member of the Regional Board for Industry in succession to MR. G. H. FLETCHER.

MR. C. E. PROSSER has been appointed deputy chairman of Imperial Chemical Industries Ltd., Metals Division. Mr. Prosser has been succeeded as joint managing director, Metals Division, by MR. M. J. S. CLAPHAM, who is at present I.C.I. Midland Regional Manager and a member of the Metals Division board. Both appointments became effective on October 1.

MR. G. E. CHICKEN, commercial manager of Dorman, Long & Co., Ltd., Zetland-road, Middlesbrough, and MR. C. HIPWELL, general manager and a director of the associated company, Redpath, Brown & Co. Ltd., Edinburgh, have been made directors of Dorman, Long & Co. Three senior officials, MR. S. BARLOW, M.I.Struct.E., manager of the Dorman, Long Bridge and Constructional Works, Middlesbrough, MR. JAMES JACK, chief accountant, and MR. J. H. PATCHETT, operations superintendent, iron and steel works, have been appointed special directors of the firm.

MR. T. E. SHAW, shipyard manager to Smith's Dock Co. Ltd., North Shields, since 1945, has retired after 37 years of service with the firm. The new yard manager is MR. J. H. KIRBY, who joined the firm six years ago.

MR. O. M. WHITE, A.M.I.C.E., M.I.E.E., chief electrical engineer to Balfour, Beatty & Co. Ltd., has been elected a director of the company.

MR. EDWARD PLAYER, managing director of Birmid Industries Ltd., Dartmouth-road, Smethwick, Staffordshire, has been appointed chairman of the Aluminium Industries Council, in succession to MR. H. E. JACKSON, of Imperial Chemical Industries Ltd., Metals Division.

MR. J. W. THOMAS, B.Sc. (Tech.) (Manc.), LL.B. (Manc.), director of training, safety and welfare, British Electricity Authority, retired on September 30 on reaching the age of 65. He has accepted the position of part-time secretary of the Association of Managerial Electrical Executives, an organisation catering for managerial staffs in the industry.

MR. S. C. TYRRELL, F.C.W.A., F.I.I.A., chief accountant and local-board director of Newton Chambers & Co. Ltd., Thorncliffe Ironworks, near Sheffield, and President of the Institute of Cost and Works Accountants, has received the Gold Medal of Honour at the recent Paris Congress of the Société Industrielle de la Province de l'Est, France.

MR. JAMES SMITH, secretary and organiser to the West of Scotland Joint Committee on the Organisation of Classes in Science and Technology, has retired after 25 years of service.

MR. ALEX. LYLE, of Montreal, has been appointed assistant vice-president of the Canadian Pacific Railway. He has been assistant to the vice-president since 1942 and took up his new duties on October 1.

MR. TOM SMITH retired from his position of labour director, North-Eastern Division, National Coal Board, on September 30.

Opperman Gears Ltd., Newbury, Berkshire, have appointed MR. WILLIAM BRUCE to be their sales engineer for London and the Home Counties.

Owing to certain difficulties regarding the title of BRITISH & DOMINION PROCESS ENGINEERING LTD., in Canada, the name of the new company formed, as recorded on page 239 *ante*, jointly by DOMINION WHEEL AND FOUNDRIES LTD., of Canada; the BALFOUR GROUP OF COMPANIES, Leven, Fife; and W. S. BARRON AND SON LTD., Gloucester, has been changed to DOMINION, SCOTT, BARRON LTD. The new firm's address is 171, Eastern-avenue, Toronto, 2.

CHAMBERLAIN INDUSTRIES LTD., Staffa Works, Leyton, London, E.10, announce that their Scottish representatives, GERARD WAKEHAM LTD., have moved from Carlton House, 26, Blythswood-square, Glasgow, C.2, to 1, Clifton-street, Glasgow, C.3.

W. T. HENLEY'S TELEGRAPH WORKS CO. LTD., have opened a new stores depot at 4, Richmond Ope, Richmond-street, Plymouth. (Telephone: Plymouth 5759.)

THE KELLOGG INTERNATIONAL CORPORATION have removed to new offices at Kellogg House, 7-8, Chandos-street, off Cavendish-square, London, W.1. (Telephone: MUSeum 4010.)

THE ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS, 54, Station-road, New Barnet, Hertfordshire, inform us that their telephone number has been changed to BARnet 9141-2.

THE CHEMICAL SOCIETY, Burlington House, Piccadilly, London, W.1, have drawn our attention to their new telephone numbers, which are REGent 0675-6.

OPENING OUT BROTHERTON TUNNEL TO FORM A CUTTING.

(*For Description, see Page* 447.)

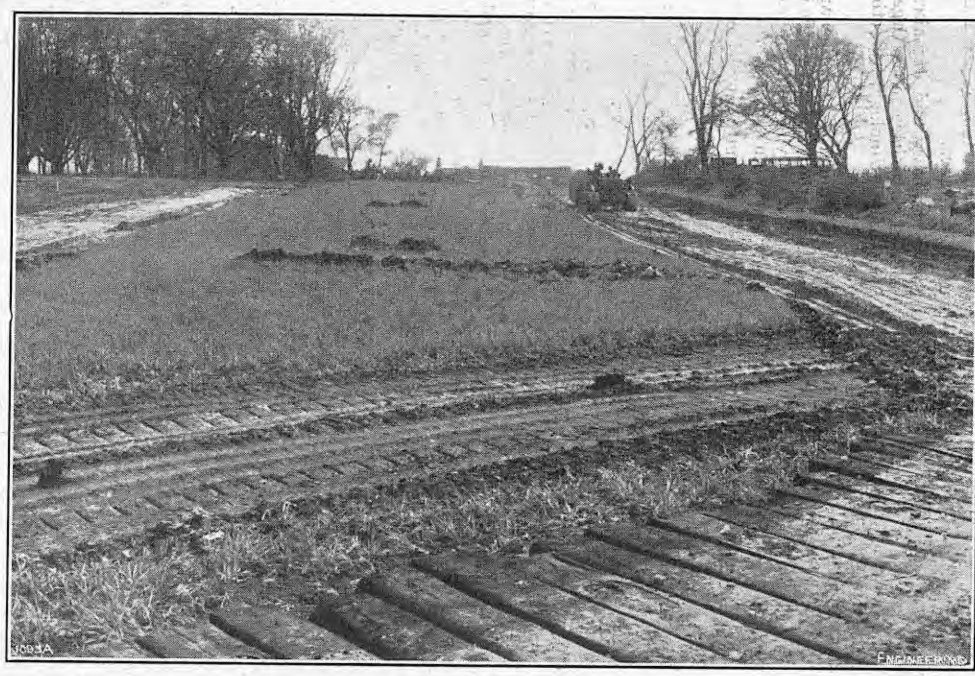


Fig. 1. Early Stage of Excavation.

Fig. 2. Demolition by Explosives.

Fig. 3. Using Drag Line Excavator and Face Shovel.

Fig. 4. Opening-Out Completed.

ENGINEERING

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

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CONTENTS.

ENGINEERING

FRIDAY, OCTOBER 3, 1952.

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TEN YEARS OF R.E.M.E.

In Europe to-day there is hardly a man or woman who has not had the experience of doing his duty on some purely administrative or technical task while suffering the fear, or at least apprehension, of imminent danger in war. The possibility of sudden battle in the skies above, or on the land or sea about him, has evoked a courage in the Twentieth Century European which, in former times, was usually confined, though not exclusively, to the fighting men. Every man to-day carries with him the recollection of such moments, and if he is not prepared to talk about them it is because he knows his experience of them cannot be translated into words and because, after all, his compatriots have similar and, to them, equally poignant memories. Those who served in the Corps of Royal Electrical and Mechanical Engineers during the second World War remember, perhaps, an occasion when, under cover of darkness or in the noon-day heat of the desert, they recovered a damaged tank. How other-worldly it seems in retrospect: they first made a technical reconnaisance of the casualty, brought up a Scammell tractor, did some winching, and then slowly (they would like to have done it quickly, but for mechanical reasons they could not)—slowly towed it away to the comfort of "B" echelon or the brigade workshops, while, all the time they were working on this rather crude but none the less skilled engineering operation, they, and the tank, and the Scammell, stood a good chance of being blown to pieces.

The Corps was formed ten years ago this week, on October 1, 1942, at the time when repeated set-backs in the field were about to give way to repeated successes. Rommel's "reconnaisance in force," with which he had hoped to reach the Nile, had been crushed, and the Battle of El Alamein was only three weeks ahead. To the R.A.O.C. soldier in the Western Desert, however, the forthcoming transfer to a new Corps seemed to be singularly inconsequential. He understood that there was to be a new Regimental Paymaster in England, and he hoped that gentleman would succeed, where none had succeeded before, in arranging his accounts to his satisfaction. Beyond that, he could see no marked change; there would not even be an issue of new cap-badges, owing to certain difficulties in the R.A.O.C.—the Corps from which he was being separated. Thus unimpressed, he returned to his Scammell, to clean its engine and be ready, like a fireman, to answer a sudden call.

The outlook of a private soldier, however, is necessarily restricted. He did not know—neither, perhaps, did some of his senior officers—that within a very short time the new Corps would achieve distinction for the way in which it dealt with the heavy casualties to equipment at El Alamein; that it would be increased in numbers and scope until it was responsible for, or took a major part in, the design, repair and maintenance of a wide range of equipment from tanks to ox-carts and howitzers to radar sets; and that it would become imbued with an *esprit de corps* which was stronger than anyone could have expected. The officers, warrant officers, N.C.O.'s, and craftsmen (as the R.E.M.E. tradesmen were designated) were not normally required to fight—though they belonged to a "combatant corps" and there were instances of brave action in the field—but they shared, in a special way, that experience of doing a technical job in an environment that was usually inimical to skilled work. In the eyes of other corps and regiments, too, they were thus more clearly defined as the men who undertook recovery, repair and maintenance of the growing number of fighting vehicles, transport vehicles, guns, small arms, radio and radar, instruments and equipment.

The direction and administration of the Corps, from the War Office through Command Headquarters at home and overseas to the armies, corps, divisions, brigades and regiments, became distinct and separate. The foundations of the system of work already existed in the R.A.O.C. organisation, which was itself based on the earliest experience, gained in the first World War, of large-scale mechanical engineering for military purposes. The system of echelons, characteristic of army organisation, provided for workshops of several magnitudes: the Light Aid Detachments (L.A.D.), staffed by a dozen or so men, were attached to regiments and brigades, for whom they carried out "first-aid" work; the brigade workshops, constituting the second echelon, dealt with rather heavier work, including engine changes and jobs that were beyond the resources of the lightly-equipped L.A.D.; the third-echelon workshops took even heavier work, but did not move so frequently; and the fourth echelon—the base workshops—undertook vast programmes of major overhauls, as well as a considerable amount of actual manufacture.

In principle, this system was proved to be sound, though it was modified in detail as a result of experience during the war. The ideal behind the formation of R.E.M.E. was, broadly, to have everyone concerned with the upkeep of mechanical and electrical equipment incorporated as members of the Corps. Only thus, it was believed, could the system function satisfactorily, for, in addition to the actual work of repair and maintenance, the design and improvement of Army equipment could be aided by using the professional knowledge and experience of R.E.M.E. officers who were in close touch with the using arms. In war-time, such officers tended to confine themselves to the practical work of, say, keeping a regiment's tanks on the road, but in the long run the interests of the regiment and, indeed, of the whole Army, could properly be served only if they reported back to higher formations the defects and shortcomings of the tanks they were so anxious to maintain.

It was, of course, at regimental level that close liaison between the R.E.M.E. officer and the officers of the regiment was of fundamental importance, since efficient maintenance in the first echelon minimises the work of all other echelons. In this respect some diplomacy was needed when the Corps was formed. Armoured regiments, for example, had their own fitters, who worked in conjunction with the L.A.D. Though this arrangement often worked out quite well, it was not logical, and since the war steps have been taken to transfer such tradesmen from regiments to R.E.M.E. This development, which was known as Phase II of the formation of the Corps, was completed in March this year.

While, at regiments, the E.M.E.'s (electrical and mechanical engineer—the title which replaced the ordnance mechanical engineer of the R.A.O.C.) were dealing with their immediate problems, others were expanding the facilities of base workshops, often adopting the mass-production methods of firms at home to meet the tremendous load which was placed on them, particularly in the Middle East and Italy. During January, 1943, the base workshops in the Middle East completely overhauled 550 armoured fighting vehicles, 2,420 " B " (i.e., transport) vehicles, 4,920 engines and 280 guns. In the same month they also repaired 440 armoured fighting vehicles, 1,180 " B " vehicles and 460 guns. In addition, a large amount of other work, particularly manufacture, was carried out. In Italy, to quote only one example, the output of overhauled engines rose to 9,000 a month by March, 1945. In that theatre, the personnel employed in base workshops amounted to 8,700 British military and 23,700 civilians.

In quoting such figures by way of examples, much other engineering work undertaken by R.E.M.E. is omitted. Apart from the work carried out in North West Europe and elsewhere—the workshop establishments grew differently in different theatres of war according to their position in relation to the United Kingdom, to the requirements of the armies in that theatre, etc.—there were the fortress workshops in Gibraltar, Malta and Malaya, the workshops of Anti-Aircraft Command and coast artillery, the work of R.E.M.E. personnel in the design, development and experimental establishments, the field and base-workshop repairing and testing of telecommunications equipment, the unprecedented task of waterproofing equipment for combined operations, the proofing of equipment against tropical and arctic conditions, and the ever-present problem of modifying equipment to make it more serviceable. The rapid expansion of the Corps to meet these requirements presented many problems, and in many cases professional engineers and skilled craftsmen found that they had to do work for which their civilian training and experience had not prepared them. Nevertheless, in general, those who had the honour to serve in the Corps had the satisfaction, denied to most temporary soldiers, of turning their civilian qualifications to good account in the interests of their country. That, perhaps, was the essence of the strength of the Corps, and in the future, too, R.E.M.E. officers and men will continue to cherish a pride in engineering ability combined with soldierly proficiency.

TIME CLAUSES IN ENGINEERING CONTRACTS.

The old legal rule that " Time is of the essence of the contract " is no longer of universal application. Time may, however, be made " of the essence " by a plainly expressed stipulation in the contract, but such a condition is not to be inferred. Engineering contracts of any magnitude now embody clauses which specify dates of commencement and completion, provide for extensions of time necessitated by unforeseen delay in execution, and deal with the question of damages payable by the contractor in the event of delay being due to his default. There have been several recent High Court cases affecting the interpretation of such clauses. It might, therefore, be helpful to consider the question of extension of contract time and penalty clauses in the light of modern decisions.

Delay in completion may be caused by events over which neither contracting party has control, or it may be due to the fault of the purchaser or his engineer, or the contractor may be to blame. The first cause will obviously provide grounds for an extension of time, whereas the last will invoke the penalty clause against the contractor. The second should, and generally does, entitle the contractor to an extension; but it is customary for the purchaser to ensure that delay on his part, or by his engineer, cannot found a claim for damages by the contractor, however unfair and inequitable that might be in some cases.

The term " penalty clause " is a misnomer. The Courts have always refused to recognise attempts to exact any sum in the nature of a penalty, even though no objection is raised by the contractor. In theory, only the actual loss suffered by the purchaser as the result of the contractor's default will be allowed. In practice, if a fixed sum or percentage of the contract price has been agreed as payable for each day or week by which the contract time, including extensions, is exceeded, and that sum or percentage is reasonable in all the circumstances, it will be accepted as being a sum fixed by way of pre-estimated (or " liquidated ") damages; but the use of such expressions as " liquidated damages " or " liquidated and ascertained damages " does not ensure that the Courts will not look behind those words in order to find the true purport and intention of the clause as a whole.

The actual point at which a contract may be said to be completed is sometimes difficult to determine. It is of some importance in connection with lump-sum contracts, for, prima facie, payment cannot be claimed until the work has been completed. This question has received judicial consideration on a number of occasions, and in the result it may be said that when the work is " finished " or " done " in the ordinary sense, though some details may be lacking, the contract is " complete." Even actual defects in the work would make no difference, unless they were of such magnitude as to go to the very root of the contract, for the purchaser's remedy is a claim in damages if the defects are not put right. The principle is applicable when deciding whether the contractor has completed to time, and is recognised by those who use the phrase " practical completion."

In contracts for constructional work, or for the supply of machinery with erection, it is usual to include a clause permitting the contract time to be extended to meet unpremeditated eventualities; but where the contract is for the supply and delivery of goods or equipment, there being no question of erection or work on site, such provision is seldom made. A recent decision by the Court of Appeal* is of interest in this connection. The facts of the case, which concerned the sale of a motor-car, need not be detailed here. Time was of the essence of the contract. After the stipulated date for delivery had passed, the buyer continued to press the seller, and by so doing he waived his right to rescind the contract on the grounds of non-performance. The Court held, however, that he could thereafter fix a fresh date for delivery, which was a reasonable one in the circumstances then prevailing, and by such action time would again become of the essence. At the expiration of the new period, the buyer would be entitled to cancel the contract (if delivery had still not been made), despite any supervening circumstances not previously contemplated by either party.

* Charles Rickards, Ltd. *v.* Oppenheim (1950), *Law Reports* 1 K.B. 616.

Failure by a contractor to complete to time will, if there is a properly drafted penalty clause, involve him in the payment of liquidated damages. Suppose that these damages are fixed at the rate of 1 per cent. of the contract price for each week by which the contract time is exceeded, with a maximum total of 15 per cent. This means that the contractor, after the expiry of 15 weeks, is liable for no further damages, and if he finishes in 20 weeks he is still liable only for the 15 per cent. If, however, he has still not finished, even at that stage, the question arises whether the purchaser may then, or, for that matter, at any time after the first 15 weeks, repudiate the contract. This is a matter upon which there has been as yet no decision; there is, therefore, no certain answer. Any decision will depend to some extent upon the wording of the relevant clause or clauses. On the face of it, it would seem that no right of repudiation could arise in such a case, for the mere limitation of the liquidated damages to a fixed maximum cannot, in itself, create a fresh time for completion. The only certain way is to make time once more of the essence, by the purchaser and contractor agreeing a new completion date, as in the motor-car case already mentioned.

Extension-of-time clauses need careful drafting, and proper exercising, if they are to fulfil their object. For example, it has been held* that a clause empowering the engineer to grant " such extension of time for completion of the work, and that either prospectively or retrospectively, and to assign such other time or times for completion as to him may seem reasonable," does not enable him to do so after the work is completed. All that the word " retrospectively " implies is that he may wait until the cause of delay has ceased to operate, and then fix a new completion date to which the contractor can work. In such a case, where the extension is a proper one, but is granted out of time, no damages will be payable by the contractor.

On the other hand, a clause which allows the engineer to " make a fair and reasonable extension of time for completion of the works," where he is satisfied that the delay has been due to one or other of certain specified causes, covers the granting of an extension even after the contract has, in fact, been completed. In giving this decision in the Court of Appeal,† Lord Justice Denning pointed out that there may be a continuing cause of delay, such as shortage of labour and materials or inclement weather, which is operative right up to the finishing of the work. It follows that, in such circumstances, the engineer should, as a matter of business, be able to grant an extension whether or not the original, or previously extended, contract time has expired.

In fairness to all concerned, decisions by the engineer under an extension clause should be referable to arbitration. This is generally recognised, though there are still forms of contract conditions which, somewhat autocratically, make such decisions " final and conclusive."

* Miller, *v.* L.C.C. (1934), 50 *The Times Law Reports* 479.

† Amalgamated Building Contractors, Ltd., *v.* Waltham Holy Cross U.D.C. (1952), 2 *The Times Law Reports* 269.

NOTES.

JOHN COBB.

The engineering profession and industry owe much to the few who race and test at speed. Not intimately acquainted with the finer points of design and construction on which success depends, and fully aware that even the designers themselves cannot be sure of the results, they resolutely enter unexplored regions of motion. John Cobb, who was killed when his jet-propelled boat Crusader disintegrated on Loch Ness this week, was one of the most distinguished of this gallant company. He was 52 when he died and had only lately turned to speed-boat work after a long and successful record in the history of motor racing. He was at the time of his death the holder of the land speed record, and he had succeeded in reaching a speed estimated at 206·8 m.p.h. with the Crusader. This was about 30 miles an hour faster than the record held by the American, Mr. Stanley Sayers, but unhappily it will not class as a new record. The Crusader was propelled by a de Havilland Ghost jet engine, similar to those fitted in the Comet air-liners.

DEVELOPMENT OF POWER RESOURCES IN ARID ZONES.

The fourth session of the Advisory Committee on Arid Zone Research, which was appointed last year by the United Nations Educational, Scientific and Cultural Organisation, was held in London from Monday, September 29, to Wednesday, October 1. The duty of this committee is to consider ways in which the arid and semi-arid areas of the globe can be restored to fertility; and it is performing it by, in the first place, collecting and collating the knowledge that has been gained from world-wide experiments. In particular, certain fields of research have been selected for study, the first being that of water supply, an international symposium on which was held in Ankara last April. Next year, the theme will be plant ecology, the relation of plants to their environment, while among the plans considered at this week's meeting was one for research into the use of energy derived from wind-power and from the sun. Such work has been carried out at the National Physical Laboratory in New Delhi. If means could be developed industrially it might be possible to tap the deep-water resources under deserts and thus take a first step towards making these areas utilisable for food production. It may be added that other research work on arid regions is already being carried out at stations in Algeria, Egypt, French West Africa, Israel and the United States. The activities of these stations are to be co-ordinated with those of the committee, while arrangements are being made for the exchange of scientists and technicians between them and other institutions carrying out related work. The development is one that deserves encouragement and the results will be awaited with interest.

PROGRESS OF BRITISH BROADCASTING.

A satisfactorily large, although not disproportionate, amount of space is devoted to engineering in the annual report of the British Broadcasting Corporation, which was published by H.M. Stationery Office this week at the price of 4*s*. 6*d*. This is fitting, since it is upon technical achievement that the world-wide service of this body depends. One of the principal problems encountered during the year was, however, the combating of foreign interference, especially from Russia and Spain. Attempts were made to reduce the effects of this by adjustments at all the high-power transmitting stations, but although the strength of reception was thereby increased there was some distortion during the loud passages in the programmes. Some trouble was also experienced with fading in certain districts, a problem which has been partially dealt with by the provision of local low-power transmitters. It appears, however, that the only real solution is the use of very high frequencies, although even if the Government speedily approve plans for the utilisation of this system it will be some time before it can be brought into service. The fact is that the "ether" is overcrowded, while the whole question is complicated by non-technical factors. In January, 1952, an attempt was successfully made to operate the 150-kW transmitter at Daventry unattended. Automatic programme routing and monitoring were also introduced at the largest of the Corporation's short-wave stations, in both cases to achieve economy in skilled manpower. Several of the older studios were re-treated acoustically, so as to improve the technical quality of the transmission. There were an unusual number of outside broadcasts during the year under review, the organisation of which required considerable technical skill. Developments in the television field seem to have been confined mainly to the opening of new transmitters and studios, but a study of the work of the research department indicates that further advances may shortly be made. The remainder of the report contains a great deal of interesting information, especially under the heading of "listener research," while the statement that it is necessary to produce the daily news bulletin of 2,100 words from some 300,000 words of received matter will intrigue anyone connected with editorial work.

FULMER RESEARCH INSTITUTE.

To mark the completion of the first five years' work at the Fulmer Research Institute, Stoke Poges, Buckinghamshire, an open day attended by several hundred persons, including leading figures in Government, scientific and industrial circles, was held on September 30. At the outset of the proceedings, a memorial plaque to the founder, the late Colonel W. C. Devereux, C.B.E., F.R.Ae.S., erected in the entrance hall of the main building, was unveiled by Sir Archibald Rowlands, G.C.B., Permanent Secretary of the Ministry of Supply, in the unavoidable absence of Lord Hives, C.H., M.B.E., D.Sc., chairman of Messrs. Rolls-Royce Ltd., who was to have performed the ceremony. The Institute, which was launched in 1947, exists to carry out sponsored industrial research, the results arising therefrom, including any patents, belonging solely to the sponsors. This system makes it possible to engage the services of the organisation to investigate a particular problem for an agreed fee. The director of research, Mr. E. A. G. Liddiard, in the course of an after-luncheon speech, gave an indication of the progress made by the Institute since its foundation. He stated that during the past five years the staff had more than doubled and the income trebled. Eighty-eight patents had been taken out on behalf of sponsors, which numbered over 100, and a good many scientific papers had been published. Many important problems, mainly, but not exclusively, in the metallurgical field, had been solved or were in process of elucidation. Among other successful developments arising from the research work were the production of a new series of high-strength aluminium alloys, namely, the aluminium-copper-cadmium Alminals "500"; aluminium-tin bearing metal alloys; and the production of aluminium of high purity by a catalytic distillation process. Other important researches in hand were developing new methods of producing titanium, beryllium and other metals, and of applying and testing low-emissivity refractory ceramic coatings on metals.

NEW CONTROL TOWER FOR LUTON AIRPORT.

On Wednesday, September 24, the Rt. Hon. A. T. Lennox-Boyd, Minister of Transport and Civil Aviation, opened a new control tower at Luton Airport, to replace the original control tower which was not well sited and had been found to be too small to give adequate assistance to aircraft using the airfield. The building of the new tower was designed by the Borough Engineer's Department of the Corporation of Luton, and was constructed by David Chaslin, Limited, Hoddesdon, Hertfordshire. The electrical installation was carried out by Scientific Radio and Electrical Services, Limited, Luton. It has a pleasing appearance and its situation is such that the control room, 42 ft. above ground, has a full view of the airfield and the landing-run approaches. The overall height of the building, which has four storeys, is 52 ft. 6 in. The control room, which is surrounded by a concrete balcony, is equipped with very-high-frequency radio-telephone (V.H.F. R/T) transmitters and receivers, a Marconi A.D.200 very-high-frequency direction-finding apparatus, telephones, crash alarms, wind-speed and direction indicators. The equipment is built into the control officer's desk. The wireless aerials and the equipment for the wind-speed and direction indicators are carried on a steel mast on the roof of the tower. The leads and cables pass down the centre of the mast into a duct on the control-room floor and the equipment room, on the third floor, where the main V.H.F. R/T equipment is housed. A standby battery plant is also provided in the equipment room, which comes into operation automatically should the main power supply fail. All the electrical cables are installed in a duct running from the switchgear room on the ground floor to the various offices. The ceiling of the control room is sprayed with tinted Pyrok, which provides sound insulation and cuts down glare during the day. The windows are specially arranged to eliminate reflection from night-flying equipment. The ground floor of the building is to be used as a reception room for pilots. The first floor will ultimately be used as a meteorological office; and a records office and teleprinter room will be housed on the second floor. Future plans for the development of Luton Airport include the erection of additional hangars and the construction of a concrete runway and night lighting facilities.

WORK OF THE NUFFIELD FOUNDATION.

The object of the Nuffield Foundation is "to foster those advances in knowledge from which human welfare stands ultimately to gain" by providing grants for special individuals rather than for special projects. As shown in its seventh annual report for the year ended March 31, 1952 (which was published yesterday), within these terms of reference it is, in particular, stimulating studies in the fields of biology and sociology, although it is prepared to assist other research work of real importance and promise, which lacks the funds needed for its full development. Included under this latter heading was a grant during the year of 200,000*l*. towards the cost of a radio telescope at the University of Manchester; of 25,000*l*. to be spent over the next five years in the Mathematical Department, University of Cambridge, on the construction of a new high-speed electronic calculating machine; and of 450*l*. for three years to enable Professor J. Rotblat to pursue his studies of nuclear energy states in the Physics Department at St. Bartholomew's Hospital Medical School in London. Other endowments were made towards the cost of anthropological, chemical and geological researches in Commonwealth countries; and a number of fellowships and scholarships for training and travel have also been granted. These included 650*l*. to the British section of the private international scheme of research on flame radiation; and 500*l*. to equip a laboratory for the Slough Industrial Health Service, in which accommodation will be provided for the scientific investigation and control of health hazards in small factories. A further matter with which the Foundation is closely concerned is the care of old people. The grant of 18,000*l*. to the Psychological Laboratory, University of Cambridge, has therefore been renewed for three years with a view to research being conducted into the question of how old skills can be transferred to new jobs, thus ensuring that a man who is able to work shall have the opportunity of doing so.

THE NATIONAL SMOKE ABATEMENT SOCIETY.

The annual conference of the National Smoke Abatement Society was held in Portsmouth from Wednesday, September 24, until Friday, September 26. On Wednesday morning, an address was delivered by the President (Professor F. E. Tylecote), who, after paying tribute to the pioneers of smoke abatement from John Evelyn to H. A. Des Vœux (the first President of their Society), dealt with the enormous amount of damage done by the sulphur gases emitted from chimneys. On Wednesday afternoon, the third Des Vœux Memorial Lecture was delivered by Mr. W. R. Hornby Steer on "Smoke and the Law." He suggested that whereas in the past the steps taken to secure smoke abatement had been based on prosecution and penalties, the tendency in future would be to emphasise the necessity of preventing nuisance by controlling the conditions which gave rise to smoke. Since 1946, more than 25 local Acts had been passed, all of which gave effect to the principle of "prior approval" of new industrial installations and in many cases made provision for smokeless zones. As regards administration, control could be most efficiently and economically carried out by authorities exercising powers over large areas. A number of "progress reports" were presented at the meeting on Thursday morning, September 25. These included an account of the work of the Fuel Research Station by Dr. E. T. Wilkins, who pointed out that there were now 1,208 instruments in use throughout the country continuously measuring air pollution. He also referred to the work that was being done to recover sulphur in a commercially usable form by scrubbing flue gases with ammonia liquor. On a test plant up to 92 per cent. of sulphur had been so recovered. Dealing with smokeless zones, Dr. J. L. Burn said that at least half the pollution to-day was caused by domestic smoke, and an even higher proportion of the worst pollutants, such as sulphur and the tarry products, which might seriously damage health, came from the same source. In a paper read on Thursday afternoon, Mr. W. L. Mather considered that there were five main causes of pollution in industry: the fuel, the boiler plant, the operators of that plant, the administration and special processes. He suggested that a tax on raw coal would make industry burn it more efficiently, or not at all. At the concluding meeting on Friday, Professor R. J. Sargent dealt with air pollution from steel works and pointed out that much of the pollution caused by industry was due to dust and fumes that were not related to the combustion process. They therefore required auxiliary mechanical equipment for their removal.

LETTER TO THE EDITOR.

APPLIED PSYCHOLOGY AND MACHINE DESIGN.

To the Editor of Engineering.

Sir,—I am grateful to Mr. H. Murrell for his letter on page 380 of your issue of September 19. It would appear that, whereas the general position regarding the availability of published results of research in certain fields of engineering is undeniably unsatisfactory, there is a brighter side to the picture. One is indeed pleased to learn of the excellent progress in the field of applied psychology achieved by the Ergonomics Research Society since its inception in 1950. The results so far obtained deserve a much wider readership than is to be found in the specialist journals. The main problem, therefore, remains. It is now seen to be a part of the larger issue relating to the dissemination of technical information to engineers at various levels of the industrial organisation. In other words, it is a practical problem and consequently is capable of solution.

In the circumstances, the writer inclines to the view that primarily it is a task for the experts, the experts in this instance being the Engineering Group of the Association of Special Libraries and Information Bureaux (Aslib). Between this national clearing house for technical information and the ultimate user there stands the work's technical information officer, the key man in the situation. He it is who is in contact with the experts at top levels and also with the engineers in the various establishments where the information is actually used. Somehow these two groups, namely, the upper and intermediate, must make contact to bring the information to that level where it can be made readily available to the seeker. This is, of course, a simplified picture; but I submit that this three-way approach provides a sure foundation, permitting future elaboration when found necessary. Needless to say, a vast amount of hard work will be required, as has been already pointed out in your leader on page 210 of your issue of August 15.

Yours faithfully,
S. C. McKenzie.

Allendale,
63, Sidney-road, Rugby.
September 26, 1952.

CENTENNIAL OF AMERICAN ENGINEERING.

(*Concluded from page 369.*)

As reported previously, the centenary of the American Society of Civil Engineers was recently celebrated in Chicago by the organisation of a Centennial of Engineering, a great concourse of engineers and engineering societies, mainly American but including also delegations from most other parts of the free world. The greater part of the period was spent in technical discussions, which lasted from September 3 to September 13, but there were, besides, a number of special occasions marked by ceremony, and, at some of these, British representatives figured prominently. One such occasion, the "Honorary Membership" dinner of the American Society of Civil Engineers, at which the principal guest was Mr. A. S. Quartermaine, President of the Institution of Civil Engineers, was mentioned on page 369, *ante*; others are referred to below.

An International President's Luncheon, given by the American Society of Mechanical Engineers in honour of the presidents of engineering societies from other countries, took place in the Sheraton Hotel on September 9. Dean O. W. Eshbach, of North Western University, Chicago, presided, and Mr. J. D. Cunningham, past president of the A.S.M.E., delivered an address of welcome to the guests. Mr. R. J. S. Pigott, President of the A.S.M.E., presented Mr. C. S. Proctor, President of the American Society of Civil Engineers, with a commemorative scroll and expressed his society's congratulations to the A.S.C.E. on their attaining their centenary. Mr. Proctor, in returning thanks, spoke of the value of the Centennial of Engineering celebrations in drawing attention publicly to the part played by engineers in modern society and as testifying to the unity of the engineering profession. Responses to Mr. Cunningham's address of welcome were made by Mr. L. Giannattasio, President of the Pan-American Federation of Engineering Societies, and by Sir David Pye, vice-chancellor of London University and President of the Institution of Mechanical Engineers, who spoke on behalf of all the delegates from overseas. Sir David recalled that six out of 34 honorary members of the Institution of Mechanical Engineers were past presidents of the A.S.M.E., that of seven recipients of the James Watt Medal, two, namely Mr. Henry Ford and Professor Timoshenko, were American citizens, and that five of the nine Clayton Lectures so far delivered had been given by Americans, all of whom were members of the A.S.M.E.

Sir David also recalled that the A.S.M.E. and the Institution of Mechanical Engineers had collaborated before the second World War in a discussion on lubrication, and, in 1951, had held a conference on heat transfer, the proceedings of which were shortly to be published. He was also glad to learn that the A.S.M.E. intended to reprint the proceedings of the British symposium on Gas Turbine Techniques. At the conclusion of the formal speeches, Mr. R. J. S. Pigott delivered an address entitled "What is Not Yet, May Be," in the course of which he reviewed the present stage of development and the future prospects of power units and expressed the view that the day was in sight when gas turbines would operate at temperatures in the neighbourhood of 3,000 deg. F.

Wednesday, September 10, was designated "Centennial Day," and no formal meetings were held then. Instead, the day was the occasion of the principal social events of the celebrations. A centennial luncheon was held in the Conrad Hilton hotel, at which the John Fritz Medal and the Hoover Medal, two of the highest honours conferred within the engineering profession in America, were awarded. Ex-president Herbert Hoover, in whose honour the second medal was struck, was present and made the presentation. The gathering was presided over by Major Lenox R. Lohr, President of the Centennial, and an address of welcome to the convocation was delivered by the Mayor of Chicago, Mr. Martin H. Kennelly. Mr. A. S. Quartermaine, President of the Institution of Civil Engineers, brought greetings and good wishes to the American Society of Civil Engineers from all the foreign visitors and expressed his pleasure at the presence of ex-President Hoover who, he mentioned, was an honorary member of the Institution of Civil Engineers. Mr. C. S. Proctor, President of the A.S.M.E., responded.

The John Fritz Medal, first struck in 1902 in honour of John Fritz, of Bethlehem, Pennsylvania, a pioneer in the American iron and steel industry, and awarded by a board consisting of representatives of four American engineering societies, was presented to Mr. Benjamin Franklin Fairless, President of the United States Steel Corporation, "for notable achievements in the production of steel." In making the award, Mr. R. E. Dougherty, chairman of the board, described Mr. Fairless as "a champion of the American free-enterprise system." In returning thanks, Mr. Fairless spoke of John Fritz as one who had contributed not only to the science and technology of steel making but also to the integrity of the steel industry and its products. Fritz was, he said, distinguished by his pride in honest workmanship and his contempt for mediocrity: the present-day world would have little to fear if the same uncompromising passion for integrity prevailed in every walk of life.

Turning to a discussion of human relations in industry, Mr. Fairless said that he wondered how many of those gathered together in Chicago to celebrate the great achievements of engineers during the past century realised the alarming extent to which national advances in the fields of science and engineering were being discounted by the failure of America to make similar progress in the field of human relations. As an example, since the end of the recent war, the American steel industry had been engaged on a vast programme of expansion which had added approximating 2,500,000 tons annually to its ingot capacity. Yet, during the same period, the nation had lost an average of 7,000,000 tons annually as a result of strikes. At Morrisville, Pennsylvania, the United States Steel Corporation was building the largest integrated steel plant ever constructed in so short a time, yet it would take this plant ten years to turn out as much tonnage as the nation had lost in less than eight weeks in the summer of 1952. Mr. Fairless suggested that the solution to the problem presented by labour disputes could not be found in government action. There must be a genuine attempt to reach better relations between management and labour within industry itself.

The Hoover Medal was founded in 1929 to commemorate the civic and humanitarian achievements of Mr. Herbert Hoover, and its recipients are chosen for their distinction in public service. The award for 1952 was made to the Rt. Hon. Clarence Decatur Howe, Minister of Trade and Commerce and Defence Production, Canada. Mr. Howe, in reply, recalled that he had been a cabinet minister for 17 years and a member of the American Society of Civil Engineers for 40 years. A century ago, he continued, engineers were technicians concerned with design and construction, while management and direction were undertaken by others. At the present day, however, executives who were trained engineers were to be found in the highest managerial posts, and the direction of policy was frequently undertaken by them. This was as it should be, for a training in engineering was an excellent foundation for such a career.

After the conclusion of the ceremonies connected with the presentation of the Hoover Medal, ex-president Hoover was invited to address the company. He received a great ovation. Mr. Hoover began by expressing his pride at his association with the Institution of Civil Engineers, referred to earlier by Mr. A. S. Quartermaine, and added that it was also a source of gratification to him that his honorary membership dated from a period before that in which he had taken to managing wars. Engineers had contributed greatly to the building of the modern world, and Mr. Clarence Howe had proved that an engineer had something to contribute to public affairs that could not be obtained from a lawyer. He thought that if they could keep out of wars, and avoid inflation and high taxes, the American people were on the threshold of greater advances than had ever been known previously, and this even without any further scientific inventions and discoveries. He was certain, however, that discoveries and inventions would be made, for North America had over 5,000 research laboratories. Science and engineering, besides producing a world of plenty, could contribute to the moral and spiritual welfare of mankind, for they were founded on truth and depended on it.

In the evening, a Centennial Party was held in the International Amphitheatre. After dinner, the audience heard an address by Mr. C. F. Kettering, research consultant of the General Motors Corporation; his subject was "A Review of the Century."

At a luncheon held in the Congress Hotel on Thursday, September 11, under the auspices of the American Institute of Electrical Engineers, Sir John Hacking, President of the Institution of Electrical Engineers, presented the Faraday Medal of the Institution to Professor E. O. Lawrence, of the University of California, well known as the inventor of the Cyclotron. The presidents and secretaries of the Institution of Civil Engineers and the Institution of Mechanical Engineers, and the secretary of the Institution of Electrical Engineers were also present. Sir John, in making the presentation, recalled that the award had been founded in 1921, on the occasion of the fiftieth anniversary the Institution, to commemorate the work of Michael Faraday, chiefly conducted at the Royal Institution, London. Faraday, he said, was a man of simple tastes and ways and it had, therefore, been thought fitting to commemorate him in a simple manner, namely, by the striking of a bronze medal. He would remind the company, besides, that the highest British military honour, the Victoria Cross, was also a bronze medal. The Faraday Medal on this occasion was being awarded to Professor Lawrence for his outstanding work on nuclear physics. He had also undertaken earlier researches on photo-electric effects and on linear resonance-accelerators, the limitations of which had led him to develop the Cyclotron. Professor Lawrence was also a Nobel Prizeman and had received the Hughes Medal of the Royal Society in 1937. Professor Lawrence, in returning thanks, said he had had the good fortune to work with engineers for 20 years in the development of the Cyclotron, and he paid tribute to the assistance given by British engineers in the "Manhattan Project."

The conclusion of the Centennial of Engineering celebrations was not marked by ceremony. The series of public addresses forming the symposium, referred to on page 369, *ante*, ended on Friday, September 12, and the meetings of the specialist societies were concluded on September 13.

LOCOMOTIVE SHED NUMBERING; BRITISH RAILWAYS.—A booklet giving the code numbers and letters of the locomotive running sheds on British Railways has been prepared by the Locomotive Publishing Co., Ltd., 88, Horseferry-road, London S.W.1 (*Locomotive Shed Code*, price 1*s*.) The shed to which each engine is allocated is indicated by the code number and letter on a small plate which is fixed to the smokebox door.

CHURCHILL GOLD MEDAL.—The Society of Engineers, 17, Victoria-street, London, S.W.1, announce that the Churchill Gold Medal of the Society "for the most noteworthy development in engineering or contribution to contemporary engineering," has been awarded, with the approval of the Prime Minister, to Air Commodore Sir Frank Whittle, K.B.E., F.R.S., Hon.F.S.E. The presentation will take place at the Society's meeting on October 6, particulars of which are given on page 493, *ante*. It is the first award to be made by the Society.

LAUNCH OF INSHORE MINESWEEPERS.—The Admiralty announce that two inshore minesweepers have been launched recently: the M.2001, built by J. Samuel White & Co., Ltd., Cowes, Isle of Wight, on September 3; and the M.2604, built by Philip and Son, Ltd., Dartmouth, on September 30. This series of vessels, which is of an entirely new type, embodies a number of novel features introduced as a result of experience gained during the war and subsequently. The vessels are designed to operate in shallow waters, such as rivers and estuaries. Each has a length of 106 ft. 5 in., a beam of 20 ft. 6 in., and, in addition to mine-sweeping equipment, mounts one small gun. The main machinery for the M.2001 was constructed by Foden, Ltd., Sandbach, Cheshire. According to the Navy Estimates, 29 of these vessels were in the course of construction, but not launched, at the end of March last.

THE BRITISH ASSOCIATION MEETING IN BELFAST.

(*Continued from page* 402.)

CHEMICAL ENGINEERING IN INDUSTRY.

THE subject of chemical engineering was dealt with in Session B on Monday morning, September 8, the chair being occupied by Sir Ben Lockspeiser, President of the Section. Two papers were read and discussed, the first being "The Training of Chemical Engineers," by Professor D. M. Newitt, M.C., F.R.S., which is printed, in slightly abridged form, on page 388 of our issue of September 19; the second paper, entitled "The Chemical Engineer in Industry," was by Dr. E. H. T. Hoblyn, and is printed in this issue.

After both papers had been presented by their authors, the discussion was opened by Sir Harold Hartley, K.C.V.O., C.B.E., M.C., F.R.S. Sir Harold said the authors of the papers had dealt with the subject on very broad lines from the point of view of the future place of chemical engineering in industry, the composition of chemical engineering and the part industry should play. He did not think, however, that they had been sufficiently provocative in view of the very urgent problems which the country had to face. He asked why it was that the big construction companies in New York could point with satisfaction to the designs they were making for great plants to be erected in this country and in the Dominions. Both authors, he continued, had claimed that chemical engineering was the fourth primary technology and would like to think that was accepted by other engineers. Historically, it was quite simple: first, there had been civil engineering, which had claimed the whole field; then, from the introduction of the steam engine, the specialised techniques of the mechanical engineers had developed; and the same process had happened again in the case of the electrical engineers. Now, in the Twentieth Century, with the great development of the chemical industry and the invasion of all processing industries by chemical techniques, this fourth primary technology had been developed.

Sir Harold then read a summarised statement by Professor Elgin, of Princeton, as follows: "There has developed a distinct body of science which is fundamental and peculiar to chemical engineering. This involves principles, theories, procedures and techniques fundamental to the majority of chemical-engineering operations. While, in some cases, this body of science involves and utilises subject matter and principles common to other sciences, it modifies, extends, orients and combines those principles in a unique manner."

That, Sir Harold said, gave very briefly the general groundwork of chemical engineering. The authors, he continued, had spoken of the spheres of operations of chemical engineering (research, the design and construction of plant and its operation); but he did not think they had emphasised that chemical engineering was not self-sufficient. The big chemical construction companies had their civil, mechanical and electrical engineers, but it was the chemical engineer who was the co-ordinator of those activities. There was, perhaps, an idea that this was all chemistry. When the chemical engineer took the ideas and the basic research from the laboratory, the design, as in other engineering, was based mainly on classical physics. There was a danger that chemical engineering, like other branches of engineering, was faced with the fact that, with the lure of nuclear physics and electronics, the classical physicist was becoming extinct. In America, a professor of chemical engineering had said that "the classical physicist is going out of business, and we have to take over."

If, continued Sir Harold, he were asked for an example of what the chemical engineer had achieved recently he might take the "fluidisation" processes, which depended on contact between gases and solids; where, in the old days, gases were passed over fixed solids, nowadays, with an enormous increase of efficiency, those processes were carried out by air-borne particles in the gas stream. That development was due entirely to a week-end party of chemical engineers; one of them put up a pilot plant in a very few weeks, and a full-scale plant was erected within a year. That was the kind of approach that the chemical engineer had to these problems. During the last twelve months, Sir Harold said he had made a series of pilgrimages in this country, America and South Africa, to try to inform himself of the progress that chemical engineering was making, of its position in industry and of the methods of training used. In South Africa, for instance, he had found everywhere a great demand for chemical engineers.

Speaking of the leeway that had to be made up in this country to satisfy the demands, he said that in the United States 5,000 chemical engineers were being produced in a year, whereas we were producing about 200. That presented a very serious position for industry to face because, as Professor Newitt had pointed out, the importance of chemical engineering as a technology was the generality of the approach of the chemical engineer and his adaptability. Going around the universities, Sir Harold had found a very wide diversity in the methods of training. In America he had found in the engineering faculties a division devoted entirely to chemical engineering, and the training or education there was given almost entirely by teachers of chemical engineering. He felt that in that way perhaps the maximum of efficiency was obtained for the large amount of ground that had to be covered. As a general rule in this country, chemical engineering was combined with the chemical, engineering and physics training in the universities, using these courses as a preliminary to the final year of chemical engineering proper. This had the advantage of bringing chemical engineers into touch with their colleagues, but it meant that they spent a certain amount of time on things not absolutely essential to them. Then there was the extreme case at Cambridge, where students took the first part of the tripos in either chemistry, physics or engineering, and the second part in chemical engineering. Thus there was a wide diversity of educational methods, and every university must follow the practice best suited to its conditions. Sir Harold said he thought that chemical engineering should be a part of the engineering faculty; it was engineering, and that was where it belonged. In some universities there was still what he regarded as an extinct subject for universities, namely, chemical technology, which had its place 50 years ago, but was no substitute for chemical engineering. Chemical technology too often depended on local needs—fats and oils, fuel, textiles, and so on. This tended to produce men with a somewhat specialised type of experience and a rather limited outlook. Referring to the fact that Queen's University, Belfast, was at present laying the foundations for new schools of engineering and chemistry, Sir Harold expressed the hope that in those schools a place would be found for chemical engineering.

Sir Harold concluded with an appeal to engineers to recognise and to give their support to this fourth primary technology. It was, he said, complementary to the older technologies, and not competitive with them. "Give it a place in your team," he added, "because on your teamwork so much of the future industrial prosperity of this country depends."

The next speaker in the discussion, Mr. C. C. Inglis, said he considered it vital to educate students in fundamental principles; but it was also most important to educate them to recognise these principles when they cropped up; often he found that highly educated men failed to do so. He urged that educationists should give as many examples as possible of cases where underlying laws had been disguised by unnecessary detail. Suggesting that eight weeks' practical experience in a works during his vacation was useless to a student, Mr. Inglis said he thought that less than a year in a works rarely gave a student time to appreciate the practical side. He would not say that a student was useless to industry unless he had had seven years' practical experience; a well educated man to-day could pick up in 18 months or two years as much as his precedessors would in five years. For this reason he favoured the sandwich system—a year at the university and another at the works—over five years. Continuing, he said that in any development there had to be a certain objective, and the conventional method was a step-by-step process to reach that objective. He would like to hear whether some of the younger men in the audience felt that their education had been right, and whether they felt that they had had their money's worth out of it.

Mr. H. Young, the next speaker, first mentioned, to avoid any misunderstanding, that he had served his time for five years. He agreed that the business of the chemical engineer was primarily one of engineering and a young man should, therefore, begin with a sound basis of shop practice. A period of seven years, or even of five years, was too long; on the other hand, eight weeks in the shops was really of no use unless the young man had some previous background knowledge. The present educational system was arranged so that, unless the young man was wealthy, it paid him to go on from school to a course in a university. Mr. Young believed in the method he had followed with his own children with successful results—that they should serve for at least two years on the shop floor before entering a university on an engineering course, particularly in chemical engineering. Having obtained a degree and entered industry, he might be employed on shift supervision; it was a hard life, but it provided a very good training ground. He might then go forward and be concerned with the actual design of plant, and then on to plant evaluation, where he would have to consider whether a thing could be made to pay. Subsequently came the consideration of all the possible ways of doing a job.

When considering the building of plant, it was first necessary to have a talk with the chemists, who explained how the process worked. Sometimes, however, they overlooked some important matter, such as that the conversion was only 5 per cent., and the consumption of thermal energy would be out of question in such a case. Such matters were likely to be overlooked unless a man had had a good training at the beginning in the practical things that could be learned only on the shop floor and in the drawing office. Mr. Young pleaded for the encouragement of a system by which it would be worth a student's while to put in a least two years on the shop floor, followed eventually by at least one year in the drawing office.

Mr. J. Taylor, dealing with the problem of providing chemical engineers in sufficient numbers in a fairly short space of time, said that although he did not disagree fundamentally with making chemical engineering a separate technology and making it an automatous subject from the beginning, as was done in some American universities, he considered the most rapid progress would be made here by providing a post-graduate course, such as the M.Sc., in chemical engineering practice at the M.I.T. Most people in the chemical industry believed in the pure-science degree course as first training, and he thought that, on the whole, honours graduates in chemistry or physics were preferred to train as chemical engineers later. That was not contrary to the American idea; Professor Lewis had told him that they preferred honours graduates at 24 or 25 years of age to take a post-graduate course. The difficulty was to provide finance to enable a man to take that type of training. It was relatively easy to obtain a grant for research, but it was very difficult to get one for any form of training. Men should be selected after taking their first degree; those who were fitted primarily for research should go into research, and a certain number, of equal quality, who were more fitted for training in the application of science to practical problems should be given an opportunity to take the post-graduate training courses. That would need support from industry. Many people thought that we must introduce practice schools into this country similar to those used in the M.I.T. He felt that the practical training could be provided by industry, preferably under the direction of a university. Urging that it was a mistake to base a chemical-engineering school on an engineering faculty, he said the great amount of chemical engineering work required in progressive industries was more on the chemical side, and it related to working out the processes on a semi-technical scale from the laboratory scale. That was largely the work of men with fundamental training supplemented by chemical engineering training; then the work was turned over to chemical engineers, mostly mechanical engineers with that kind of additional training, and he felt that this training could be done by the chemical faculty.

Dr. E. R. Thomas, O.B.E., expressed the hope that as the Higher National Certificate in chemical engineering developed, it would be possible for the better students to enter a university. That was being done in mechanical engineering in one university, and recently he had been meeting the products; they were a very fine type and should not remain in the "N.C.O." category.

Mr. Kenneth R. Evans, whose firm, Messrs. Metropolitan-Vickers, engage about 120 graduates in electrical and mechanical engineering and in other sciences each year, supported Dr. Hoblyn's point that those with a H.N.C. (the N.C.O.s) should have an opportunity to become "commissioned," for he felt it would be very bad for the world and for industry if the higher positions became a "closed shop" for university graduates. He suggested that a lot of the H.N.C. candidates would do equally well in industry and commerce without a university degree; to deny the higher positions to those who, for one reason or another, could not take a degree would be to remove incentive, and it would give graduates an inflated impression of their importance. He was glad to say that the teachers of electrical and mechanical engineering whom he knew throughout the country, almost without exception, were strongly urging their young men, at the end of their university studies, to take a course of practical training in industry before settling down to a specialised job; there was no question of the universities not co-operating with industry in that respect. Lastly, a year in industry before going up to the university matured a man and enabled him to find out whether engineering was the kind of work he wanted to do.

Dr. Hoblyn, replying to the discussion, said that a matter which had become very confused was the difference between training and education. The references to having university courses upset by lengthy spells in industry, and to young men, having advanced in their school work to, say, university entrance standard, going into industry for two or three years before going up to the university, seemed to have produced a rather confused state of mind.

He agreed with Mr. Evans' remarks concerning the position of the H.N.C. men, and said that was why those in chemical engineering were so glad to see the H.N.C. courses developing. Commenting on the question of whether some chemical engineering study superimposed on, say, chemistry was better than a direct four-year course, Dr. Hoblyn urged that both should be available and it should be made possible for any chemist who wanted to become a chemical engineer to train for that purpose. On the matter of vacational training, he considered that a period of eight weeks in a works was better than none at all, but he would prefer that, having obtained his education in school and university, a man should then go on with his training and spend a year or two, preferably two, in industry; he would then feel that he was something like a trained man. Finally, remarking that he had deliberately not used the word "humanities" in his paper, he said that when the education and training of technologists was being discussed there was usually frequent reference to the humanities; and he was in complete agreement with the importance of this matter.

Professor Newitt, who also replied, said he was glad to find that so much attention had been given to the relations between the schools and industry, for that was the crux of the whole matter. On the whole, he thought the easiest way from the teacher's point of view was that which Dr. Hoblyn had suggested, namely, that a young man should go from school to university, recognising that when he left the university he still needed training. That method, however, might not necessarily be the best. With sandwich courses a great responsibility was placed upon industry, and he did not know what kind of control would have to be exercised to ensure that industry conformed to the standards required for the students to benefit by the method. His misgiving regarding sandwich courses concerned the machinery for linking up the training in industry with the university training. He was sorry that Mr. Taylor had again put forward his view that the right way in which to train a chemical engineer was for him to take a first degree in chemistry and then to have something superimposed upon it. He did not believe Mr. Taylor would say that the right way to train a man to become a mechanical engineer was for him to take a degree in physics and then have something superimposed upon it; but that was a parallel case, for mechanical engineering was applied physics, just as chemical engineering was applied chemistry. He did not think anyone would agree that a mechanical engineer could be trained economically in that way, and neither could a chemical engineer.

Although he had great sympathy with the scheme for establishing practice schools, he thought that the machinery for getting them going would be rather difficult to organise. It was a costly business; if it were to be done properly, a member of the university staff should be attached to the firm in which the course was undertaken so that he was able to organise and direct it. He had more sympathy with the points raised by Mr. Inglis. The recognition of first principles by students was one of the matters which every teacher had at the back of his mind; but teachers were dominated at the moment by the examination system. During the first two or three years, the students became obsessed with examinations, and they had not time to think about the recognition of first principles. That was why it was so important, after the examinations were over, to provide a post-graduate period during which that second part of a man's training could be given emphasis. That was his solution of the problem.

The President, in thanking Professor Newitt and Dr. Hoblyn for their papers, said it would be extremely useful if, as suggested by Dr. Hoblyn, the young people who felt strongly about the matter could discuss it round a table. The meeting had carried the discussion of the subject a useful step forward, and by the expression of views round a table something further might be achieved.

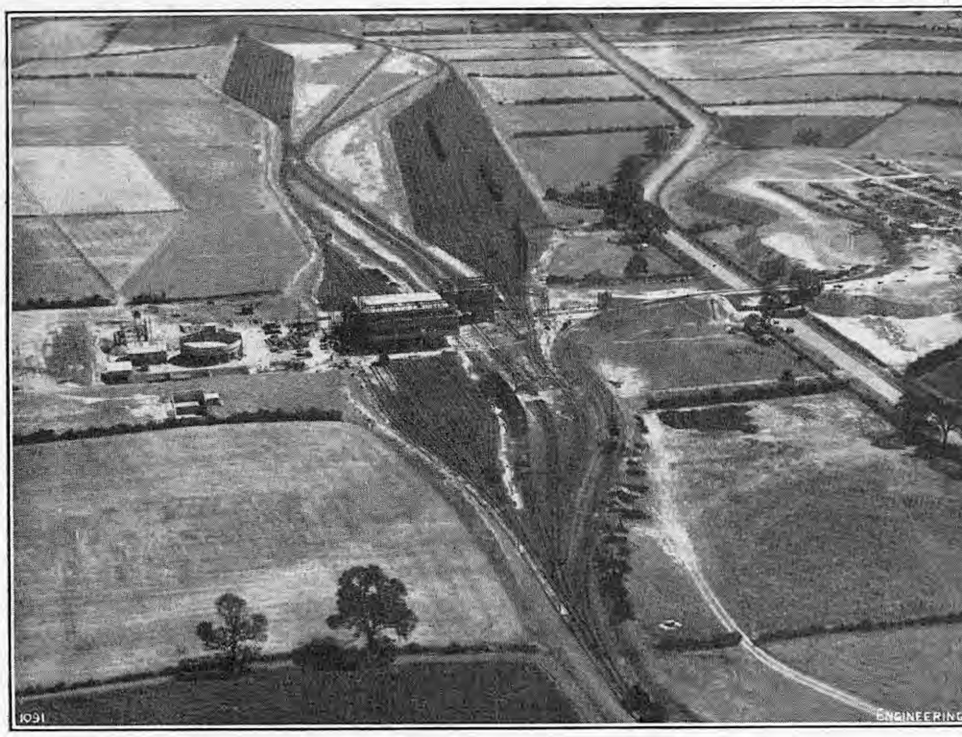
This concluded the programme for the morning and the meeting was adjourned. For the afternoon, visits were arranged to the Linen Industry Research Association, and the works of Messrs. Wm. Ewart and Sons, Limited. There was also a tour of Belfast harbour. In the evening, members of Section G were invited to a reception at Belfast College of Technology by the Technical Instruction Sub-Committee of the Belfast Education Committee.

(To be continued.)

MINIATURE SOLDERING IRON.—For use in soldering miniature electrical and radio components, Oryx Electrical Laboratories, 3, Tower-hill, London, E.C.3, have introduced a miniature soldering iron, 6 in. in length, which has a net weight of only $\frac{1}{4}$ oz. It is designed to operate on one of three low-voltage supplies—6 to $6\frac{1}{2}$ volts, 12 to 13 volts or 24 to $27\frac{1}{2}$ volts—and consumes less than 9 watts. It will accommodate detachable push-on bits, $\frac{5}{32}$ in. or $\frac{3}{32}$ in. in diameter. No ceramic or porcelain insulators are employed, and the tool will withstand shock loads.

ELECTROTHERMAL RUBBER SHEETING.—Electrothermal Engineering Limited, 270, Neville-road, London, E.7, have recently introduced a range of rubber sheeting in which electrical heating elements are embodied. It is considered to be particularly suitable for quick-setting synthetic resin glues, for heating chemical apparatus, and for any process requiring a flexible or mobile heating source. The material, known as E.R.S. (electrothermal rubber sheeting) is available in ratings of 150, 250 or 400 watts per square foot, and will radiate heat at controlled temperatures of 100 deg., 150 deg. or 200 deg. C. Normally it requires about 20 to 30 minutes to attain the maximum temperature, but it can be designed to reach a specified temperature in a shorter period. The sheet will withstand considerable pressure. It can be supplied as strips up to 6 ft. wide with a thickness of $\frac{3}{16}$ in. The standard sizes of sheets range from 12 in. by 6 in. to 96 in. by 48 in., but non-standard sizes are available if required. It will operate on 100/120 or 200/250-volt alternating or direct-current mains. The sheeting has been tested satisfactorily for resistance, completely immersed in water and subjected to 1,800 volts alternating-current and 2,500-volt direct-current supplies. A production sample, still working efficiently, has been operating continuously at 180 deg. C. for over 2,000 hours.

CALVERTON COLLIERY.



CALVERTON COLLIERY.

As reported on page 441 of last week's issue of ENGINEERING, Lord Leathers, P.C., C.H., Secretary of State for the Co-ordination of Transport, Fuel and Power, officially opened the colliery and Branch Line at Calverton, Nottinghamshire, on the previous Wednesday, September 24. Calverton Colliery is the first large, new colliery to come into production since the mines were nationalised; it is sited about seven miles to the north-east of the City of Nottingham. The new colliery, planned as an extension to Bestwood Colliery, was conceived, and the project started, by B.A. Collieries, Limited, under the guidance of Col. C. G. Lancaster, chairman and managing director of the company. The first work of construction was begun in June, 1937, and the development is being completed jointly by the National Coal Board and British Railways.

The sinking of No. 1 shaft was completed in November, 1939, when it reached the Top Hard Seam with which connection had been made from Bestwood Colliery. It was put into immediate operation for riding men to the seam and to assist with ventilation of the working face, although the coal from the mine continued to be raised at Bestwood. The canteen, pithead baths, lamproom, offices and 22 houses of the proposed new colliery village were erected by September, 1939, when the war interrupted the work. In 1945, the original proposals were reviewed and arrangements made to sink a second and larger shaft to be equipped for skip winding, together with the most up-to-date provisions for coal handling and preparation. In that year negotiations were opened with the railway company for providing transport facilities at the colliery, and parliamentary powers for the construction of $7\frac{1}{2}$ miles of branch line were obtained under the London, Midland and Scottish Railway Act, 1947.

The No. 1 shaft, 18 ft. 2 in. in diameter, has an overall depth of 1,680 ft. to the Top Hard Seam. During sinking, water was encountered at a depth of 60 ft. and for a further 300 ft. down, and a cementation process was therefore used to seal the working chamber. The shaft is lined with reinforced concrete, 18 in. thick, through water bearing strata and 14 in. thick elsewhere. The No. 2 shaft, 20 ft. 2 in. in diameter is of the same depth as No. 1, and is situated within a few yards of it. In order to sink through the water in this shaft, however, a freezing process was used. The lining is of concrete in the dry sections and of cast iron segments in the water-bearing measures. Ultimately No. 2 shaft will be used for raising the coal and No. 1 will be restricted to men and materials, although at present No. 1 shaft alone is in operation. Lifting the coal will be at the rate of 400 tons per hour in 10-ton skips, and from the pithead it will travel on a rubber conveyor belt to the coal-preparation plant. The conveyor belt operates in a box tunnel, built in cut and cover, and, where it crosses the Oxton-road, the tunnel is built within the constructional depth of the bridge over the road, as shown on the right of the accompanying illustration.

The coal-preparation and handling plant, which is as yet only partly completed, has been designed to handle an output of 450 tons per hour. Coal gradings over 8 in. are being sorted on a "Hardwick" picking table, which is well illuminated by daylight strip lighting; the "Hardwick" is a circular rotating bench with the sorters stationed on the inside and with discharge ploughs arranged round the outer periphery of the table. As the coal comes off the main conveyor belt on to the table the waste and different gradings are successively pushed to the outside, where they are ploughed-off on to a further series of conveyors. At present everything below 8 in. is being taken out and transported elsewhere for sorting and washing as the necessary plant has still to be installed at Calverton. Ultimately, grades of 8 in. down to 1 in. will be dealt with in a "Barvoys" washer and still finer coals will pass through "Blantyre Baum" wash boxes. The arrangements will be such that the grades below 8 in. will by-pass the "Hardwick" table and can then be either washed or handled in the dry state. Below the preparation plant there are eight wagon roads, each fitted with a mechanical device for the correct location of the wagons; control of the wagons is maintained from the plant room above.

All the surface buildings have been designed in keeping with modern architectural practice and the canteen and pithead baths, constructed in 1937, have a possible accommodation of 1,250 men. To obviate the usual practice of carrying pipelines, cables, etc., overhead, all services have been collected into a 5-ft. square reinforced-concrete duct, constructed below ground, which connects with all principal buildings.

Rail access to the colliery is provided by a double-track branch line connecting with the Midland Region's Leen Valley line near Bulwell. The total length of the branch line is just over $7\frac{1}{2}$ miles, of which a considerable part has been built in cutting and, in all, nine new bridges have had to be provided. Mechanical signalling has been installed and four new signal boxes built. The new branch line has been designed to handle the $1\frac{1}{4}$ million ton annual output of the colliery as well as all stores and materials that are required. The layout of the sidings is well shown in the illustration. The three clusters of sidings have a total capacity of 1,000 full and 770 empty wagons, and Diesel locomotives will be used for all local shunting. As they become available, British Railways' new $24\frac{1}{2}$-ton mineral wagons will be used exclusively for transporting the coal from the colliery.

In all, five good seams, with a total of 130 million tons of coal, have been proved during the sinking and by surrounding boreholes, and the reserves ensure a life of about 100 years for the colliery. All electrical power for both surface and underground workings will be obtained from the national grid. It is expected that a total labour force of 1,800 will be employed.

OPENING-OUT OF BROTHERTON RAILWAY TUNNEL.

BECAUSE evidence of deterioration and of settlement of side walls had grown during recent years, tending to reduce the clearances, Brotherton railway tunnel, constructed in 1848 on the York-Sheffield main line, has been opened out to a cutting. The total length of the tunnel was approximately 320 yards, and at the north end it carried the A1 trunk road. Only 100 yards at the north end of the tunnel had been driven through limestone, the remaining 220 yards being of cut-and-cover construction with a covering of approximately 1 ft. 6 in. over the crown of the arch. The construction of this latter portion consisted of a brick arch, four rings thick, supported on side walls 4 ft. thick, of fairly loose stone rubble backing, faced with masonry. In 1912, a length of about 50 yards of the side wall on the down side was rebuilt in brickwork on mass-concrete footings. Inspection holes cut in the northern section of the tunnel showed a minimum of six rings of brickwork in the arch generally. The side walls, as in the remainder of the tunnel, consisted of dry rubble filling, masonry faced, the thickness varying between 2 ft. and 3 ft. The clear span is 24 ft. 10 in. and the rise of the arch 7 ft. Strutting from toe to toe at sleeper level had been carried out in the past at two points to seek to arrest the movement. Further movement developed in recent months and it was therefore decided to demolish the cut-and-cover section of 220 yards, and open out to a cutting.

Permission was obtained from the owners of adjacent land to use it as a tipping site for the earth spoil. The top soil was to be scraped off, laid aside, and re-spread over the filling on completion. It was further arranged for the material from the demolished arch and side walls to be used to fill an old wagon-way which ran along one of the boundaries of the adjacent land. It was estimated that the wagon-way would accommodate all this material, so that no provision for removing the spoil from immediately adjacent to the work would be required in the opening-out operation. The contract for carrying out this work was let to Messrs. Leonard Fairclough, Limited, Adlington, Lancashire, and arrangements were made for all traffic using the line to be diverted between Sunday, May 11, and Sunday, May 25. Work commenced on Thursday, April 24, with the scraping of the top-soil from the adjacent land, leaving the soil over the arch to be removed by dragline excavator.

In view of the very limited time of complete occupation of the line, as much of the excavation as could safely be removed without affecting the stability of the tunnel was cleared during the two weeks prior to taking possession. Fig. 1, on page 440, shows the initial excavations. By use of draglines and scrapers, the excavation was carried down behind the side walls to the final level of the slope at that point, approximately 3 ft. above the top of the sleepers, and the slopes were trimmed back to a grade approximating to the final one, the spoil being tipped and spread over the adjoining land, filling hollows and irregularities. Over a period of two weeks, operating between the hours of 6.0 a.m. and 9.30 p.m., three dragline excavators, with bucket capacities of $1\frac{1}{2}$, $1\frac{1}{4}$ and $\frac{5}{8}$ cubic yards, were employed, with attendant lorries, and three tractors with 6-cubic yard scrapers; some 17,000 cubic yards of spoil was removed, tipped and spread.

By Saturday, May 10, all excavation which could be carried out with safety while traffic still operated had been completed, leaving the tunnel arch and side walls bared and ready for demolition. The demolition of the tunnel was carried out by use of explosives (Fig. 2), holes having been drilled at 4 ft centres from inside the tunnel in the side walls, one line immediately below the arch springing and another line 3 ft. above cess level. Ashes were deposited on the tracks to rail level throughout the length of the tunnel to be cleared, to give protection to the chairs and sleepers from the falling material, and also to provide for working an excavator with face shovel, loading into lorries at track level. A complete section of brickwork and masonry in the arch and side walls was cut out to separate the length of tunnel to be demolished from that which was to remain. The blasting operations were not completely successful, and more holes were drilled to enable charges to be placed at 2-ft. centres. This gave more satisfactory results although several portions of arch and walls were, in fact, removed with the buckets of the dragline excavators. By the evening of Tuesday, May 13, two days after commencement, the brick arch and side walls of the tunnel had been demolished throughout the whole length, and clearing out the rubble commenced. For this work, the two larger excavators, equipped with draglines, worked from the top of the new side slopes and the smaller one, equipped with face shovel, operated at track level from the south end and proceeded clearing up behind the work of the draglines. This operation is illustrated in Fig. 3.

As soon as sufficient debris had been removed from the end of the length of tunnel being retained, construction of the new portal commenced. It included a reinforced-concrete facing to the end of the existing arch brickwork. As centering had to be erected for the construction of this arch, it was essential for it to be completed during the period of complete occupation of lines. The lines were restored for traffic operation, as planned, at midnight on Sunday, May 25.

Thereafter, the portal with artificial-stone facing and concrete backing was completed on Sunday, July 6. This job may be seen in Fig. 4, which shows the work complete. The re-soiling of the field was carried out as soon as the excavation, spreading, and levelling were completed, and top soil for the cutting slopes was heaped along the top of the slopes ready for raking down and spreading. The tractors and scrapers were released from the site on May 30. It was necessary to provide a new footbridge on the line of a public footpath which had crossed the tunnel approximately 75 yards north from the old south portal.

As inspection holes cut through the side wall had shown the backing to be loose, confirmed by the evidence available during demolition, it was decided to strengthen the 100-yard length of tunnel remaining by pressure grouting, the aim being to consolidate the side walls and arch, particularly around the springing. Three rows of holes were drilled at 4-ft. centres, one row 4 ft. below springing line, one immediately below springing line, and one in the arch 3 ft. above the springing line. The drilling was carried out during the final week of line possession. Pressure grouting then proceeded during the normal running of traffic.

The mix used was generally one bag of cement to an equal quantity of sand, but for the lower holes in the southern half of the tunnel a mix of one bag of cement to $1\frac{1}{2}$ of sand was used. The pressure used was generally between 60 lb. and 80 lb. per square inch, but in some instances 100 lb. per square inch was used. The total number of mixes used to complete the work was 2,251 and the quantity of cement used $112\frac{1}{2}$ tons. The grouting was completed on Sunday, July 6. The whole of the work was directed and supervised by Mr. A. Dean, M.Sc., M.I.C.E., civil engineer, North Eastern Region, York.

LABOUR NOTES.

Engineering industries are the ones which it is most necessary to expand, if more British goods are to be exported and if British industry in general is to be modernised and its productivity increased. Emphasis was laid on this, as an essential factor to the correct understanding of the industrial situation, by Mr. Harry Earnshaw, the chairman of the Labour Party, in his opening address at the Party's annual conference at Morecambe on Monday. Britain's basic industries, Mr. Earnshaw affirmed, held the key to greater production. The country needed coal, steel and home-grown food in increasing quantities. Moreover, it would be necessary to embark on a big new investment programme. This was something which could only be accomplished if people were willing to go without a good many things to eat or use. It might be necessary to forgo improvements and, perhaps, to accept reductions in the general standard of living. In this connection, the Labour Party must be sure that the sick and the poor, the young and the old, were protected, but it should be understood that there could be no easing up for the great majority of the people.

Earlier in his speech, Mr. Earnshaw stated that the biggest of the problems that confronted the British people was that of selling sufficient goods overseas to pay for what was bought abroad. That problem was paramount. It affected the country's foreign policy, because an economically stronger Britain would carry greater weight in the councils of the nations. It affected Britain's policy towards under-developed areas, where the nation had declared war on want, just as it had done at home. To win this war against want, it was necessary to build ports, roads, factories and railways. Many other things also, from schools to agricultural machinery, must be provided. This could be achieved only by producing and sending abroad many more goods of every description.

The same problem, of selling British products overseas, affected the policy to be adopted to the country's social services. However much it might be desired to expand the welfare services, there could be no great improvement until sufficient was earned to pay for the additional benefits. Last, but not least, the problem affected the balance of payments. Recurring crises in that connection seriously affected the certainty of full employment. The day would come, unless everyone worked and planned to prevent it, when the country would not be able to obtain enough food and raw materials from abroad, simply because it was not able to pay for them. Such a position could only result in mass unemployment and a lower standard of living.

Some of the goods produced at the present time, Mr. Earnshaw considered, were not the right kind of goods. Too much of the country's industry had been organised to serve the kind of world which no longer existed. The world had changed, and if Britain wanted to sell its products in world markets, its products and manufacturing methods must change to meet the altered world conditions. The textile industry, for example, could no longer carry the major part of the burden of the export drive.

Sharp differences of opinion marked the consideration of a motion from the Salford West branch, which advocated, among other contentious matters, that support should be given to the trade-union movement when it was forced into industrial action to defend the living standards of its members. Delegates in favour of the motion contended that the Government had forced the trade unions to take industrial action and that they must be shown that both the Party and the unions were united against them. The principle of industrial action for political ends was roundly condemned, however, by several subsequent speakers.

Mr. Arthur Deakin, the general secretary of the Transport and General Workers' Union, said that it should be clearly understood that no decision taken at that conference would commit the trade-union movement to taking industrial action for political purposes. The Trades Union Congress had openly expressed its opposition to such tactics. Sir William Lawther, President of the National Union of Mineworkers, condemned the motion because it tried to tell the National Council of Labour to instruct the trade unions how they should manage their own concerns. After much debate, during which Mr. J. Tanner, President of the Amalgamated Engineering Union, promised support for the motion, which, he affirmed, had been misinterpreted, the motion was rejected, on a card vote, by a substantial majority.

A composite resolution expressing "unalterable opposition" to the de-nationalisation of the iron and steel and civil-aviation industries was moved by Mr. Deakin. The resolution also approved the declared intention of a future Labour Government to restore the road-haulage industry to public ownership and urged that the terms of any re-nationalisation should be such as would prevent private owners from profiting at the expense of the nation. This resolution was eventually carried without opposition, but a motion which was debated at the same time, and introduced by the Party's Heston and Isleworth branch, was defeated on a card vote. This motion demanded, in effect, that, should de-nationalisation take place and the industries concerned be re-nationalised by a subsequent Government, there should be no further compensation for industries returned to public ownership in that way, and that profits made during the period of de-nationalisation should be expropriated.

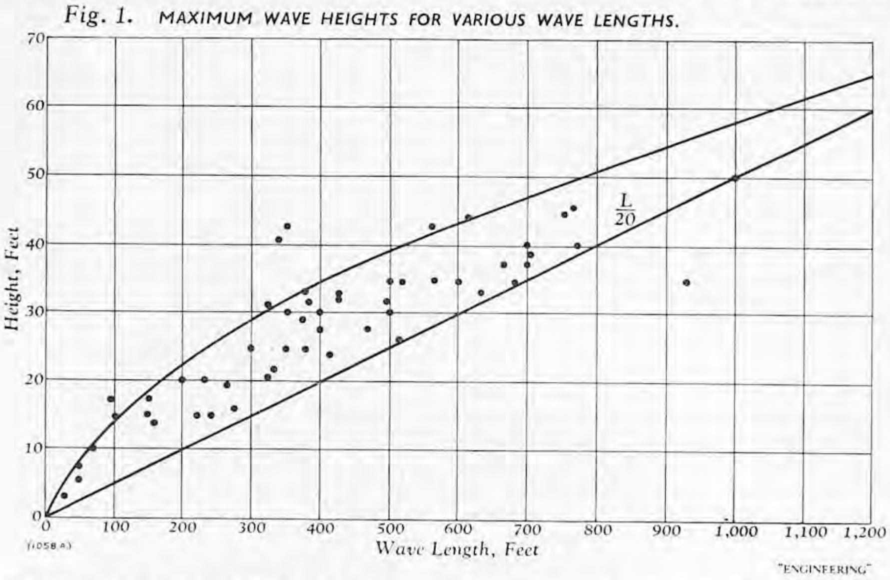
Pleas for the formation of a central authority with power to plan and control wages throughout the country, are contained in a pamphlet published by the Chemical Workers' Union last Monday. Mr. R. Edwards, the union's general secretary, states in the booklet that the wage increases now being presented are only natural in the present economic circumstances and that the nation must not expect to reduce prices at the expense of workpeople's living standards. At the same time, he considers that increases must be much more closely related to what the national economy can afford, than is the case at present. Unless this is done, he fears that the gains by employees in wages and social-welfare benefits will be negatived by inflation, at the risk of a subsequent deflationary situation and considerable unemployment.

Changes in rates of wages in the United Kingdom, which came into force during August, resulted in an aggregate increase of approximately 275,000*l.* net in the weekly full-time wages of some 1,310,000 workpeople. The increases principally affected agricultural employees in England and Wales, and workpeople employed in the iron and steel industry, goods transport by road, and in hosiery manufacture in the Midlands. Increases in weekly full-time rates of wages granted during the eight months, January to August, 1952, are estimated by the Ministry of Labour to total 2,339,000*l.* and to have benefited over six million people. In the first eight months of last year, there was a net increase of 3,713,000*l.* in the weekly full-time wages of some 8,504,000 persons.

Stoppages of work occurring as a result of industrial disputes in the United Kingdom numbered 143 during August last, and, in addition, 23 strikes which commenced earlier were still in progress when the month began. In these 166 stoppages, 44,200 workpeople were involved and 165,000 working days were lost. The comparative figures for July were 138 stoppages in progress, with 40,900 persons involved and 272,000 days lost. During the first eight months of this year, a total of 1,162 strikes were begun, involving 269,000 persons and causing the loss of 1,335,000 days. In the corresponding months of 1951, there was also a total of 1,162 strikes and the loss 1,335,000 days, but a larger number of persons, 276,500, were concerned in these stoppages.

THE LONGITUDINAL STRENGTH OF SHIPS.

Fig. 1. MAXIMUM WAVE HEIGHTS FOR VARIOUS WAVE LENGTHS.



THE LONGITUDINAL STRENGTH OF SHIPS.*

By JAMES TURNBULL, O.B.E.

THE longitudinal strength of ships has been constantly under review since the days when it was first appreciated by naval architects that a ship's hull was simply a large girder subject to variations in loading and having, when among waves, a violent and varying form of support, difficult if not impossible to assess. Theories were therefore devised for estimating the longitudinal bending moments to which ships are subjected in a seaway, and these have been applied and interpreted by experienced naval architects; nevertheless, the longitudinal scantlings of ships are still based mainly on the records of service behaviour of earlier similar ships.

The principal theory has been the standard graphical longitudinal bending-moment calculation, in which the ship is assumed to be poised momentarily on a trochoidal wave having a length from crest to crest equal to the length of the ship, and having a height equal to one-twentieth of its length. The "Smith correction," although theoretically acceptable, is not often applied, presumably because designers of hull structures consider it a refinement of a calculation that is used only for purposes of comparison and which, in any event, will not give the actual bending moments a ship is likely to experience in service. For the same reason, the "Read correction" has not been generally included. Although the methods hitherto adopted have proved satisfactory, naval architects are not entirely satisfied in assuming values of the support given to a ship by the sea; furthermore, knowledge of the detailed behaviour, in regard to stresses and strains, of hull structures in a seaway is by no means complete.

In 1942-43, several welded ships developed serious fractures, and at that time it was thought that there must be some fundamental difference in structural behaviour between welded and riveted ships, since the latter had not suffered to nearly the same extent. It was obvious that new problems had arisen and it was decided, in the United States and in the United Kingdom, to set up research committees to investigate why welded ships were behaving differently from riveted ships. This presented a good opportunity to obtain additional knowledge of ocean waves as well as of the detailed behaviour of some typical ships' structures. The work thus instigated has undoubtedly resulted in a clearer understanding of many of the factors involved in the longitudinal strength of ships.

The first full-scale experiment carried out under the direction of the Admiralty Ship Welding Committee was a comparison between the behaviour of the welded tanker Neverita* and the riveted sister ship Newcombia† under hogging and sagging bending moments applied in still water, but no important overall difference was revealed. These ships were 460 ft. (140 m.) in length, 59 ft. (18 m.) in breadth, and 34 ft. (10·38 m.) in depth. They were framed longitudinally, and the maximum mean stress induced was of the order of 5 tons per square inch (790 kilo. per square centimetre) in the deck and bottom plating. The next ships compared were the welded Ocean Vulcan and the riveted Clan Alpine, sister dry-cargo ships 416 ft. (126·9 m.) in length, 56 ft. 10½ in. (17·33 m.) in breadth, and 37 ft. 4 in. (11·38 m.) in depth to the strength deck. They were of standard design and were transversely framed, and slight differences in behaviour were observed during the still water tests.

The decision was made to fit the Ocean Vulcan‡ with instruments capable of recording at sea the wave pressures, the wave profiles on the ship's sides, the wind velocities, angles of roll, pitch and yaw and the forces imposed on the ship and cargo by accelerations. The observations to be made at sea were to include the determination of ocean waves by stereophotographic survey and other methods. With these instruments, the Ocean Vulcan made eight double crossings of the Atlantic in 17 months, and rough sea conditions were experienced on several occasions. Much valuable information was obtained, and, in addition to the measurement of waves and wave pressures on the ship, investigations were carried out on the effects on the hull structure of vertical bending, horizontal bending, torsion, heaving and pitching, axial compression and slamming. This was a new approach, some of these factors not having been considered in previous investigations.

OCEAN WAVES.

It was evident from the observations that waves of earlier storms were almost always superimposed on the existing wave system, with the result that the seas were seldom regular. However, the important conclusion was reached that, under the most severe storm conditions, there is a tendency for the waves produced by that storm to dominate all earlier disturbances and therefore closely to resemble trochoidal form. Since the waves recorded on this trial were evidently not the most severe that could be met, a study was made of the greatest waves reported by earlier investigators, many of which were estimated by visual observations of ships' officers. It is usual, in such circumstances, for wave heights to be over-estimated and lengths to be under-estimated. These observations, together with those obtained on the Ocean Vulcan sea trials, are plotted in Fig. 1, herewith.

It will be seen that the highest waves having the length of the Ocean Vulcan (416 ft.) are probably 35 ft. (10·7 m.) in height, i.e., a height to length ratio of 1 : 12, which is much steeper than the value L ÷ 20 assumed in the standard longitudinal bending-moment calculation. According to Fig. 1, the greatest waves for ships of 300 ft. (90 m.) in length have a height to length ratio of approximately 1 : 10 and for 600 ft. (180 m.) ships approximately 1 : 14. It is noteworthy that Professor G. Schnadel reported that the 430-ft. (131 m.) San Francisco* experienced waves of a height of L ÷ 13·5. In many instances, waves of exceptional height have been reported, but the length from crest to crest has not been mentioned. The highest wave ever reported was 112 ft. in height. Its length from crest to crest is not known, but was probably about 3,000 ft. (915 m.).

It is possible that ocean-going ships seldom experience these maximum wave conditions, and, when they do, they are most probably proceeding on a course inclined to the direction of the waves, which would have the effect of reducing the relative steepness of the wave traversing the ship's sides. The wave pressure records showed reasonable agreement with those derived from the Smith correction, and this, too, has the effect of reducing the effective steepness of the waves.

From the foregoing, it may be deduced that, in using the L ÷ 20 wave without the Smith correction, the theoretical longitudinal bending moment amidships would approximate the actual bending moment experienced in severe storm conditions by ships of about 400 ft. (120 m.) in length. In longer ships, the stresses derived from the classical theoretical calculation would, of course, be higher, and in shorter ships lower, than those actually experienced.

ACTIONS AT SEA AFFECTING LONGITUDINAL STRENGTH.

In the Ocean Vulcan sea trials, the horizontal bending moments were found, as would be expected, to be greatest when the seas were advancing at an angle of between 30 deg. and 45 deg. on either the bow or the stern, and appreciably high stresses resulted. Horizontal bending was frequently in phase with the vertical bending, so that, at one sheerstrake (or bilge), the stresses due to the horizontal and vertical bending moments became additive, while on the other side of the ship they tended to cancel each other. However, when the vertical longitudinal bending moments were at their highest values, the horizontal longitudinal bending moments were at their minimum.

The greatest range of vertical bending moment derived from these observations at sea was 190,000 tons-ft. (58,800 tonnes-m.) corresponding to a range of stress of 8 tons per square inch (1,260 kilo. per square centimetre) at the top of the sheerstrake amidships. There is no experimental evidence to show the actual separation of this range into hogging and sagging, though the investigators are inclined to the view that the sagging moment was slightly greater than the hogging. This range was associated with waves 35 ft. (10·7 m.) in height and between 600 ft. (180 m.) and 700 ft. (210 m.) in length. More severe conditions than these could, no doubt, be encountered, with a correspondingly larger range of stress. The highest range of stress recorded on the San Francisco, with waves L ÷ 13·5, was 9·6 tons per square inch (1,510 kilo. per square centimetre)—8·2 tons per square inch (1,290 kilo. per square centimetre) without the addition for slamming which occurred at the time—which bears a reasonable relationship to the highest range recorded on the Ocean Vulcan.

Torsion moments in the case of the Ocean Vulcan were estimated to cause longitudinal stresses not exceeding ½ ton per square inch (80 kilo. per square centimetre). However, under the wave conditions which cause the greatest vertical bending moments, the torsion moments were small. It would appear, therefore, that no special allowance may be necessary for horizontal bending or for torsion when computing the probable greatest longitudinal stress.

The effects of heaving and pitching were investigated, but were considered to be relatively unimportant, even under the most severe wave conditions, so long as slamming did not occur. Although

* Paper presented, in Genoa, at the Autumn Meeting of the Institution of Naval Architects, on September 26, 1952. Abridged.

* Trans. I.N.A., vol. 88, page 78 (1946).
† H.M. Stationery Office, 1948.
‡ Trans. I.N.A., vol. 91, page 29 (1949).

* Trans. I.N.A., vol. 80, page 387 (1938).

the instrumentation on the Ocean Vulcan was not suitable for recording shock loading, some general observations were made. It was estimated that normal slams resulted in stresses at the strength deck amidships of the order of $\pm 1\frac{1}{2}$ tons per square inch (240 kilo. per square centimetre). The highest stress due to slamming recorded by Schnadel on the San Francisco was 1·4 tons per square inch (220 kilo per square centimetre) when the ship was pitching as much as $\pm$ 12 deg. Slamming stresses recorded by other earlier investigators were less than $\frac{1}{2}$ ton per square inch (80 kilo. per square centimetre).

Slamming was only noted when the ship was in the light condition with a draught forward of from 8 ft. 2 in. (2·5 m.) to 10 ft. 1 in. (3·1 m.), i.e., from about 0·02 L to 0·024 L. Slamming was experienced on one day in every three while the ship was in the open ocean on a ballast voyage, and while no exact count was kept it is estimated that between 2,000 and 4,000 slams were experienced during the 17-month period of the sea trials. From the evidence of two slams identifiable from the records, it was deduced that slamming had resulted in a greater increase in the sagging stresses amidships than in the hogging stresses. It was observed that it was not necessary for the ship's bottom forward to leave the water for slamming to occur.

The greatest axial thrust was estimated to result in a compressive stress of less than $\frac{1}{2}$ ton per square inch (80 kg. per square centimetre) over the section amidships. In high-speed ships, however, this factor may be more important. It would appear that, of these various actions, only vertical bending, axial compression and slamming require special consideration. It is not suggested that the foregoing views should be accepted without reserve, as the investigations have been carried out on one type of ship only.

As it was generally believed that the failures in welded ships were, to come extent, due to such ships being more rigid than riveted ships and since such a conception could not be proved or disproved without actual tests, the Admiralty Ship Welding Committee arranged for a comparison to be made between the deflections of the welded tanker Neverita and the riveted tanker Newcombia and between the welded cargo ship Ocean Vulcan and the riveted cargo ship Clan Alpine. The results show that there was no significant difference in deflection between the riveted and welded ships. In the case of the dry-cargo ships, the welded ship was slightly the more flexible. However, this slight difference might be accounted for by the normal inaccuracies in recording. The ships were not subjected to very high stresses during these tests.

Another general belief was that, while riveted structures, because of rivet slip, could automatically adjust themselves so that each part of the structure took its fair share of the load, welded ships did not possess this desirable property. Because of this belief, special efforts were made to detect rivet slip. The accuracy of the instruments was such that any slip large enough to have an appreciable effect on the behaviour of the structure would have been revealed, but none was noted. In the paper describing the British Admiralty's bending tests on the riveted destroyer Albuera,* which was tested to destruction, it is specially mentioned that no rivet slip was observed.

The foregoing does not prove that rivet slip never occurs in service. In fact, it is thought that some such action occurred at the corner of one of the hatchways near amidships during the still-water tests on the Clan Alpine, as some relief of stress was detected. This action may have been only a slight adjustment of the joint. By and large, the evidence supports the view that riveted construction, under high stresses, is capable of an adjustment, the exact nature of which, however, is not yet fully understood.

(To be continued.)

FAIREY "GANNET" PERPETUAL CALENDAR.—We have received from the Fairey Aviation Co., Ltd., 24, Bruton-street, London, W.1, a reproduction in full colour of an oil painting of a Fairey Gannet in flight. A perpetual calendar is incorporated.

* *Trans. I.N.A.*, vol. 94 (not yet published).

ON THE FOOT-HILLS OF THE PLASTIC RANGE.*

By PROFESSOR H. W. SWIFT, M.A., D.Sc., M.I.Mech.E.

(Concluded from page 421.)

THE ENGINEER'S APPROACH.

IN the time available it would be useless to attempt even a summary of the work which has been done in recent years on the various technological applications of plasticity, such as rolling, forging, extrusion, drawing and forming. So I propose to invite your attention to one corner only of this field and to use the deep-drawing of a cylindrical shell to illustrate the methods we have been able to develop.

In its general form this problem is at present well beyond the range of the theoretical plastician. The conditions approximate to those of plane stress and are therefore intrinsically more difficult to handle than those of plane strain. On the other hand, it has certain simplifying features which make approximate solutions worth attempting, particularly when they can be checked from stage to stage by empirical data. The stress system is symmetrical, and its axes remain unchanged in the material throughout the drawing process. Stress and strain vary only in the direction of principal flow and, apart from bending over the die profile, there is no significant reversal of strain. On the other hand, the conditions are more complex than in tube drawing, for example, because the stress and strain in a particle are functions of its initial position as well as its current location, so that the solution involves step-by-step computation; and the problem is further complicated by the fact that the strain development and plastic requirements of one part of the metal blank are fundamentally different from those of the other part.

In order to determine the punch load at various stages of the drawing process and the changes in thickness which are induced, both matters of evident importance to the press-tool engineer, it is necessary to follow the changes in stress and strain which develop as material is drawn radially inwards in the flat blank and over the lip of the die into the cylindrical walls of the cup. This process has at least three functional constituents: plane radial drawing, plastic bending and un-bending over the die, and the frictional implications of the blank-holder and die profile. In the most complete analytical treatment so far† these three constituents are treated separately, then superposed on the assumption that their effects on one another are small.

Several other important assumptions are made in this treatment. It is assumed that the whole of any blank-holding force is transmitted at the outer rim of the blank; it is assumed that, although changes develop in the flange thickness from stage to stage, this thickness is effectively uniform at any instant, and it is assumed that the rate of straining is so slow that stress/strain equilibrium is maintained throughout the operation. In the bending analysis no account is taken of the Bauschinger effect. Throughout the treatment the Tresca shear-stress relation is adopted, and empirical strain-hardening characteristics are simulated by a power law, modified to allow for initial hardness, and simplified to a linear relationship over the relatively small strain interval covered by bending and unbending. In the treatment of die-profile friction, consideration is given to hoop compression in relation to the cup radius as well as radial tension in relation to the die profile, but these effects are superposed. The analysis leads at several points to implicit equations soluble only by processes of successive approximation; and the distribution of strains in particular can be determined only by step-by-step computation from the outer rim.

By taking reasonable conditions, it is possible also to estimate the relative importance of bending and friction in tube-sinking.* These are shown in Table I. As a matter of interest, Table II gives an analysis of the press work involved in a typical cup-drawing operation, and shows the contributions required by plastic bending and by friction.

TABLE I.—*Constituents of Total Sinking Stress.*

Constituent.	Wall Thickness 0·0635 in.		Wall Thickness 0·1305 in.	
	Lb. per sq. in.	Per cent.	Lb. per sq. in.	Per cent.
Pure radial deformation..	24,800	75·6	27,320	68·2
Bending and unbending..	3,920	11·9	8,280	20·7
Surface friction	5,530	16·8	5,970	15·0
Thickness variation ..	—1,400	—4·3	—1,560	—3·9
Total	32,850	100	39,990	100

TABLE II.—*Punch Work in Typical Cup-drawing.*

Blank diameter	8·0 in.	Punch diameter	4·0 in.
Blank thickness	0·039 in.	Punch head radius ...	0·25 in.
Blank-holding	15,500 lb.	Profile radius ...	0·25 in.

Material: 0·08 per cent. carbon rimming steel.

—	In.-lb.		Per cent.
Strain work in radial drawing ..		41,000	70
Strain work in bending	4,660		
Strain work in un-bending	5,610	10,300	$17\frac{1}{2}$
Friction work:			
Blank-holder	3,150		
Die-profile	4,460	7,600	$12\frac{1}{2}$
			100

So far, so good. For given conditions we can predict the drawing load and the thickness changes from point to point. But can we predict whether the drawing operation will be successful or not? The answer is that at present we cannot. Our treatment has in fact covered only those outer parts of the blank which are drawn in and over the die profile. The conditions of stress and strain in those inner parts which have not come under the direct influence of the die, but have been stretch-formed over the head of the punch during the drawing process, are quite different and need separate treatment. When fracture occurs during drawing, it generally occurs in this stretch-formed zone.

If we consider the drawing operation as a whole, we shall realise that although the drawing load required is determined by conditions in the outer drawing zone, the capacity of the cup to sustain this load is determined by conditions in the inner, stretch-formed zone. It follows that a knowledge of the process of stretch-forming is essential. The conditions which control stretch-forming are no less complex than those which control true drawing, for even in a simple symmetrical draw they include the profile geometry of the punch-head, the degree of lubrication over the punch-head and the stretch-forming tension imposed by the conditions in the drawing zone. The stress system in the stretch-forming zone is essentially biaxial tension, varying in ratio and intensity from point to point and from stage to stage. The effect of this biaxial tension is to thin the metal everywhere, and locally this thinning is generally more severe than any produced in the drawing zone and more likely to lead to fracture.

For this reason, a full study of the stretch-formed zone must include, and indeed be based upon, a study of strain under biaxial tension of various and varying proportions, and in particular of the conditions under which this strain will reach locally the critical conditions for necking and consequent rupture. Some progress has been made in the study of stretch-forming under the simplified conditions when the solid punch is replaced by unilateral fluid pressure. Hill has been able to predict strain development during the earlier stages of "bulging," and at Sheffield it has been found possible to predict the critical degree of thinning at which instability occurs.

We are still a long way from a full understanding of the deep-drawing of even a cylindrical shell; and this is the simplest technological form of the deep-drawing process. Problems which assume importance in unsymmetrical drawing operations have scarcely even been formulated.

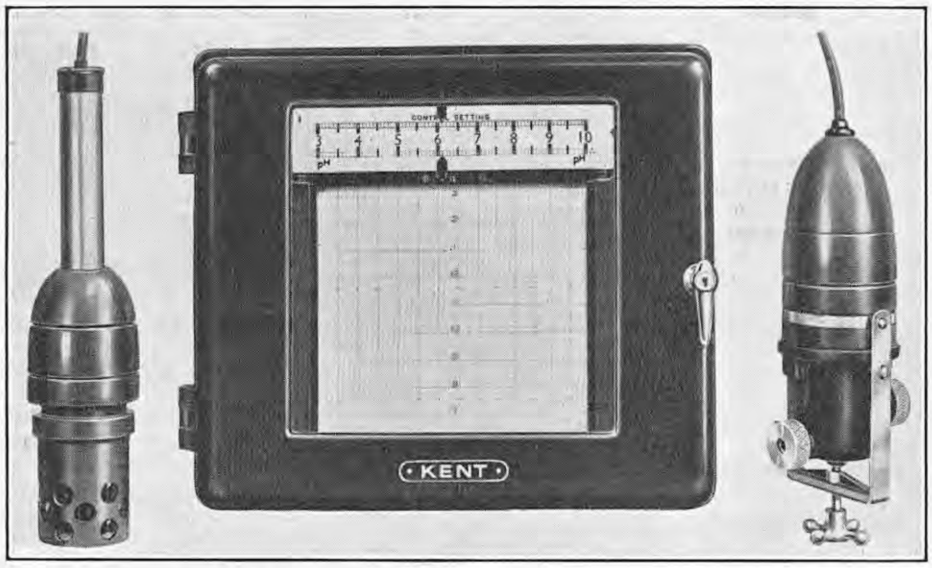
* Twenty-third Autumn Lecture delivered before the Institute of Metals at Oxford on Monday, September 15, 1952. Abridged.

† S. Y. Chung and H. W. Swift, *I.Mech.E., War Emergency Proc.*, vol. 68 (1952).

* S. Y. Chung and H. W. Swift, *Jl. Iron & Steel Inst.*, vol. 170, page 29 (1952).

*p*H RECORDER AND CONTROLLER.

GEORGE KENT, LIMITED, LUTON.



CONTINUOUS *p*H RECORDER AND CONTROLLER.

THE glass-electrode *p*H recorder shown in the accompanying illustration has been designed by Messrs. George Kent, Limited, Luton, Bedfordshire, to enable many industrial processes to be automatically controlled. As is well known, the continuous measurement of the *p*H value of industrial solutions is a complicated matter and necessitates the frequent maintenance of the instruments employed. With the new instrument it is, however, claimed that great accuracy is obtainable over periods of several months without any attention being required, while the addition of potassium chloride solution to the salt bridge is also unnecessary. It is, moreover, possible to measure the *p*H value of liquids under pressures up to 75 lb. per square inch, while the employment of plug-in electrodes with quick-acting glands simplifies cleaning when the sampling conditions are such as to cause rapid fouling.

The primary element, the body of which is made of high-temperature grade material, can be arranged so that the electrodes just dip into, or are completely submerged in, the liquid to be measured. This assembly is shown on the left of the illustration. By a simple replacement of accessories it is, however, possible to convert this pattern into one of the flow type, as shown on the right of the illustration, in which the liquid to be measured passes through a sealed hopper on the electrode holder, thus enabling measurements to be made under pressure. In both types, all parts in contact with the sample are of non-metallic materials, which are resistant to the attack of most agents. The combined reference/salt bridge electrode is unbreakable and pressure-compensated, while the liquid junction is resistant to fouling and, being a separate component, can easily be replaced. Three types of glass electrode are available, with *p*H ranges from 0 to 10, 0 to 14 and 10 to 14, respectively. It is estimated that the continuous operation life of the first before servicing is over six months, of the second about 2,000 hours at 100 deg. C. and of the third more than 2,000 hours at a temperature greater than 75 deg. C. A nickel resistance thermometer, which is protected by a moulded-rubber sheath, provides automatic temperature compensation for the electrodes.

The measuring system is in two parts: an electrometer and recorder, the latter being visible in the centre of the illustration. The electrometer, which is of the impulse type, is operated from the alternating-current mains and measures the potential of the electrode system without imposing any significant load upon it. The input impedance of the electrometer circuit is very high and is symmetrical with respect to earth, so that robust electrodes can be used. The electrometer contains only one valve, of a standard radio type, so that replacement is easy. Variations in the valve characteristics do not cause zero drift and changes in the mains supply voltage do not affect the accuracy of the instrument. The electrometer is housed in a sealed case, which can be mounted up to 100 ft. from the primary element, while the self-balancing potentiometer-recorder may be located up to 500 ft. from the electrometer.

An important advantage claimed for the new instrument is that, by using it, automatic control can be applied to processes such as those involving the circulation of hot process liquor, since the time previously required for cooling the sample is saved.

TRADE PUBLICATIONS.

Cast Aluminium Alloys.—Alar Ltd., a technical association of light-alloy refiners, 3, Albemarle-street, London, W.1, have issued data sheets, relating to aluminium casting alloys for general engineering purposes, mounted on a card for hanging on the wall. On one side are given the trade names, related specifications and minimum mechanical properties of the alloys, and, on the, other side, their chemical composition, physical and general properties and indications of their casting characteristics.

Domestic Lighting.—A 16-page booklet in two colours, which we have received from the British Thomson-Houston Co. Ltd., Crown House, Aldwych, London, W.C.2, contains some useful advice to the householder on the type of lamp to employ and how to place it to obtain the maximum benefit from its light. The same firm have sent us a catalogue giving full details of the Mazda lamps they manufacture.

Electric Lamps.—Details of the different types of electric lamps manufactured by them for a variety of purposes are given in a catalogue received from the Lamp and Lighting Department of Metropolitan-Vickers Electrical Co., Ltd., St. Paul's Churchyard, London E.C.4.

"Low Hydrogen 35" Welding Electrodes.—Particulars of their Low Hydrogen 35 electrode, which has been designed to provide an ultimate tensile strength of 35 tons per square inch in the weld metal, are contained in a circular received from the Quasi-Arc Co. Ltd., Bilston, Staffordshire.

Alternating-Current Portable Welding Set.—The Quasi-Arc Co., Ltd., Bilston, Staffordshire, have published a booklet giving instructions for the installation, operation and maintenance of their Type ACP 300 alternating-current portable arc-welding plant.

Prismatic Lighting Fitting.—Messrs. Dorman and Smith, Ltd., Manchester, 5, have sent us particulars of their latest industrial prismatic lighting fitting which is known as the Diopal. It is of die-cast aluminium alloy and takes lamps up to 100 watts.

Air Cleaners.—An illustrated leaflet describing the operation, installation and maintenance of the Cycoil oil-bath air cleaner for internal-combustion engines has been issued by Air Control Installations Ltd., Ruislip, Middlesex. In the Cycoil cleaner, the dust-laden air is thoroughly mixed with oil, which is then centrifuged, most of the dust being removed with the oil. The remaining dust and oil in the airstream is removed by a filter

THE FUTURE DEVELOPMENT OF THE FLYING-BOAT AIRLINER.*

By HENRY KNOWLER, A.M.I.C.E., F.R.Ae.S.

THE outstanding example at the present time of a high-speed airliner is the de Havilland Comet. The performance of this machine gives some indication of the speed which will be demanded in the future, but, because of the high fuel consumption associated with a jet engine, it is not yet able to cover, in direct flight, the maximum stages necessary for global travel; in fact, there is no airliner in existence to fulfil this requirement. An early solution to the latter problem is exemplified by the Princess flying boat where, by the use of propeller turbine engines—operating at their most efficient altitude—and with a sufficiently large aircraft, it has been found possible to design a machine capable of covering the longest stages at present envisaged. However, it is the intention, in this paper, to look further into the future and to predict the direction in which development is likely to proceed.

One notices development trends in three directions, two of which have already been mentioned. These are: a very much higher speed of travel, the second, greatly increased range, and the third trend, which appears to be very definite at this time, is towards improved passenger comfort. There is no difficulty in establishing the necessity for high-speed travel, since it is universally agreed that this is what the aircraft has to sell. It is sufficient, therefore, to decide the maximum speed which can be achieved economically. Drag increase, due to compressibility, will set the limit, and the maximum cruising Mach number will be decided by the action that can be taken to delay the onset of compressibility effects by the use of thin wing sections and sweepback, or other methods. This speed appears to be limited to a Mach number in the neighbourhood of 0·8 to 0·85, and, for reasons stated later, a figure of 0·83 has been assumed, giving a cruising speed of 550 miles per hour. Speeds as high as this can only be achieved economically in the stratosphere. The most efficient height for the turbine engine is at the tropopause, but a number of other factors will influence the altitude at which the best efficiency is obtained for the aircraft/engine combination. There is, however, an artificial upper restriction in altitude with passenger aircraft, due to the present fear of failure of the pressurisation. This limit is set at 40,000 ft., since it has been stated that a failure at that height will not prove fatal to passengers.

The desirability of direct flight over long stages has already been mentioned. For example, the use of a high-speed aircraft, combined with one or more refuelling stops at present necessary on the Atlantic crossing, reduces the overall mean speed of the fastest aircraft to a somewhat pedestrian value, and it is clear that not only must speed be high, but the range potential must also be adequate to ensure direct flight. Hence, the problem before us has now been crystallised into the design necessary to make flight possible at 0·83 Mach number with a limitation in altitude to 40,000 ft. for stage distances representative of global travel. There are, however, a number of other factors which will have an important influence on the configuration of the machine, many of which are associated with the passengers' comfort.

First, it is necessary to assess the payload capacity which is to be carried to meet operators' requirements. This factor is critical to the design since the greater the capacity the bigger the relative body size, and, hence, higher drag and structure weight. Examination of the statistics of trans-atlantic travel over the last few years indicates a steady annual rise in the number of passengers carried, both by airlines and shipping, with a potential increase of 60,000 passengers per annum, this increase being equally divided between the two modes of transport. At this rate of increase, in six years twice the number of passengers will travel by air relative to those now carried, without counting on transfer from surface to air travel.

* Paper read before Section G of the British Association at Belfast, on Monday, September 8, 1952.

This will create a problem of traffic control at the already congested airports. The difficulty can be solved by duplicating airports, by increasing the size of aircraft, or by both these alternatives at the same time.

A statistical examination of present practice shows that for long journeys, such as the staged transatlantic flight, the seating capacity per aircraft is from 40 to 60, each seat requiring about 2,500 lb. of aircraft weight. The amount of space allocated to each passenger, together with that for ancillary accommodation, is the determining factor in deciding the size of body necessary. In this respect it is considered that comfort standards must rise, particularly for long overseas journeys. Present seating conditions are probably satisfactory for unbroken journeys of 5 hours to 6 hours, but for a longer duration the passenger needs greater freedom of movement, with the addition of luxuries, such as a separate lounge bar and possibly a dining cabin, as well as increase in cloakroom, lavatory and toilet space.

At the present time, with the object of encouraging air travel by reducing fares, practically all airlines are introducing coach seating on a number of their schedule flights. This, naturally, involves a deterioration in passenger comfort, but it is considered this can only be a temporary expedient since it is general experience that the competition of other forms of travel will force continual improvement in the comfort facilities offered to passengers, and, since this inquiry concerns the future airliner, it is assumed that the general trend in comfort improvement will continue; consequently, greater volume must be provided, and, in accepting this condition, an increase in relative body drag must be faced. Translated into terms of payload percentage, the increased capacity trend represented by passenger weight, luggage, mail and freight, is of the order of 12 per cent., or about 2,000 lb. of aircraft weight per passenger.

A factor in passenger comfort which may have considerable influence on the general design, is the avoidance of noise. Propeller installations are noisy in the plane of the propeller and accommodation must be arranged accordingly. In the case of jet engines noise is excessive aft of the jet outlet, and this can have considerable effect on the disposition of passenger seats and calls for the location of jet outlets as far aft as possible. Another quality the passenger will expect from the future airliner is a "smooth ride." There is no doubt that the use of turbine engines results in considerable improvement in this respect, ensuring freedom from vibration in the structure, and, since their economic use is only possible at high altitudes, most of the flight takes place in regions where turbulent air is an infrequent occurrence.

It remains to refer to one more factor, but one of primary importance, the economic efficiency of the aircraft. It was stated earlier that speed of travel is what an airline has to sell, but, clearly, the cost of operation must permit the price of travel to be competitive. In this connection, it has been noticed that in every form of transport the greatest economy is found with the largest unit, which tends to increase in size until limited by external restrictions, such as the size of railway tunnels, the width and radius of corners on roads, the depth of water in harbours, and, with aircraft, by the length and strength of runways. Past experience has proved that aircraft transport is no exception to this rule, and, as a consequence, the size has steadily increased. There is, at this time, no indication of an upward limit except, perhaps, for landplanes for the reason just mentioned.

Although the improvement in efficiency, due to size, is an accepted fact, it is proposed to explore the reasons with a view to establishing a basis for extrapolation to the future flying boat, the theme of this paper. First, however, it is desirable to review the improvements which can be made arising from the latest hydrodynamic research. In the past, although this is less noticeable to-day, the air drag of flying boats relative to landplanes has been high due to the larger size of body and, further, to the drag associated with hydrodynamic necessity. In recent years the primary aim of development has been to reduce or eliminate this drag difference so that flying boats can compete on equal terms with the corresponding landplanes. The first reason has now disappeared due to the volume of body necessary to carry the payload of passengers and freight exceeding that required for buoyancy.

Analysis of the factors contributing to flying-boat hull drag compared with a streamline body shows that by far the greatest increase has been due to the main step, other items such as the chines, keel, bow shape, etc., being relatively unimportant. It

Fig. 1. TARE WEIGHT LESS POWER FOR VARYING AIRCRAFT SIZE.

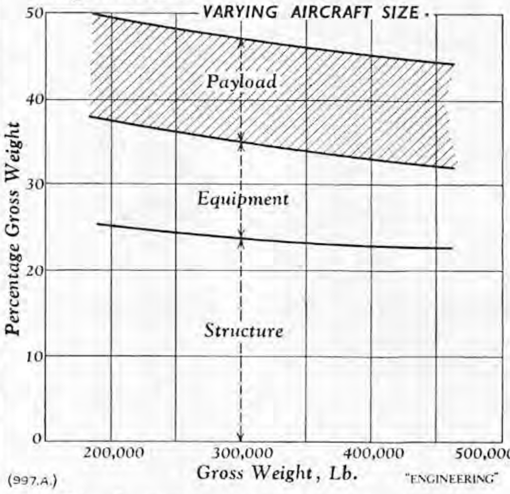


Fig. 2. CRITICAL MACH NO. FOR COMPRESSIBILITY DRAG RISE.

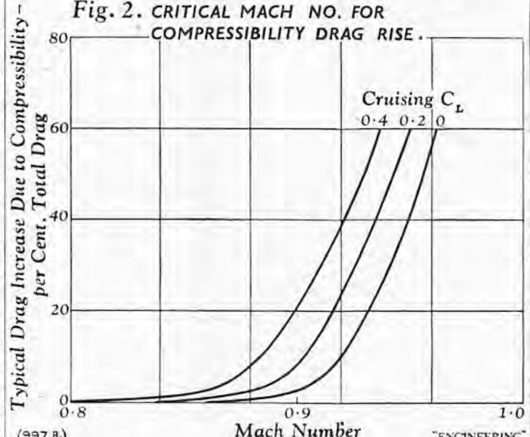
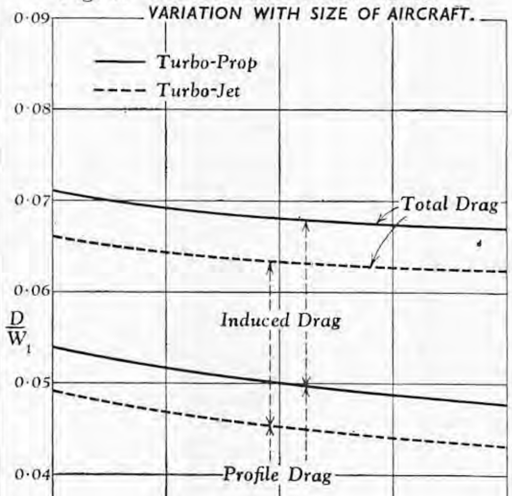


Fig. 3. CRUISING DRAG:WEIGHT RATIO VARIATION WITH SIZE OF AIRCRAFT.



is natural, therefore, that step-drag reduction has been the primary target in recent investigations. The purpose served by the step is to break the water flow over the bottom of the hull at a point approximately where the normal pressure from the water diminishes and farther aft changes to suction. The position is chosen a short distance aft of the centre of gravity. A hull without a step cannot leave the water due to this suction and, therefore, any improvement in shape aerodynamically must not adversely affect ventilation aft of the step. A recent solution of this problem is embodied in the "Princess." Subsequent tank and tunnel work indicates that the drag of the basic streamline form need not be "spoiled" to a greater extent than 10 to 12 per cent. in converting it to a satisfactory hull.

In looking to the future the possibility of eliminating the whole of the drag loss must not be ruled out. Several methods have been proposed and model investigations have been carried out. Retracting the step completely has been tried full scale, but the additional weight, cost and maintenance difficulties cause the method to be of doubtful advantage. Interrupting the water flow by compressed air ejected through slots or nozzles at appropriate positions in the bottom has also been investigated. This system is found to be successful hydrodynamically but suffers from the same objections to those against a retractable step. The addition of hydrofoils, to eliminate the necessity for steps and chines, holds out some prospect of success, but there are a number of problems to be solved, and at present their solution is not clear.

Hydro-ski have also been investigated and have the advantage that they can be completely retracted. So far, hydro-ski systems have involved increased water resistance and, therefore, are more suitable for application to military types where surplus power is available at take-off. The hydro-ski system, in one form developed, is in effect a highly-loaded retractable bottom. Reduction of the water loading would have the effect of reducing the resistance and it is possible, therefore, to foresee a fully-retracting flying-boat bottom. Weight, cost and maintenance again will decide whether this would be worthwhile.

Improvement in water resistance has also had its share of research. The resistance components are, in addition to the air drag of the aircraft, that due to wave-making, which diminishes as the wing lift increases with speed and becomes unimportant beyond the "hump" speed; planing resistance, which is, in fact, the horizontal component of the normal force on the planing bottom; and, finally, the skin friction. The resistance for a given boat varies considerably with attitude; hence, if it is possible to control the aircraft to optimum attitudes throughout the take-off run some reduction in resistance can be made. However, it is considered that for the future commercial flying boat there are only limited improvements which can be applied. At present a refined form of hull on the conventional pattern can have a peak resistance to weight ratio of 0·18.

Probably the most important factor in determining the general configuration of a flying boat is the propagation of spray. This occurs in two forms: that emanating from the forward contact of the planing bottom with the water surface (ribbon spray) and the heavier form of spray called the "blister," which leaves the chine at its forward point of contact with the water. Both forms of spray are due to peak pressures developed in the stagnation area where the planing bottom intersects "solid" water. Ribbon spray is fairly light, and although it may cause inconvenience in misting up the windscreen and so on, it has no damaging effect on the structure, and since it first travels forward over the bottom surface it can be directed downward by curvature below the bow chine. On the other hand, the blister has free release laterally and rises in a hollow cone of heavy spray. The height to which it rises determines the relative position of the propeller tips above the water and, in some cases, the position of the wing and tailplane.

Recently, during the course of systematic investigations into the source and control of spray, it came to light that the coefficient of water loading, proportional to beam cubed, heretofore considered to be the major factor in determining the height of spray, could be replaced by a coefficient proportional to the square of the planing-bottom length multiplied by the beam. At once the way was open to the use of hulls of greatly-increased fineness ratio without adverse effect on the water behaviour of the hull; in fact, it is claimed that there is some improvement in seaworthy qualities. From the aspect of future design, this new conception is of the greatest importance, since it permits us to decide the cross-section of the hull primarily from the requirements for passenger accommodation rather than from the necessity for a specific planing-bottom width. It is also possible to improve the drag characteristics by improved fineness ratio and by the consequent reduction in step width to reduce its spoiling drag. The fineness ratios of hulls are tending to increase in new types from a ratio of, say, six to more than double this figure.

The water stability of the flying boat does not enter into this inquiry except, perhaps, in regard to the lateral stabilising which is necessary. Recent systems, as exemplified in the "Princess" for instance, use outboard floats retracting to a position at the wing tips. It is not considered necessary to use wholly-retracting floats since experience has shown that the cost in weight of reinforced structure in the neighbourhood of the recess in which the float is buried offsets the fuel saving on long-range flying boats. On the other hand, floats of suitable design retracted to the wing tips, by improving the induced drag due to increased aspect ratio and end-plane effect, are capable of compensating to a large extent for the rise in profile drag.

Returning now to our discussion of transport efficiency, this is dependent on a number of factors, the most important of which are the ratio of the tare-weight to all-up weight and the $\frac{L}{D}$ of the aircraft in cruising flight configuration. In regard to the former, there have been two misconceptions which have had to be overcome by protagonists of big flying boats—that the flying boat is necessarily heavier than the landplane, and that the law of scale increase, the square-cube law, applies adversely to the structure weight when the aircraft size is increased. Both these theories have been repudiated with vigour and the flying boat has survived the attack with flying colours, since it is now generally agreed that in the largest sizes it can, in fact, be built to a lighter weight than the landplane. The weight of an aircraft is usually considered in sections which are more or less independent. These are—the power installation and fuel weight which, for convenience, are dealt with as one item; the aircraft structure; equipment—to which has been added the crew; and, finally, the payload, which, it will be remembered, has been assumed to be 12 per cent. of the all-up weight. The factors influencing the structure weight are: the body size, dictated by the volume necessary for accommodation of passengers and freight; the wing area and configuration; the tail surfaces; and the chassis. It will be remembered that the chassis is replaced on a flying boat by wing-tip floats of relatively low weight.

In Fig. 1, the structure weight percentage for increasing size of aircraft is plotted against total weight. It will be noticed that the percentage improves as the size is increased. This is attributed to a natural gain due to a reduction in body surface area relative to the volume, and to adverse scale laws being circumvented in the wings by permitting the loading to increase and the aspect ratio to decrease. The weight of equipment comprises those parts which vary in weight with size, the remainder being common to all aircraft—e.g., in the former is included the passenger seats, in the latter the control-cabin equipment. In Fig. 1, the curve for equipment plus structure slopes down with increasing size of aircraft and shows a useful gain in disposable load.

It was pointed out earlier that, to cruise at the Mach number chosen, consideration will have to be given to the wing loading as well as the configuration. Here we find the necessity for compromise since the critical Mach number will change with the C_L developed for any given configuration. This is shown in Fig. 2. It will be seen here that to develop the Mach number desired places a limitation on the permitted C_L unless sacrifice in drag is made. The optimum condition is dependent on a number of factors, not least of which is the effect on the structure weight of aspect ratio, the degree of sweep, wing thickness and the wing loading. The factors chosen have been found after exploration and are considered to give the best compromise. The profile drag of the body is also dictated by the volume necessary for the payload. We see, therefore, that as increasing size of aircraft is considered the factors affecting both the profile and induced drag will vary. All these considerations have been taken into account, and the changing $\frac{D}{W}$ which can be achieved under mean flight conditions is shown in Fig. 3. It will be noticed that small variations are made in this to cover the effect of different forms of propulsion. The curve of $\frac{D}{W}$ is not, of course, for the maximum which can be developed but that associated with the C_L for mean cruising operation at the chosen Mach number. These curves indicate a general improvement in profile-drag coefficient when the size of aircraft is increased. It will be seen that this improvement is, to some extent, offset by the increase in induced drag, which arises from the greater wing loading and reduced aspect ratio which has been used in the larger aircraft in order to avoid an increase in weight of structure.

(*To be continued.*)

MOTIVE POWER FOR RAILWAYS.*

By C. M. COCK, M.I.Mech.E., M.I.E.E.

(*Concluded from page 424.*)

THE incidence and cost of indigenous energy in any country have a strong influence on the form of motive power. Railways in most countries depend on the reciprocating steam locomotive for traction; the great majority use coal as fuel, and while coal continues to be abundant and cheap this form of traction will no doubt be perpetuated. But in some countries oil is used extensively, notably in the United States, with Diesel-electric locomotives, and for steam locomotives in other territories where oil is comparatively cheap and conveniently obtainable. In general throughout the world, Diesel traction is extending. Even in Europe, where mainly for economic reasons straight electric traction is displacing the steam locomotive on a large scale, there is a complementary and active growth of Diesel traction for main lines and shunting, and the use of Diesel rail-cars is extending. Sweden, Switzerland and Italy are important examples of rail traffic being moved by electrical energy from water power. Usually, in such countries, alternative forms of energy are non-indigenous, or scarce, or costly, leading to a policy of national development of water-power resources. In terms of ton-miles, nearly all the rail traffic in Sweden and Switzerland is worked from water power.

COAL IN GREAT BRITAIN.

The Coal Survey in 1946, while not attempting to estimate the total reserves in Great Britain, considered that, for the next hundred years, there were sufficient reserves to maintain the total output at an annual rate of over 200,000,000 tons. The National Coal Board, in their Plan for Coal, state that, because so much of the best and cheapest has already been mined, there will be increasing difficulties in mining coal economically. The impression conveyed by the Plan for Coal is a trend towards scarcity of special coals, lower average quality and greater difficulty in mining. It is difficult to discern how higher costs can be avoided. When the Coal Survey estimate was made in 1946, the production of deep-mined coal for that year was some 181 million tons. Last year's (1951) production was 211·8 million tons, 11·7 million tons of which was exported.

In submitting evidence this year to the Ridley Committee on the national fuel policy, the Federation of British Industries estimated that by 1960-65 the total demand for coal in Britain will have increased to 293 million tons a year. The F.B.I. also estimated that the true shortage was now between 10 million and 20 million tons a year, and on the present trend would grow to about 50 million tons by 1960-65. Even if reserves of coal prove ultimately to be better than can be foreseen, the position can never be one for complacency. How can assistance come from the railways?

In Britain, some 19,500 steam locomotives with an optimum thermal efficiency of 8 per cent. consume approximately 14 million tons of our best coal per annum. With electric traction, much less coal would be consumed in central power stations, expected by 1960 to have an average therma efficiency of 26 per cent.; and, taking into account the transmission and conversion losses, probably not more than 81 per cent. of the total energy of coal would be lost in translation to useful work. Moreover, there are no "stand-by" losses—an important factor, which is often forgotten and difficult to assess precisely. It is a reasonable estimate that general electrification in Britain would reduce coal consumption to two-fifths, at the most, of that now required by steam-locomotive haulage, i.e., an annual quantitative saving could be made of not less than 8½ million tons, which is 4 per cent. of the present national production. But the actual saving in quality could be more, amounting to the full 14 million tons of best-quality coal now consumed in locomotive boilers, the traction power required being obtained from low-grade fuels used in generating stations.

The gas-turbine locomotive may also prove to be of assistance. In November, 1951, Dr. Roxbee Cox, lecturing before the Institution of Mechanical Engineers, anticipated that a coal-burning gas-turbine locomotive could be built with a thermal efficiency of 19 per cent. at full load. Fuel consumption for the London-Glasgow run has been calculated as about half that of the conventional steam locomotive. I have already discussed the gas-turbine locomotive and can offer no comment until some running experience has been obtained.

Apart from conservation, the cost of coal must be a factor of some influence in regard to extravagance in its use and ability to compete with other forms of energy. In 1951 the cost of fuel (exclusive of carriage charges) for operating British Railways was nearly 38*l*. millions, i.e., 11·2 per cent. of the total working expenses. Reasons are given in the Plan for Coal for a trend in the future to scarcity, lower average quality, and greater difficulty in mining. Man-power and efficiency in mining methods are also relevant matters for serious consideration. Mechanisation and other improved methods are expected to reduce production costs, but it would appear that ultimately the consumer will not benefit very appreciably. Mechanical cutting and conveying must surely represent quite a large proportion of the improved methods, and not much margin remains for completing this process. Moreover, a 50 per cent. increase of the output of mechanically-cut coal during a period of 20 years has increased the output per man per year by only about 10 per cent. It may well be that in the years ahead more coal will be found. With new and better machinery and with greater effort from the men in the industry, rising costs may be checked. This is the hope. For the present we must accept the reality.

PETROLEUM.

Because of the many reasons, economical and technical, for the use of oil of various grades, it may be regarded as complementary to, rather than competitive with, other forms of energy such as coal, and for some time the world consumption of petroleum has been increasing more rapidly than that of coal. Europe is a striking example of the dependence of an expanding economy on oil. Between 1929 and 1950, the rise in use of energy from oil was 216 per cent., whereas the rise in use of all other forms of energy was only 5 per cent. Most of this has occurred since 1937, yet in 1950 the average *per capita* oil consumption in Western Europe was still ten times less than in North America.

For countries like Great Britain having an insignificant indigenous production, sea transport has an important bearing on the cost of oil and it also introduces strategic problems. Other questions of strategy are that the maintenance of supplies and the cost of petroleum may be disturbed by rupture of international relations, and also by avarice. The world's proved reserves of petroleum at the end of 1951 were 14,450 million tons. Present world consumption is around 600 million tons per annum. Over half the reserves are in the Middle East, and upwards of 25 per cent. in the U.S.A. and Canada. Estimates of the true extent of oil reserves can only be speculative and, in fact, are usually conjectural; while the proven reserves are constantly being extended, new fields are being discovered and old

* Presidential Address to the Institution of Locomotive Engineers, delivered in London on September 24. Abridged.

fields are being developed. In the past, the numerous prophecies on the exhaustion of oil have, with monotonous frequency, been falsified, and a speculation that there will be an abundance of oil supplies in the world for at least another 100 years is probably as good as the speculation that coal will exist for the same time in Great Britain. Proved reserves in the world, although larger than ever before, are still increasing rapidly and the areas remaining to be explored in the United States and other countries are enormous.

With regard to motive power for railways, it is found in the United States that one ton of Diesel fuel will do the work of at least $9\frac{1}{2}$ tons of coal. On this basis, and in the event of complete "Dieselisation" of British Railways, the annual consumption of Diesel fuel would be less than 1·47 million tons. The total imports of crude oil and refined products to the United Kingdom in 1951 was 26·53 million tons, and the railways would place an additional load on sea transport of 5·5 per cent., which would become smaller as the consumption of oil for other purposes tends to increase. On the other hand, the coal traffic on the railways would be reduced by an appreciable extent.

Nuclear Energy.

According to Sir John Cockcroft, one major objective in developing nuclear energy is to supply the world, and particularly this country, with an additional source of energy to supplement existing overstrained and diminishing reserves of conventional fuel. The only method in sight is to use a nuclear reactor as a source of heat to replace the fuel burners of a power-station boiler. Alternatively, it may be possible in the long-term future to use the heat in gas-turbines. It is estimated that the cost of nuclear power with these methods would not be very different from the cost of power from coal—perhaps not much more expensive. Developments of mobile nuclear power units are proceeding and reports indicate that they are in fact practicable for ship propulsion; but they are expensive. Mobile reactors for aircraft propulsion are likely to be much more difficult, and it is presumed that this would apply to locomotives also due to the measure of protection required. If, however, mobile reactors for locomotives were practicable, a sensible forecast is that it would be more economical to provide one big reactor at a central power station rather than large numbers of small units in locomotives. Electric traction, therefore, would be a natural lead-in to the age of nuclear energy.

Conclusion.

The reciprocating steam locomotive has survived for so long not by any claim to technical superiority, but because it is cheap, and sturdy, and simple. For these reasons, and for some time ahead, it will remain on many railways. But the proven success of alternative forms of traction should give cause for serious thought to railway administrations all over the world as to whether, indeed, the ancient tradition of steam continues to be valid. The inventions of the modern age offer alternatives more powerful, and even more reliable than the steam locomotive. Under given conditions they are better suited to the national economy and they can bring improvement in amenities to a community in general and to a railway itself, including the operating personnel. Countries such as Sweden and Switzerland provide abundant evidence of the economic and social benefits of electrification. Rail travel is pleasant and attractive, mainly due to the cleanliness of the railway property, and the regularity and frequency of the services.

In the United States, the success of Diesel traction on a vast scale is quite unique. More and more reports continue to give evidence of improvements in train operation and savings in working expenses, due entirely to the Diesel locomotive. Diesel traction, however, is seldom in direct competition with electrification. It depends on such things as the characters of the local terrain and traffic density and the availability and cost of fuel, which differ widely in various parts of the world. Annual charges such as running maintenance and repairs, depreciation and interest on the capital cost, also affect the issue. It might reasonably be expected, however, that the American pattern, which has been outstandingly successful, could be followed in many parts of the world. The examples of the success of electric and Diesel-electric traction in the world to-day are substantial and real. The potential of the gas-turbine locomotive cannot be forecast.

One set of conditions may suit one form of motive power for a particular railway. Elsewhere a different set of conditions might be suitable for another form of motive power. Each railway must consider its own conditions and work out its own salvation, which must be influenced to a large degree by the incidence and cost of indigenous energy from coal, petroleum or water. The conclusion must be based mainly, but not entirely, on the economics of the case; the alternative forms of motive power under review have proved themselves technically reliable tools for transportation suitable for service in any part of the world. Here in Britain, the long experience and economic results of electrification provide sufficient proof and justification for further large-scale extensions which could confer immense benefits on the nation, economic and otherwise. A new type of transport would give the railways a new lease of life and bring them back to their proper prime place in the transport system as a whole, save precious coal, diminish pollution by smoke, and bring some improvement to the load factor on the national electricity-supply grid.

There is also room for extensions of Diesel traction. The economic success of this has already been established for shunting in just the same way as a start was made in the United States, and the experiments made with main-line locomotives have proved their technical superiority over steam locomotives. These experiments, however, have not been sufficient to demonstrate convincingly the true operational and economic advantages of this form of traction on a really large scale. Many of the factors quoted for the United States as fundamental to the economics of Diesel traction are so near to those in Britain that there seems no reason to doubt that conversion of large areas, so as completely to replace steam locomotives, should be successful.

Our coal must be conserved. Unless the Coal Board magically can produce more coal of satisfactory quality from yet unknown fields, the position will degenerate from one of gravity to utmost gravity. Electrification at least will assist in easing the position. The use of oil with Diesel locomotives would also assist. If strategic hazards are to be taken into account, it must be remembered that without oil all our defence services would be immobilised; and even in the event of a complete changeover to oil by the railways, the maximum additional load imposed on the supply organisation would be, if American results are repeated here, of the order of only 5·5 per cent. When nuclear energy becomes available, electric traction would appear to be the most convenient way to use it.

LONG SPAN OF TRANSMISSION LINE.

LONG SPAN OF POWER-TRANSMISSION LINE.

The accompanying illustration shows four towers which have been fabricated and erected by the Dominion Bridge Company, Limited, Vancouver, Canada, to carry a 72-MVA, 170-kV electric transmission line across Kootenay Lake in British Columbia, a distance of 10,656 ft. This, as far as is known, is about 3,000 ft. more than the previous longest span, which is in Switzerland. The span forms part of the connection between the Consolidated Mining and Smelting Company's hydro-electric stations on the Kootenay River, near Nelson, and the mining, concentration and future chemical fertiliser plants at Kimberley. The alternatives to its construction were to carry an extra 80 miles of overhead line round the end of the lake or to lay a cable under it, both of which would have been too expensive. As will be seen from the illustration, the line is carried on three 50-ft. towers, which have been erected on a hill 1,200 ft. above water level on the west side of the lake, and on a single 366-ft. high tower on the eastern shore. Each of the 10,733-ft. long galvanised steel lines used is $1\frac{1}{4}$ in. in diameter and weighs about 18 tons. They were pre-stressed and designed for a maximum tension of 55 tons.

Stoke-on-Trent Association of Engineers.—The Reginald Mitchell Memorial Gold Medal for 1952 of the Stoke-on-Trent Association of Engineers has been awarded to Sir William Arthur Stanier, F.R.S., D.Sc., Hon. M.I.Mech.E., M.I.Loco.E., and the presentation has been arranged to take place at a public meeting to be held in the Victoria Hall, Hanley, Stoke-on-Trent, on Wednesday, October 15, commencing at 7 p.m. Sir William will afterwards deliver the Reginald Mitchell Lecture on "Locomotive Development, Past, Present and Future." The presentation will be made by the President of the Association, Mr. F. J. Goodson.

The Presentation of Technical Information.—The Communication Training Centre, a Department of the British Association for Commercial and Industrial Education, whose address is Management House, 8, Hill Street, London, W.1, is holding an evening meeting on Thursday, October 16, and a day conference on January 5, 1953, to discuss the problem of communicating technical information to specialists and to laymen. The evening meeting, which is intended particularly for senior members of technical managements and is to be held in Management House at 6 p.m., and the day conference, which is intended for graduate engineers and others whose duties involve the submission of written or oral reports, will be held in University College, Gower-street, London, W.C.1, from 9.30 a.m. to 4.30 p.m. For the conference the fee is 30s., but admission to the lecture is by ticket which may be obtained from Management House without charge. The speakers on both occasions will be Professor R. O. Kapp, B.Sc.(Eng.), M.I.E.E., Professor Emeritus in the University of London, Mr. B. C. Brookes, M.A., and Mr. A. C. Leyton, B.A., LL.B.

THE CHEMICAL ENGINEER IN INDUSTRY.*

By E. H. T. HOBLYN, M.B.E., PH.D., A.R.C.S., F.R.I.C., M.I.CHEM.E.†

IN any discussion on higher technological education it is necessary to consider, among others, two factors—the part which the technologist is to play in industry and the contribution which industry must make to his training. This paper is devoted to these factors in so far as they concern the education and training of a chemical engineer. The growth of the chemical industry in Great Britain, in the United States, in Germany and elsewhere has brought with it the realisation that chemical engineering is no haphazard admixture of chemistry and engineering, but a distinct technology in its own right—that it has, in fact, emerged as the fourth primary technology. Although comparatively young, the chemical engineer to-day stands shoulder to shoulder with the civil, mechanical and electrical engineer in contributing to the growth of the world's technological industries.

During and since the war there has been a rapidly-growing awareness of the lack of technologists in the United Kingdom. This shortage has resulted in others, notably the Americans, developing on a commercial scale the discoveries of our pure scientists, and as Sir Harold Hartley pointed out in his recent presidential address‡ to the Institution of Chemical Engineers, "know-how" and designs in certain fields have had to be obtained from abroad. This was not because of any shortcomings in our native skill and ingenuity, but because there were not available the appropriately-trained men in sufficient numbers to enable us to do the development work ourselves with the necessary speed. As was pointed out in the Dunsheath Report,§ many Americans believe that their large numbers of chemical engineers have been an important factor in the rapid progress of industry in the United States. In 1949-50, the number of first degrees in chemical engineering in the United States was 4,529, to which must be added 712 Masters and 178 Doctor's degrees. It is doubtful if the United Kingdom's output of chemical engineers from graduate and post-graduate courses will exceed 250 in 1953. Dr. Dunsheath's team was impressed by the importance attached to chemical engineering in America and reported that this is a field to which American industry looks for a large and increasing number of its graduates.

It is not too soon, therefore, that so much attention is now being focused on chemical engineering education in Britain. Before the end of the war, industry was active in putting forward its views on this subject and was instrumental, with the very ready co-operation of the Ministry of Labour and National Service and the Ministry of Education, in establishing soon after the war short-term courses in chemical engineering to bridge the gap until more men were available from the normal university courses. These courses proved most valuable; they not only produced good men but many of them have since grown into full-time degree courses.

The Work of the Chemical Engineer.—Before discussing the part which industry must play in the training and utilisation of chemical engineers it is desirable briefly to examine the main types of work in which they find employment in the chemical and allied industries, including the gas and oil industries. These are research, development and design of plant, construction and installation of plant, process control and plant operation, and plant maintenance. The nature of the work, the type of man employed and the level of qualification required all vary from job to job and from section to section of the industry.

Chemical plant manufacturers use chemical engineers for research and for designing and installing plant and handing it over to the customer operating satisfactorily. Such work is fundamentally the same whether the plant is to be used in the chemical, gas or oil industries and requires to be carried out by fully-qualified chemical engineers of high technical ability and preferably having had some plant-operating experience. The plant manufacturer also employs chemical engineers on his sales staff.

The chemical and allied industries employ chemical engineers in two very different spheres which require different levels of educational attainment in the subject. In the first place, the chemical industry uses chemical engineers for research and development and the subsequent design and installation of plant for its own particular processes. This often involves the linking up of specialist equipment supplied by a number of plant manufacturers. Such work may also include the costing of the plant and process and its comparison on technical and commercial grounds with an alternative process. A fully-qualified chemical engineer is required for such duties and he must be competent to work closely from the outset of the project, on the one hand with the chemist who has evolved the process in the laboratory and on the other with the civil, mechanical and electrical engineers who will be concerned with the erection and servicing of the plant and the structures which support it or the building which houses it. The chemical industry also employs chemical engineers for plant operation and process control. While large numbers are employed in this way, the number could, with advantage to productive efficiency, be greatly increased, if men with the right type of training were available in sufficient numbers; a lower level of training can normally be accepted for such work, for which Higher National Certificate chemical engineers, to whom reference is made later, should be admirably suited. The oil industry and the gas industry, like the chemical industry, use chemical engineers for design and development work and for process control and technical supervision. It is clear, therefore, that in the chemical and allied process industries and in the engineering industries which serve them, there is tremendous scope for chemical engineers of varying levels of competence and inclination. What, then, does industry require in their training?

The Education of the Chemical Engineer.—There has always been a close and mutually valuable relation between British industry and the universities; as a result, courses in chemical engineering, as in many other subjects, are usually a sound blend of the ideas of academy and industry. Opinions on the method of training a chemical engineer will obviously differ as they do in the case of the training of any other technologist. There is little doubt, however, that the four-year undergraduate course to an honours degree is now accepted as the most usual form of training for a top-grade chemical engineer. It is important to stress that the chemistry and engineering content of the courses leading up to the study in the final year of chemical engineering proper should always be planned with that end in view. Chemistry and engineering must be taught for chemical engineering and there must be no stuffing of the student with facts at the expense of fundamental principles. For example, there is no need for the student to be familiar with a wide range of complex organic syntheses but he should have a clear understanding of the functions of oxidation, reduction, esterification, saponification, and so on, in organic chemical processes, and of the wide applications of reactions such as the Friedel-Craft and the Grignard and the conditions under which they have to be carried out. Similarly, his engineering training should be directed towards a clear understanding of such questions as the flow of fluids, the transfer of heat, the strength of materials and its application to vessel design rather than towards, for instance, a study of mechanisms. It is to be hoped that eventually more of the early training will be given in the chemical-engineering departments themselves.

Courses vary from college to college, and it is desirable that they should, and that each college should build up its own tradition for producing a man with a certain type of training. Depending upon the nature of the work for which the new entrant to industry is required, so should the prospective employer be able to lean towards the products of a particular school of chemical engineering.

Originally, chemical engineering was taught as a post-graduate subject to graduates in chemistry, physics or engineering. Such courses still and must exist for the benefit of those who at a later stage in their academic careers decide to study chemical engineering rather than to proceed to research work in their subject of graduation.

The most significant advance which has been made recently in the scope of chemical-engineering training is the establishment of Higher National Certificates in the subject; the courses to the H.N.C. will be taken by students holding a National Certificate in chemistry or engineering. Industry should welcome these new courses, which will produce what have already been described as the N.C.O's of the chemical and chemical-plant industries. It is for industry to ensure that sufficient raw material is forthcoming from its ranks to warrant the establishment of H.N.C. courses in various centres. It must also ensure that it uses these N.C.O's properly; first, they should be employed at a level of work suited to their training —in some cases this should enable better qualified men to be released for more responsible duties, while in others it should enable more chemical engineers to be used on duties for which at present they are sadly lacking, such as plant and process control, as mentioned earlier. Secondly, industry must provide the N.C.O. with the incentive of promotion, where competent, to commissioned rank. Care must be taken by those concerned that H.N.C. chemical engineering courses are not established in centres which are so close together that they compete for students. It is far better, initially, to have fewer courses and for those courses to be good and supported by properly-equipped laboratories.

Industry's Part in Education.—One of the comments made by witnesses to the Chemical Engineers' Sub-Committee of the Hankey Technical Personnel Committee was that "Chemical engineering is essentially an applied science. . . . The object of a university training should not be to turn out a ready-made chemical engineer, but to teach a man to think along the right lines so that after practical experience he can become one."* Industry, therefore, must make its contribution to the education of the chemical engineer by being prepared to train him further after he leaves the university. In this connection the graduate must come to industry in the proper frame of mind and there is an onus on the teaching staffs to ensure that students do not leave the universities feeling that they are a heaven-sent gift to industry. Some firms in the chemical-plant field and elsewhere have developed two-year trainee courses for chemical engineering graduates which not only give the men extended training while employed, but also enable the employer to determine the type of work for which a given individual is best suited. At the end of these courses, the trainees are free to go elsewhere should they so desire.

In addition, industry must help the student while he is still at the university by providing facilities for vacation and sandwich courses. There is, understandably, a school of thought which prefers the student to do something totally different during his long vacation, but most students prefer to obtain practical experience at some time during this period. Many firms now have excellent vacation training schemes from which the student can gain real benefit. It is imperative that firms accepting students for vacation work should do so with a full sense of their responsibility in assisting in their training and that close liaison is maintained between the firms and the students' professor. Examples of the type of work on which students can be employed are operational tests on plant or the carrying out of pilot-scale work in connection with some research problem.

There is also good reason to devote one vacation to working on the shop floor. This does not mean that the student should spend hours learning to file flat or to operate some machine tool. He can, however, work on the assembly of plant in the

* Paper read before Section G of the British Association at Belfast on Monday, September 8, 1952.

† Director, British Chemical Plant Manufacturers' Association.

‡ *Trans. Inst. Chem. Eng.*, vol. 30, No. 1, page 13, (1952).

§ *Productivity Report: Universities and Industry.* Anglo-American Council on Productivity, November, 1951.

* *Present and Future Supply and Demand for Persons with Professional Qualifications in Chemical Engineering.* H.M. Stationery Office.

shops, learning from this good and bad features of design; he can gain some knowledge of the foundry and its problems by working as a mate to a good moulder; physical operation of a plant which does not readily lend itself to modern methods of automatic control will provide an experience the value of which cannot be lost. There is also a vitally important human aspect of this type of vacation work—it brings the student right alongside the workman; he learns something of his outlook on life, how he thinks, how he works out problems and above all he learns how to get on with him. Many first-class technical men have failed in plant work because they possessed the unhappy knack of upsetting workpeople.

Works experience can also be obtained by sandwich courses which can be developed into something of real value to industry as well as to the student. The report of the Cremer Committee on Chemical Engineering Research pointed out the need to collect and analyse data from large-scale plant operation. Work of this nature could be carried out by a team of students working under appropriate guidance. There have already been cases in which students on vacation courses have carried out tests on plant, and the data they have collected has led to modifications resulting in greater efficiency of the plant. Investigations on the actual working plant planned jointly by the teaching staff at the university and the technical staff of the company concerned and carried out under supervision during the students' actual course should be developed on an increasing scale in this country. This use of industry as the chemical-engineering laboratory has met with great success at the Massachusetts Institute of Technology, and there is no reason why it should not do so in this country.

Another and totally different aspect of the contribution which industry must make to the training of the chemical engineer concerns particularly the man working for the Higher National Certificate or other external qualification. First, he must be so stimulated that he wants to become a chemical engineer. Then, once he has embarked on this course, those responsible for his work must take an active interest in his studies and by precept and practice indoctrinate him with their own trained methods of working. For such a man, industry is his only university and therefore his boss must try to be his professor.

The Future.—The report of the Chemical Engineers Sub-Committee of the Hankey Technical Personnel Committee (*loc. cit.*), published in 1950, gave estimates of the future demand for chemical engineers, but, in view of the expansion of Britain's technological industries and the ever-growing appreciation of the part which the chemical engineer can play in industry, these estimates may well prove to be low. In his presidential address to the Chemistry Section, Professor Wardlow referred to the changing structure of British industry and the increasingly important part which is being played by the chemical industry. This will undoubtedly continue and it is therefore imperative that further investment be made in chemical engineering education, for it will undoubtedly pay high dividends. Facilities for chemical-engineering training in this country should therefore expand rapidly over the next few years, but at the same time there must be no relaxation of teaching or qualifying standards. In this respect, it is fortunate that the Institution of Chemical Engineers has such a keen sense of its responsibility for maintaining the high standard so properly demanded by the profession.

THE ROYAL RESEARCH SHIP, "DISCOVERY II."—Discovery II sailed from Plymouth on Wednesday, September 24, for the western end of the English Channel and the Bay of Biscay, where she will be engaged for a month on further researches into marine physics. Equipped with underwater television, wave-recording apparatus and echo-sounders, etc., measurements will be made of the formation of waves and the transfer of energy from the atmosphere to the oceans. Such information will be of use both for estimating the requirements of coast-protection schemes and for long-term weather forecasts. On her return, the Admiralty state, it is expected that she will have to be laid up owing to a shortage of funds.

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Guide à travers la Mécanique des Fluides. By PROFESSOR LUDWIG PRANDTL. Translated from the third German edition by ALBERT MONOD. Dunod, 92, Rue Bonaparte, Paris (6e). [Price 4,600 francs.]

History of the Second World War. Works and Buildings. By C. M. KOHAN. H.M. Stationery Office, Kingsway, London, W.C.2; and Longmans, Green and Company, Limited, 6 and 7, Clifford-street, London, W.1. [Price 32s. 6d. net.]

The Principles and Practice of Prestressed Concrete. Vol. I. By DR. P. W. ABELES. Second revised edition. Crosby Lockwood and Son, Limited, 39, Thurloe-street, London, S.W.7. [Price 21s. net.]

Practical Mathematics. By LOUIS TOFT and A. D. D. MCKAY. Vol. II. Third edition. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 30s. net.]

United States Coast and Geodetic Survey. Annual Report of the Director of the Coast and Geodetic Survey for the Fiscal Year Ended June 30, 1951. United States Government Printing Office, Washington 25, D.C., U.S.A. [Price 30 cents.]

The Nile. By DR. H. E. HURST. Constable and Company, Limited, 10, Orange-street, London, W.C.2. [Price 30s. net.]

Beitrag zur Berechnung kreuzweise gespannter Fahrbahnplatten im Stahlbrückenbau. By DR.-ING. GERHARD FISCHER. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany. [Price 10 D.M.]; and Lange, Maxwell and Springer, Limited, 41-45, Neal-street, London, W.C.2. [Price 17s. 6d.]

Die Traversen-Methode. By RALPH W. STEWART. Translated into German and edited by PROFESSOR ADOLF KLEINLOGEL. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany. [Price 17.50 D.M.]; and Lange, Maxwell and Springer, Limited, 41-45, Neal-street, London, W.C.2. [Price 30s. 8d.]

Mitteilungen aus dem Institut für Aerodynamik an der eidgenössischen technischen Hochschule in Zürich. No. 19. *Ebene Plattengitter bei Überschallgeschwindigkeit.* By DR. RASHAD M. EL BADRAWY. Verlag Leemann, Stockerstrasse 64, Zürich, Switzerland. [Price 15 Swiss francs.]

Mitteilungen aus dem Institut für Baustatik an der eidgenössischen technischen Hochschule in Zürich. No. 24. *Brückeneinstürze und ihre Lehren.* By DIPL.-ING. CONRAD STAMM. Verlag Leemann, Stockerstrasse 64, Zürich, Switzerland. [Price 12.50 Swiss francs.]

Mitteilungen aus dem Institut für Elektromaschinenbau an der eidgenössischen technischen Hochschule in Zürich. No. 2. *Der Einfluss der Harmonischen auf den Anlauf des Synchronmotors.* By DR. HAROUN MAHROUS. Verlag Leemann, Stockerstrasse 64, Zürich, Switzerland. [Price 12.50 Swiss francs.]

Examples of the Design of Reinforced Concrete Buildings in Accordance with the British Standard Codes. By CHAS. E. REYNOLDS. Concrete Publications, Limited, 14, Dartmouth-street, London, S.W.1. [Price 10s.]

Mitteilungen aus dem Institut für Thermodynamik und Verbrennungsmotorenbau an der eidgenössischen technischen Hochschule in Zürich. No. 10. *Versuche an einem raschlaufenden Zweitakt-Gegenkolben-Dieselmotor.* By DR. A. I. IBRAHIM ABDELFATTAH. Verlag Leemann, Stockerstrasse 64, Zürich, Switzerland. [Price 7.30 Swiss francs.]

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Engines for Power and Speed. By F. E. DEAN. Boys' Power and Speed Library. Temple Press, Limited, Bowling Green-lane, London, E.C.1. [Price 9s. 6d. net.]

Light. By PROFESSOR R. W. DITCHBURN. Blackie and Son, Limited, 17, Stanhope-street, Glasgow, C.4. [Price 45s.]

Mitteilungen aus dem Institut für thermische Turbomaschinen an der eidgenössischen technischen Hochschule in Zürich. No. 1. *Wahl und Entwurf einer Gasturbine und Untersuchung ihrer Eignung zum Antrieb eines Frachtschiffes.* By DR. JOHN J. MCMULLEN. [Price 13 Swiss francs.] No. 2. *Graphische Behandlung der kompressiblen und inkompressiblen Strömung durch Turbomaschinenstufen.* By DR. ADEL GAZARIN. [Price 13.50 Swiss francs.] Verlag Leemann, Stockerstrasse 64, Zürich, Switzerland.

The Design of Rolling Mills. Seventh Conference, held at Church House, Dean's Yard, Westminster, London, June 13 and 14, 1951. British Iron and Steel Research Association, 11, Park-lane, London, W.1. [Price 10s., post free.]

LAUNCHES AND TRIAL TRIPS.

M.S. "HUDSON DEEP."—Single-screw cargo vessel, built by John Readhead and Sons, Ltd., South Shields, for the Hudson Steamship Co., Ltd., London, E.C.3. Main dimensions: 434 ft. 5 in. overall by 55 ft. 8½ in. by 33 ft. 10 in. to raised quarter deck; deadweight capacity, 7,800 tons on a summer draught of 23 ft. 6 in.; bulk cargo-carrying capacity, 397,130 cub. ft. N.E.M.-Doxford four-cylinder opposed-piston airless-injection oil engine, developing 3,000 b.h.p. at 106 r.p.m. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Service speed, 12 knots. Trial trip, August 28.

M.S. "TYNEFIELD."—Single-screw oil tanker, built and engined by R. and W. Hawthorn, Leslie & Co., Ltd., Hebburn-on-Tyne, County Durham, for Hunting and Son, Ltd., Newcastle-upon-Tyne. Main dimensions: 557 ft. overall by 70 ft. by 39 ft. 6 in. to upper deck; deadweight capacity, about 18,500 tons. Hawthorn-Doxford six-cylinder opposed-piston oil engine, developing 7,600 b.h.p. at 114 r.p.m. in service. Trial trip, September 2 and 3.

M.S. "ROMANDIE."—Single-screw cargo vessel, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the Suisse Atlantique Société de Navigation Maritime S.A., Lausanne, Switzerland. Main dimensions: 430 ft. between perpendiculars by 59 ft. 9 in. by 39 ft. 3 in. to shelter deck; deadweight capacity, 10,825 tons on a draught of 26 ft. 9 in.; gross tonnage, 5,807. Sulzer six-cylinder two-stroke single-acting Diesel engine, developing 3,940 b.h.p. at 121 r.p.m., installed by the shipbuilders. Trial trip, September 3.

S.S. "LEDA."—Twin-screw mail boat, carrying 119 first-class and 384 tourist-class passengers, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for Det Bergenske Dampskibsselskab, Bergen, Norway. Main dimensions: 410 ft. between perpendiculars by 57 ft. by 30 ft. to upper deck; gross tonnage, about 7,000; cargo capacity, about 73,000 cub. ft.; deadweight capacity about 2,000 tons on a draught of 20 ft. Two sets of geared turbines with double-reduction double-helical gearing, developing 13,000 s.h.p. at 150 r.p.m., and two Babcock and Wilcox oil-burning boilers, constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Speed, 20½ knots. Launch, September 3.

M.S. "HØEGH RIDER."—Single-screw oil tanker, built by Joseph L. Thompson & Sons, Ltd., Sunderland, for Leif Høegh & Co., Oslo, Norway. Main dimensions: 475 ft. between perpendiculars by 67 ft. 4½ in. by 37 ft. 4 in.; deadweight capacity, 15,135 tons on a draught of 29 ft. Four-cylinder opposed-piston oil engine, constructed and installed by William Doxford & Sons, Ltd., Sunderland. Service speed, 12½ knots. Launch, September 3.

S.S. "RAMSAY."—Single-screw cargo vessel, built and engined by Smith's Dock Co., Ltd., South Bank-on-Tees, for the Bolton Steam Shipping Co., Ltd., London, E.C.3. First of a series of four vessels for these owners. Main dimensions: 426 ft. between perpendiculars by 59 ft. by 38 ft. 3 in. to upper deck; deadweight capacity, 9,950 tons on a draught of about 26 ft. Triple-expansion steam engine working in conjunction with a Bauer-Wach exhaust turbine and developing 3,000 i.h.p. in service, with a speed of 11½ knots. Steam supplied by three oil-burning multitubular boilers. Launch, September 4.

M.S. "LLANTRISANT."—Single-screw cargo vessel, built by Bartram and Sons, Ltd., Sunderland, for the Ethel Radcliffe Steamship Co., Ltd., and the Anthony Radcliffe Steamship Co., Ltd. (Managers: Evan Thomas Radcliffe & Co.), Cardiff. Main dimensions: 445 ft. between perpendiculars by 61 ft. 9½ in. by 40 ft. 2 in. to shelter deck; deadweight capacity, about 10,700 tons on a draught of 26 ft. 10¼ in. Swan Hunter-Doxford four-cylinder opposed-piston airless-injection oil engine, developing 4,400 b.h.p. at 116 r.p.m. in service, constructed by Swan, Hunter and Wigham Richardson, Ltd., Newcastle-upon-Tyne. Trial speed exceeded 15 knots. Trial trip, August 28.

CONTRACTS.

THE DISTINGTON ENGINEERING CO. LTD., Workington, Cumberland, have received an order from the National Coal Board for 100 five-ton mine cars for Bank Hall colliery, in the North Western Division. Negotiations are being completed for 600 thirty-cwt. cars for the same Division.

THE BRITISH INSULATED CALLENDER'S CONSTRUCTION CO. LTD., have received an order from the British Electricity Authority for the erection of the 275-kV double-circuit overhead line from Staythorpe to Elstree. The length of the route is approximately 114 miles. The towers will be of the standard type and to the design of BLAW KNOX LTD. Orders for the fabrication of the steelwork for the towers have been placed with PAINTER BROTHERS LTD., Hereford.