

THE DESIGN OF A LIGHT-WEIGHT 275-KV TRANSMISSION TOWER.

By P. J. RYLE.

A DESIGN has been prepared in Italy of a transmission tower, to carry a 275-kV single-circuit cable, which weighs only 4.8 tons compared with the 7.8 tons of the corresponding tower used by the British Electricity Authority. This has been achieved mainly by using tubes for the bracing members, high-tensile steel for the main members, and the most important bracing members, and by using electrically-welded joints where practicable. A sample tower has been constructed to this design, and the tests on it are described below.

The circumstances which led to the Italian design

and, early in 1950, tests on this tower were made at the S.A.E.'s testing station at Lecco, near Milan, in the presence of representative British engineers.

TOWER TESTING STATION.

The main differences between the British and Italian designs are indicated in the accompanying Table, while Fig. 1 shows the Italian tower erected at the testing station with the control cabin on the far hillside, almost on the tower's centre line.

The station is situated in a ravine, so that horizontal loads can be applied from pull-off points anchored to the rocky walls at any height above the tower base likely to be required. The base of the tower under test is fixed to a large permanent concrete block. This block has a central hole, about 6 ft. deep, from which radiate eight inverted-T grooves spaced at 45 deg. to allow

through multiple pulley blocks, which are suspended in the neighbourhood of the winches.

Test loads are measured by hydraulic (oil) dynamometers situated, as in British practice, at the points of final pull, so that no corrections for pulley friction, etc., are necessary. Before the tower tests, the dynamometers were checked against each other and against a master which was, in turn, tested in a certified testing machine. An ingenious and effective method of transmitting dynamometer readings to the desk in the control cabin is used to overcome the awkwardness and difficulties of long oil pipes and the need for correcting the head of oil corresponding to the height of each dynamometer above its gauge. Each dynamometer is provided with a Selsyn-type transmitter, of which the rotor is directly connected to the dynamometer needle spindle through a flexible coupling to avoid any trouble due to slightly imperfect alignment. Fig. 3 shows one of the dynamometers; the comparatively small cylindrical projection in the centre is the Selsyn transmitter. A similar Selsyn-type receiver, on the desk in the control cabin, directly operates a needle over a suitably calibrated scale. The transmitters and receivers are connected by cab-tyre cables with special multi-point plugs to ensure correct coupling.

The Selsyn principle of transmission of angular displacement is also used in the control cabin to give a continuous indication of the tower deflection. At the point of the tower at which deflection is to be measured, a large-diameter

Design Data of British and Italian 275-kV Suspension Towers.

	British Design.	Italian Design.
Base orientation	"Four-square."	"Rotated."
Member construction	All members British Standard angles.	Main leg and main cross-arm members, angles; practically all bracing members, tubes.
Steel	British Standard 15 (No. 1 quality) 28 to 33-ton quality.	All main members—high tensile of a quality slightly lower than British Standard 15 on breaking, but equal on yield point. Slender bracing members—mild steel, of a quality slightly lower than British Standard 15 on breaking, but equal on yield point.
Protection	Galvanised throughout.	Painted.
Minimum metal thickness	Main members: $\frac{5}{16}$ in. = 7.9 mm. Other members: $\frac{3}{16}$ in. = 4.8 mm.	Main leg (angle) members: 8 mm. Main cross-arm (angle) members: 7 mm. Bracing members (tubes) practically all 2.5 mm. thick (slightly under $\frac{1}{4}$ in.). Mostly bolted, but certain complete frames welded up. For tubular members with bolted connections, ends of tubes flattened and butt-welded to flat lugs.
Connections	All bolted.	
Minimum bolt dia.	$\frac{5}{8}$ in. = 15.9 mm.	12 mm.
Tower weight	7.8 tons.	4.8 tons.

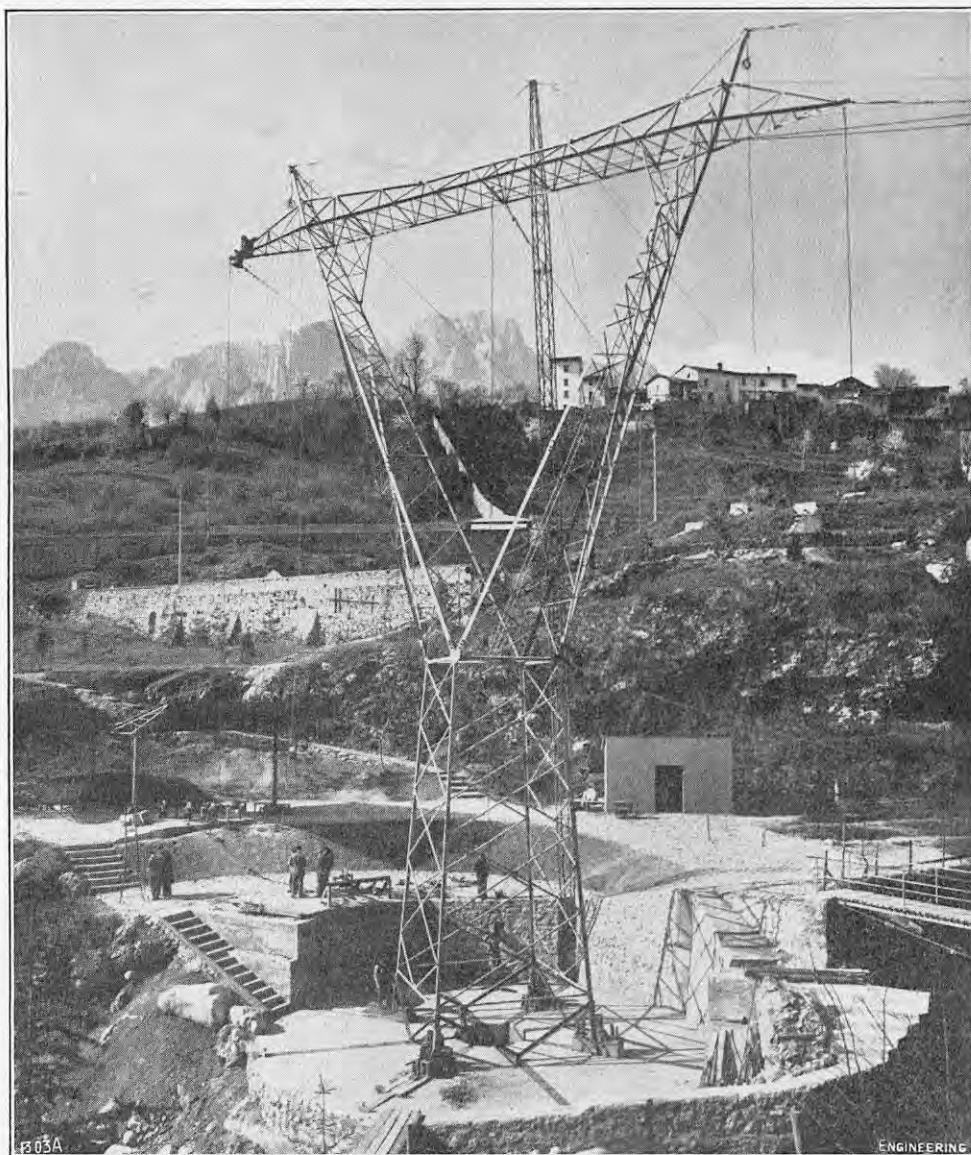


FIG. 1. ITALIAN TOWER ERECTED AT TESTING STATION.

and construction were as follows. In a paper* on "The Mechanical Design of 264-kV Transmission Lines in Great Britain," Mr. A. E. Percival outlined the main features of the single-circuit 264-kV (now 275-kV) suspension tower of the British Electricity Authority; and described the specified tests which had been successfully applied to a sample tower. Arising out of the informal discussion on this paper, Mr. F. Bianchi, of the Societa Anonima Elettificazione (S.A.E.), Italy, offered to design a sample tower with the same conductor spacings and heights and for the same external loadings as the British tower, but of a much reduced weight;

for tests on towers with either "four-square" or "rotated" bases. The tower base is held by foundation bolts carried down the vertical parts of the "T" grooves to cross-channels in the cross-grooves. Between the bottom of the leg member of each tower and the foundation bolts, a special chair with an adjustable part-cylindrical seating, to suit any slope of tower leg, is provided, as shown in Fig. 2, on page 226.

All test loads, horizontal and vertical, are applied through pulley-block systems by means of flexible steel ropes from small electric winches. These winches are similar to those used during the war on British barrage-balloon trucks. The cable runs several times round two small driven grooved drums, the slack end being taken up by dead weights acting

aluminium pulley wheel is mounted. A light cord is run horizontally from a fixed point over the pulley to a small suspended weight. During the tests, this fixed point (for the main transverse deflections) was provided by a tall stayed lattice boom, free from the tower under test; this boom can be seen behind the tower in Fig. 1. Tower deflection relative to the fixed point causes angular rotation of the pulley wheel, and this angular motion is transmitted by the Selsyn apparatus to a dial, in the control cabin, which is suitably calibrated to read deflection directly in centimetres. The continuous indication of deflection thus given is much to be preferred to the usual method of observation by a ground observer through a theodolite. Fig. 4, on page 226, illustrates the interior of the control cabin and shows the dials for recording the loads and deflections.

* Conférence Internationale des Grands Réseaux Electriques à Haute Tension, 1948. Paper No. 226.

TESTS ON 275-KV TRANSMISSION TOWER.

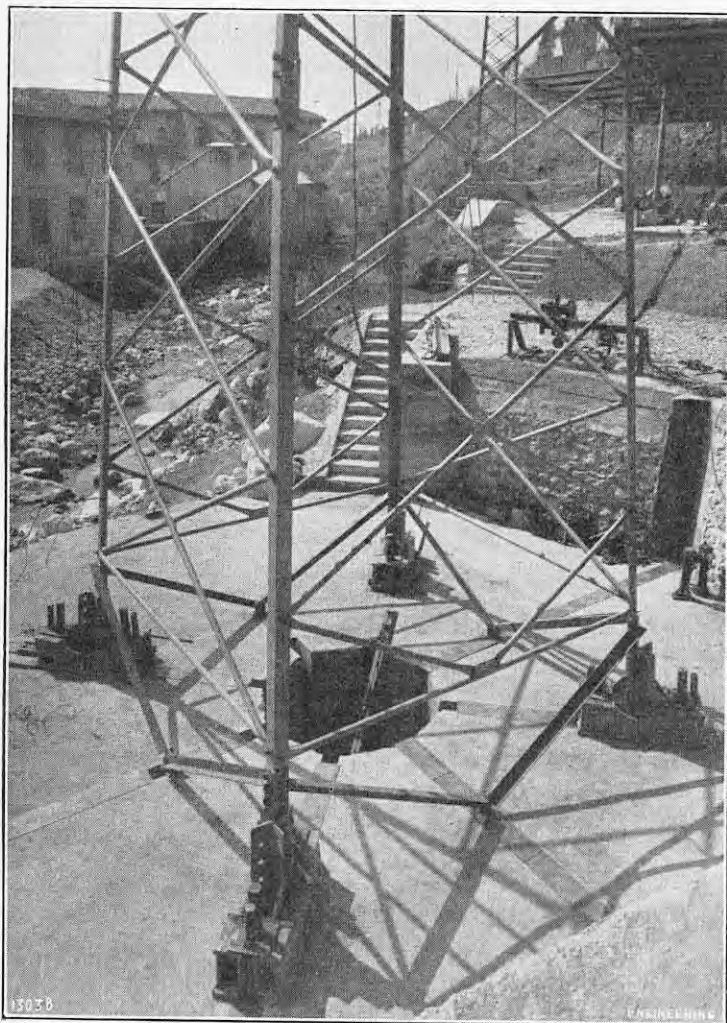


FIG. 2. CHAIRS WITH PARTLY-CYLINDRICAL SEATINGS.

TOWER TESTS.

The tests carried out were the same as those already successfully made in England on the British Electricity Authority's tower and were briefly as follows. Test 1: Maximum transverse working loads together with minimum vertical loads, all multiplied by a factor of safety of 2.5. Test 2: As in test 1, but with maximum vertical loads. Test 3: Maximum transverse and vertical loads as modified by the assumed breakage of one earth conductor, together with a longitudinal load due to the broken earth conductor, all multiplied by a factor of safety of 1.5. Test 4: Maximum transverse and vertical loads as modified by assumed breakage of one outer line conductor, together with a longitudinal load due to the broken line conductor, all multiplied by a factor of safety of 1.5. Test 6: As Test 4, except that the middle line conductor was broken instead of the outer line conductor. Another test (Test 5), the same as Test 4, but with the other outer line conductor broken, was omitted since it was agreed that, for the particular tower design, it would not introduce more serious stresses than Test 4.

All of these tests were successful. The tower was not tested to destruction, but when full loads were nearly reached on Test 2, a tensile failure of the outer cross-arm tie occurred. This failure was agreed to be ascribable to an anomalous local bending moment at the cross-arm end, which was set up by the method of applying the transverse test load. The broken part of the cross-arm, which is shown in Fig. 5, was therefore removed and a new part erected with a modified attachment for applying the transverse load. This removed the anomalous local bending moment and Test 2 was then re-applied successfully.

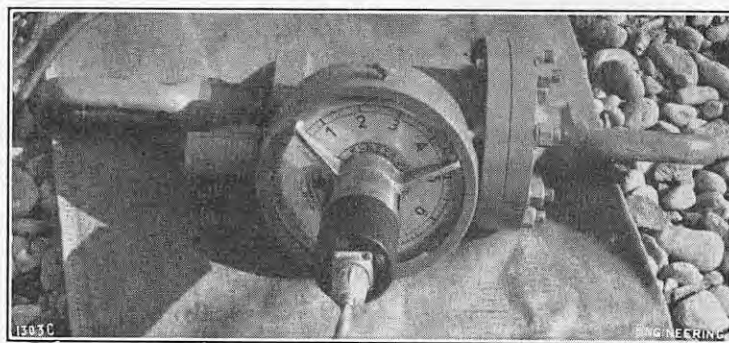


FIG. 3. TEST DYNAMOMETER.

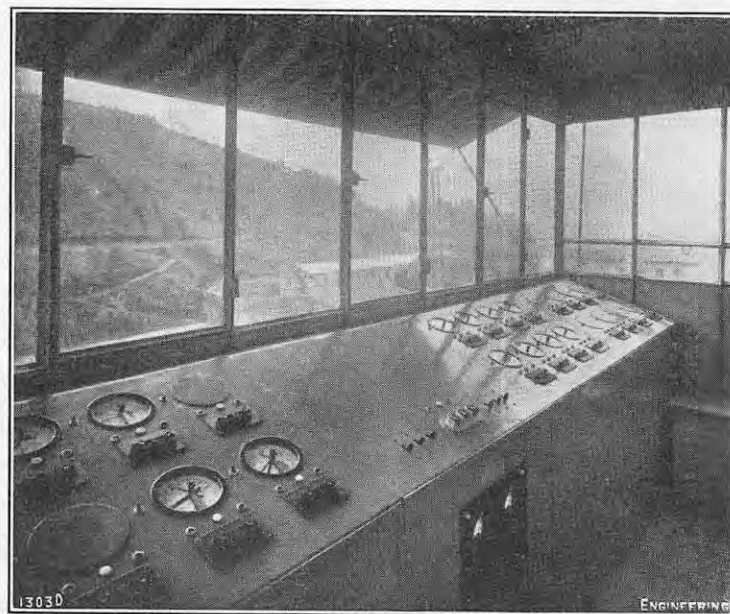


FIG. 4. CONTROL CABIN.

COMPARATIVE TOWER WEIGHTS.

Without going deeply into the whole subject of comparative tower design, it is worth while to consider broadly the main factors which bear upon the comparative weights of the British tower (7.8 tons) and the Italian tower (4.8 tons). It would appear that the main savings in weight obtained in the Italian design are due, firstly, to the use of rather thin-walled tubes (instead of angles) for most of the bracing members; secondly, to the use of high-tensile steel in the main legs and in the most important bracing members; and thirdly, to the use of electrically-welded joints, where practicable. The following is purely a tentative, and very rough, assessment, which may approximately represent the facts, although it ignores obviously important considerations of actual tower outline design. Assume that the total weight of the bracing members is half the total tower weight. The comparative weight of tubes with 0.1-in. walls, as struts, as compared with $\frac{3}{8}$ in. thick angles, as struts, may be approximated by the method outlined in the author's paper on "Steel Tower Economics."* This treatment is based on the ratio of cross-sectional area to radius of gyration of the strut section. On the assumptions given in the paper, it would appear that, for a given slenderness ratio, an unstressed tubular strut with a wall 0.1 in. thick, should only weigh about 50 per cent. of that of an unstressed angle strut $\frac{3}{8}$ in. thick, and about 70 per cent. for average stressed struts. Since the tower embodies both stressed and unstressed strut bracings, a mean value of 0.6 for the ratio of weight of

the tubular versus the angle struts may be assumed. Then, if both the British and the Italian designs were of the same quality of steel, and of virtually the same outline design, the relative weight of the latter might be expected to be as follows, taking the weight of the former as unity: Main leg members (angles), 0.5; braces (tubes), $0.5 \times 0.6 = 0.3$; total 0.8. The extensive use of high-tensile steel may reduce the weight further by, say, 20 per cent., making the total hypothetical relative weight of the Italian tower 0.64. The actual relative weight is $4.8 \text{ tons} \div 7.8 \text{ tons} = 0.615$. The Italian tower, as tested, had other features which would, in a minor degree, tend towards a low relative weight. The British tower was completely galvanised and all members had, therefore, to be connected by bolted joints. The Italian tower was not designed to be galvanised, and certain quite extensive frames were made up as complete units with welded joints, thereby saving the weights of gussets, overlaps and bolts.

ECONOMIC AND STRUCTURAL CONSIDERATIONS.

In Italy much emphasis has been laid for many years on the saving of steel, especially in view of its high cost. The extensive use of tubes (there are hundreds of miles of line of major importance in commission embodying the use of tubular tower members, wholly or in part) can obviously effect such a saving. In Great Britain to-day, however, the cost of seamless tubes per ton is about twice that of angles, so that even considerable savings in tower weight would not necessarily mean cheaper towers. It would appear that the use of tubular members in towers cannot provide financial economy unless the cost of tubes per ton can be kept down to not more than 30 to 40 per cent. above the cost

* P. J. Ryle, "Steel Tower Economics," *Journal of the Institution of Electrical Engineers*, vol. 93, part II, page 274 (1946).

275-KV TRANSMISSION TOWER.



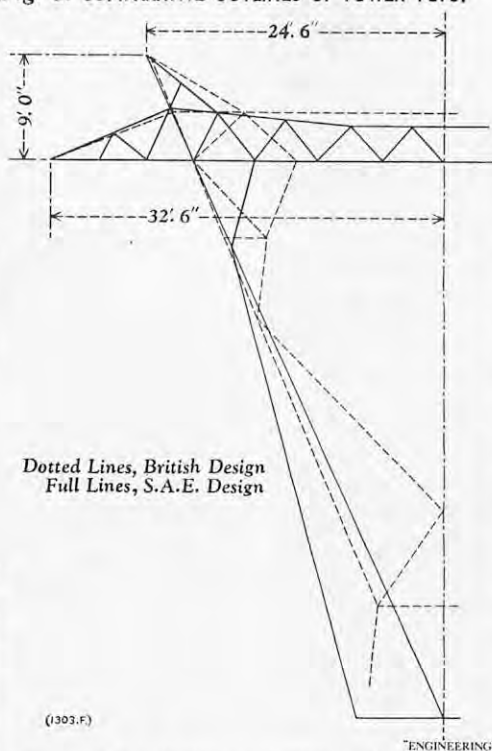
FIG. 5. BROKEN CROSS-ARM.

of angles per ton. The possibilities of obtaining relatively cheap seam-welded tubes should be worthy of exploration. The subject of galvanising versus painting is perennial; British experience strongly favours the former. The galvanising of tubular members, however, introduces several difficulties and the problems arising therefrom cannot yet be considered to be completely solved. Mr. Bianchi said that, if he were to design a tower for the same duties as that tested, but galvanised throughout and without any welding, he would probably abandon the use of tubes and revert to angles, with, of course, a corresponding increase in tower weight, from about 4.8 to 5.9 tons. If painting were to be the only anti-corrosive protection, one would certainly hesitate to use tubular members with walls as thin as 0.1 in. in Great Britain. In many parts of the country, any failure to clean and paint one or two spots properly at each routine painting would rapidly lead to dangerous corrosion.

The economics of the use of high-tensile steel in British tower construction is now a subject of recognised practical importance. In the past, the cost of this material in Great Britain has often been so high that little, if any, financial saving would have accrued from decreased tower weights. The British tower, if designed to substantially the present design, but embodying the use of high-tensile steel where economically convenient, would have been at least one ton lighter. British tower specifications call for bolts of a minimum diameter of $\frac{3}{8}$ in. On the Italian tower tested, many bolts (especially at the attachments of unstressed members) were slightly under $\frac{1}{2}$ in. diameter. On the 230-kV Sluderno-Stelvio-Cesano Maderno line, some towers of which were inspected, some of the bolts attaching unstressed braces were only a little over $\frac{3}{8}$ in. diameter. Theoretically, of course, considerable economy is attainable by carefully suiting bolt diameters to the loads to be carried, but the possibilities of mistakes in erection must not be overlooked; and there is always a certain risk that very small bolts may be over-stressed by over-powerful erectors.

One point of interest in the Italian design, as tested, is that the tower was made to give the same horizontal conductor spacing, 32 ft. 6 in., as the British tower. It appears, however, that the general outline would have permitted this to be decreased by at least 1 ft. 6 in., without encroaching on the specified live metal clearances. Such reduction in horizontal spacing would, of course, slightly decrease the tower cost and also very slightly decrease (by about 1 per cent.) the line reactance—both favourable considerations. Fig. 6 shows, approximately, the cross-arm and relevant member

Fig. 6. COMPARATIVE OUTLINES OF TOWER TOPS.



outlines of the British and Italian designs superimposed to illustrate this point. The Italian general outline clearly would have permitted the middle "window" of the tower to be reduced somewhat in width.

A fairly small, but not inconsiderable, advantage of tubular members is a reduction in the wind load on the tower itself. For any given strut member, assuming equal compressive loads and strut lengths, the projected width of the tubular strut would be less than that of the angle strut; and, over and above the corresponding reduced projected area, the effective unit wind pressure on the cylindrical strut could be taken as about two-thirds of that on the flat-surface angle strut. For a tower having angle main members and tubular bracings, the total wind overturning moment on the tower itself might thereby be of the order of 20 per cent. less than that on a tower made completely of angles. However, for towers of the general type under consideration, the overturning moment due to the conductor loads may be expected to be four to five times that due to the wind load, so that the total tower overturning moment would only be reduced by about 4 per cent., and the tower weight by only about 2 per cent. The above figures are only very rough, but give an approximate picture of the relative considerations. It may be pointed out that, for very tall radio towers, especially those with little or no transverse loads due to aerial-wire pulls, the wind load on the tower itself may be preponderating and the advantages, in this respect, of tubular members would be quite considerable.

The pros and cons of the "four-square" and "rotated" base designs depend largely on the specified tower loadings in the transverse and longitudinal directions and the proportions which these bear to each other. For the particular loadings concerned, it would not appear that the choice between the "four-square" and "rotated" bases is very critical. The Italian tower embodied the latter, and certainly indicated the excellent use of the principle in so far as this favours good distribution of torsional stresses around the lower half of the tower under the condition of an outer broken conductor.

This article is based on Technical Report No. O/T9 of the British Electrical and Allied Industries Research Association.

LITERATURE.

Essentials of Fluid Dynamics, with Applications to Hydraulics, Aeronautics, Meteorology and Other Subjects.

By LUDWIG PRANDTL. Blackie and Son, Limited, 17, Stanhope-street, Glasgow, C.4. [Price 35s.]

Guide à travers la Mécanique des Fluides.

By LUDWIG PRANDTL. Dunod, 92, Rue Bonaparte, Paris, 6e. [Price 4,600 francs.]

THE outstanding contributions made to the dynamics of fluids, and more particularly of real fluids, by Professor Prandtl during his long term of distinguished service as Director of the Kaiser Wilhelm Institut für Strömungsforschung at Göttingen, are well known and the almost simultaneous appearance of two translations of the 1949 edition of his *Führer durch die Strömungslehre* constitute a fitting tribute to the universal esteem in which he is held. The English translation is the work of Miss W. M. Deans, and the French translation, bearing a title nearer to the original and largely inspired by Mr. Darrieus of the Institut, has been carried out by Mr. Albert Monod.

The subject matter of the first two chapters is the classical groundwork of hydrostatics and the dynamics of ideal (frictionless) fluids. Here, as elsewhere, mathematics are used sparingly, often being relegated to sections interpolated in the text; attention is mainly directed towards presenting a clear physical picture in which occasional practical details are included, as, for instance, of the calibration of the Töpler pressure-level. Chapter III, on the motion of viscous fluids, turbulence and fluid resistance, occupies nearly one-third of the text. Viscosity must be taken into consideration in dealing with real fluids and this introduces difficulties with which mathematical analysis alone is unable to cope, so that recourse has to be had to experiments, usually requiring the provision of tanks or wind tunnels. It was an experimental study of relatively inviscid fluids that led Prandtl, in 1904, to introduce the fundamental concept of the boundary layer. After discussing the manner in which turbulence originates at such a layer, and the conditions promoting the formation of eddies, various methods of preventing the onset of eddies are described and illustrated. The hydrodynamical theory of bearing lubrication affords an important practical example of fluid motion in which viscosity is predominant. A summary of the essential features of flow through pipes and channels of various sections is followed by a comprehensive survey of the resistance experienced by bodies moving relatively to a fluid. The theory of the aerofoil, and its practical applications, are admirably presented, as would be expected, and the chapter ends with an account of propellers of fixed variable pitch, water turbines, pumps and compressors, together with brief references to bird flight and useful notes on hydrodynamical and aerodynamical methods of experiment.

To many, the next chapter will be the most interesting in the book, dealing, as it does, with supersonic flow and reporting much work, particularly that done in Germany during the war years, that has been released only lately for publication. The propagation of pressure, and the one-dimensional treatment of steady flow at velocities so high as to be accompanied by appreciable volume changes, lead to a discussion of the theory of the normal shock wave, supersonic flow in two-dimensions past tapering bodies, and the resistance encountered by projectiles. There is also a description of the supersonic wind tunnel at Zürich. An extensive selection of miscellaneous topics is dealt with in the concluding chapter under five headings, beginning with the combined effect of more than one state of matter, in which are included cavitation and water

hammer, transport of suspended material in fluids (sand storms and snow storms), and hydrodynamical action at a distance. Section B deals with laws of flow in rotating enclosures, with engineering applications to pumps and turbines and geophysical applications to the motion of wind and water over the rotating surface of the earth. Motion of stratified media under the influence of gravity is discussed in Section C, together with its meteorological implications; and Section D is devoted to convection and transfer of heat in moving media. "Acoustic hardness" on page 320 would appear to be a literal translation of the original, for the corresponding French translation is "dureté du son," which reads even more strangely. The French translator, however, has made its meaning clearer by adding "ou impédance d'ondes." The equivalent English term is "specific acoustic resistance."

There is a useful bibliography of recent publications on hydrodynamics, to which further notes and references have been added in the English edition. The photographs of flow patterns, vortex systems and Schlieren images are excellent: they are rather better reproduced in the English edition, though its cost is less than half that of the French edition. It is impossible, within a limited space, to indicate the full extent of the ground covered in this fascinating book, in which Professor Prandtl ranges over the whole of his vast subject in a lucid and stimulating manner, illuminated by occasional historical asides. Its appearance in two languages, besides the original, will serve to render it more readily available to those who desire to know what has been and is being accomplished in hydrodynamics.

Principles and Practices of Prestressed Concrete, Vol. I.

By P. W. ABELES, D.Sc.(Vienna), M.I.Struct.E., M.Am.Soc.E. Second edition. Crosby Lockwood and Son, Limited, 39, Thurlow-street, London, S.W.7. [Price 21s.]

It has been said on many occasions that, if nothing else, the prestressing of concrete has had at least the effect of raising the quality of concrete. The statement is justified, for it is only a short time since the top grade of concrete specified (and sometimes obtained on contractors' sites) had a working strength of 1,000 lb. per square inch for a concrete that had a proved strength of 3,000 lb. per square inch when 28 days old, yet values twice as great are now frequently being demanded and achieved. The implication, however, that prestressed concrete has no value of itself is not deserved; prestressed concrete is essentially a better material than ordinary reinforced concrete. Costs are not germane to this consideration: prestressed concrete is the better material because the sustained presence of a compressive stress ensures an absence of hair cracks, thereby raising the resistance of the concrete to corrosion, which is the source of deterioration leading to scaling and ultimate failure.

The reason for the rapid growth of the use of prestressed concrete is the enthusiasm of a few pioneers, among whom must be recognised the author, Dr. Abeles, who first published his book in 1949. As he notes in the preface to this second edition, developments in the practice of prestressing have made it necessary to divide the book into two volumes, the second of which is now in the course of preparation. Its publication, to be expected in the late autumn of this year, should make a valuable addition to English text-books on this subject. The revision of the book has made it possible to amend the text in the light of the recommendations of the committee (of which Dr. Abeles was a member) that was convened by the Institution of Structural Engineers to examine and report on the practices of prestressing concrete.*

On the title page, it is stated that "this volume deals mainly with prestressed beams." Such a

statement prompts inquiry into the nature of other constructional elements that might benefit from being prestressed; two possible examples, concrete columns and concrete barrel-vault roofs, are doubtless topics for inclusion in the second volume, along with a fuller description of completed structures. Apart from the central core of the book, which deals with fundamentals and the design of prestressed beams and is supported by a chapter of comparative examples, and sections descriptive of the practice of prestressing, there are two chapters that will appeal to the more studious reader: one gives a brief but concise history of prestressed concrete, and the other a very much condensed note on current research. This chapter on research is too short to be of value by itself, although it does contain an excellent list of 16 suggestions of matters requiring further investigation (they were given in the 1948 edition, but the author regrets that they still await investigation) and a bibliography of 73 references, principally in English. It is understood that the material on research, and recent developments generally, are to be elaborated in the companion Vol. II.

Electrical Measurements.

By DR. FOREST K. HARRIS. John Wiley and Sons, Inc., 440, Fourth-avenue, New York 16, N.Y., U.S.A. [Price 8 dols]; Chapman and Hall, Ltd., 37, Essex-street, London, W.C.2. [Price 64s. net.]

THERE can be few research workers in any engineering field who do not require to use electrical measuring instruments or methods, and this review of the whole subject of electrical measurement should be of wide service. All measurement is subject to error and it is important that the procedure chosen should have proper relation to other factors in the problem being dealt with. Dr. Harris does not rate the accuracy attained in most fields by simple means at higher than a few per cent. This may be sufficient for some shop procedures in which the accuracy of machinery may be no better. If something under 1 per cent. is aimed at, careful selection of instruments is necessary and correction may be required to allow for the effect of the measuring equipment on the thing being measured. Dr. Harris considers that an accuracy of a tenth of 1 per cent. represents the limit at which the indications of deflecting instruments can be read, and that usually corrections to allow for ambient conditions must be applied.

This book deals with the whole range of electrical measuring instruments in the direct-current and low-frequency alternating-current fields, ranging from direct-current galvanometers to alternating current bridges. The matter of accuracy is stressed throughout; for instance, it is pointed out that, if an instrument current transformer is to be used for precise measurements, the standard rating may not provide a safe basis for computation. The ratio and phase angle of the transformer should be determined at the particular burden which will be imposed during the measurements. The book is stated to be based on a course of lectures to students of electrical engineering at the George Washington University, but these must have been senior men, as adequate theoretical knowledge and some mathematical ability are assumed. The discussions of principles which precede consideration of the various methods and instruments should be of value to mature students, but the broad theme of the choice of method in relation to the accuracy aimed at is probably of more direct interest to research workers. A student has to use the apparatus that he finds, in a university laboratory; a member of an important research team will probably be given a wider choice and greater opportunity to employed refined methods. The sections dealing with experimental accuracy, random and systematic errors and laboratory practices should be of value to this class of worker.

Historical Metrology.

By A. E. BERRIMAN, O.B.E. M.I.Mech.E., F.R.Ae.S. J. M. Dent and Sons Limited, Aldine House, Bedford-street, London, W.C.2. [Price 16s. net.]

ALL measurement of length derives originally from the human body—the length of the foot, the average pace, the span of the hand, etc.; and the measurement of weight and quantity, initially, from natural objects. To-day, if some international decision were taken to adopt a new measure, its promulgation and general introduction could be organised quickly and exactly; but in prehistorical times, when the lack of dependable communications made the process of diffusion slow and uncertain, there was much more opportunity for independent development, community by community. It is interesting and deeply significant, therefore, to see how different racial conceptions of metrology evolved along parallel lines, and to realise how many points of similarity there are, all unsuspected by the peoples who were responsible for the evolution. The comparison of these systems, different, yet so curiously similar, is the aim of Mr. Berriman's absorbing study; the work of an amateur who was able to bring to the task the advantages of an engineering training and an engineering experience in many fields.

"This book begins," to quote Mr. Berriman's preface, "with an introductory summary of the results of research on which I spent much of my spare time for ten years"; but his interest in the origins of ancient measures, he states, "remained casual until I happened to notice that published lengths of the royal cubit could be expressed plausibly by 20.6265 in." Readers of the first chapter alone will appreciate our feeling, on coming across this observation, that, as an incidental comment, it deserves to rank with that classical footnote of the late Rupert T. Gould, in one of his books, that "I once read through the *Encyclopaedia Britannica* and *Chambers's Encyclopaedia* and, of the two, I prefer *Chambers's*." Succeeding chapters deal with the metrology (or particular aspects of it) of India, China, Russia, Babylon, Egypt, Palestine, Greece and Rome, France, England, and the United States, with interpolated chapters on "Metrological Aspects of Money," and a "Chronological History of the Metric System." There follow a number of appendices which are miniature essays in themselves; a bibliography which is what the word really implies, since it does consist mainly of references to books; and an excellent index which is unusual in that it is divided into ten sections ("Linear Units," "Land Units," "Persons," "Buildings," "Weights," etc.), each with its contents alphabetically arranged, but with the entries disposed in paragraphs instead of in tabular form. This disposition of the index may seem awkward at first, but it has advantages in dealing with such a widely ranging survey as Mr. Berriman presents.

Our first reaction to this book was to think of the enjoyment it would have given to that encyclopaedic engineer-conversationalist, the late Mr. H. S. Rowell, and the next was to realise—a mental leap induced, perhaps, by some of the parallels cited in the book, not less exact or astonishing—how similar was his background to that of the author: both Members of the Institution of Mechanical Engineers (Rowell in 1917, Berriman in 1918) and of the former Institution of Automobile Engineers, both closely associated with the development of the motor-car and its associated industries, both holding the O.B.E. Those who knew Rowell and his views on metrology will need no stronger recommendation to read this book; and, having read it, they will certainly wish that they knew Mr. Berriman, or, if they know him already, to congratulate him upon having presented in a new light a subject of such abiding interest.

* Report on Prestressed Concrete. The Institution of Structural Engineers, 1951. [Price 3s. 6d.]

THE EFFECT OF AXIAL SLIP ON FACING WITH A LATHE.

By P. M. GILET.

THE effect of axial slip in modifying the shape of a surface produced by facing on a lathe was first noted by the writer when he was an officer of the Commonwealth Scientific and Industrial Research Organization, at the Australian National Standards Laboratory. By axial slip or axial float is meant an axial movement of the spindle which repeats positively with each revolution as a result of manufacturing errors such as lack of squareness of thrust faces with the spindle axis. This effect is apparently not well known, and it is thought desirable to bring it to the attention, particularly, of those who have occasion to use acceptance test charts.

plane which departs from squareness with the axis by an angle ϕ such that $S = d \sin \phi$.

To illustrate the shape of the surface described, a grossly exaggerated case has been taken. Fig. 1, herewith, shows a wooden model of the surface, 5 in. in diameter (with a central hole $\frac{1}{2}$ in. in diameter) which would be produced if the cross-slide motion were square to the spindle axis and the axial float were $\frac{1}{2}$ in. Fig. 2 is a key to Fig. 1, with the radial lines identified by reference letters. Fig. 3, 4 and 5 show the profiles of the surface of Fig. 1 for sections through the points A A', B B', and C C', respectively, and containing the axis of rotation.

Such a surface will not rest on a truly flat surface without rocking and cannot be simply described as being either flat, concave or convex. If the lathe spindle has the maximum permissible amount of

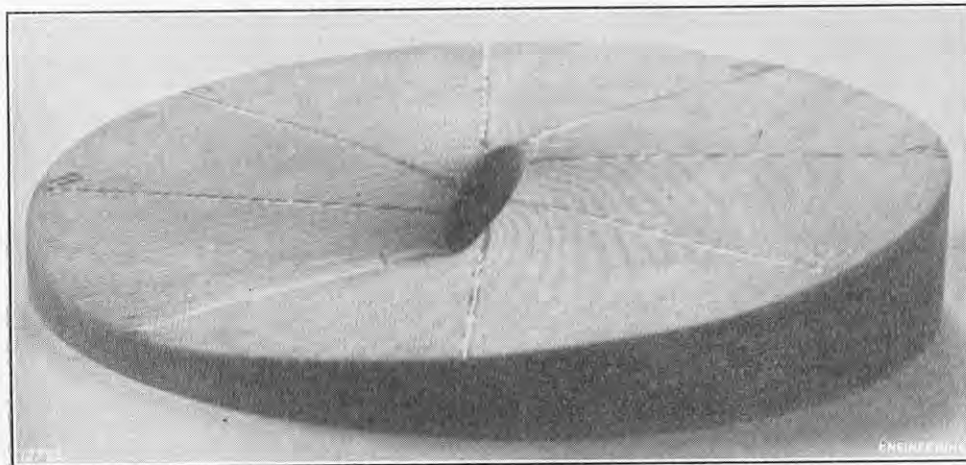


FIG. 1. WOODEN MODEL SHOWING THE EFFECT OF SLIP, EXAGGERATED.

Fig. 2.

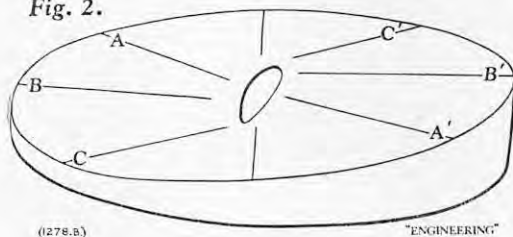


Fig. 3.



Fig. 4.



Fig. 5.

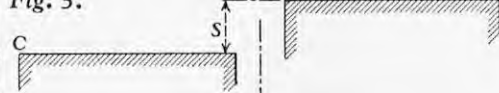
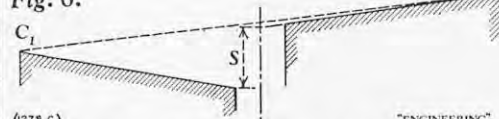


Fig. 6.



For example, the acceptance test chart for centre lathes (up to 16 in. swing, first grade), published by the Institutions of Mechanical and Production Engineers allows the axial slip to be as much as 0.0005 in. (item 6) and requires that the lathe shall be capable of producing a surface, by facing with the cross-slide, which departs from flatness by not more than 0.001 in. per 12 in. diameter (item 28). A further requirement for the facing test is that the surface produced shall not be convex. This ensures that any surface produced by facing will bear against a truly flat surface without "rocking." However, it can be shown that, when the motion of the cross-slide is perfectly square to the spindle axis, the presence of axial slip causes the production of a surface which is not flat, which cannot be described either as convex or concave, and which will not bear against a truly flat surface without rocking.

If θ be the angle through which the spindle has rotated, the motion of a point fixed relatively to the spindle and on its axis of rotation can be represented by $x = \frac{1}{2} S \sin \theta$, where S is the axial slip. If the motion of the cross-slide is perfectly square to the spindle axis, the surface produced is that generated by a line intersecting the spindle axis at right angles and moving axially, as it rotates about the axis, according to the above relationship. Alternatively, the surface produced can be regarded as that generated by a line passing through the axis and also through a certain ellipse, the generating line remaining perpendicular to the axis. The ellipse concerned is the intersection of a cylinder, of diameter equal to that of the surface produced, with a

axial slip, 0.0005 in., in order to produce a surface which will not rock (or which could be described as being hollow), the motion of the cross-slide must depart from squareness with the spindle axis in the appropriate direction by at least 0.0005 in. over the diameter of the surface. (The profile corresponding to the C C' lines of Fig. 2 would then be as in Fig. 6.)

The surface so produced will depart from flatness by 0.0005 in., which is effectively the lower limit for the departure from flatness. Since the upper limit for a surface 12 in. in diameter is 0.001 in., if the axial slip is of the maximum amount permitted, the effective tolerance for the facing test is reduced by 50 per cent. If the axial slip were 0.001 in., or if the largest diameter of surface which could be produced were 6 in., there would be no tolerance left for the facing test.

It is to be noted that the assumption has been made that the requirement that the surface produced by facing shall be flat or hollow, but not convex, is to be interpreted as a "non-rocking" requirement.

THE BITUMINOUS SANDS OF ALBERTA.

By A. A. PEEBLES.

IN northern Alberta, Canada, the vast deposits of bituminous sands along and adjacent to the Athabasca River contain oil reserves which may possibly exceed those of any single known oilfield in the world. Their full extent has yet to be ascertained, but it may greatly exceed present estimates. Sufficient data have been obtained, however, by means of borings over a wide area, to suggest a tract of probably 30,000 square miles. A series of outcrops occurs along over 100 miles of the Athabasca River and its tributaries, the exposures varying from a few feet to cliffs of over 200 ft. It is also interesting that bitumen, of an identical nature to that found in these sands, has been obtained from wells drilled into the upper Devonian limestone over 100 miles to the west.

Not all of this assessed area is suitable for commercial exploitation. Borings have shown some barren spots, while much of it has too deep an overburden or too shallow a sand layer to make mining economically possible. Discounting these facts, an immense area remains which can be profitably developed on a commercial basis. Practically no such development has taken place at present, but much research work and exploration have been carried out by both the Canadian Federal and the Alberta Provincial Governments, and the results of these investigations show that the production of oil on a profitable basis is feasible.

The Devonian limestone underlying the bituminous sands can be seen at some of the outcroppings, particularly in the vicinity of the town of Fort McMurray, about 230 miles to the north of Edmonton; its situation is shown in the map, Fig. 1, on page 230. The upper part of the limestone formation is in hard massive bands, and the top appears to be smooth and level. The sand formation, in general, is dark brown or black in colour. The rich beds appear to be fairly homogeneous, and consist of an unconsolidated sand, saturated with a particularly viscous petroleum.

Comparisons of the amount of bitumen available with the reserve of oil in normal fields are only realistic if placed on the same basis. From the data at present available, this cannot be done with precision. The percentage of the total bitumen which is recoverable may be much higher than that of the total oil under normal field development. From that portion of the bituminous sand deposits which can be mined economically, the bitumen is all potentially recoverable. At the same time, only a portion of the total bitumen is comparable in quality to crude oils obtained by drilling. Without any basis of exact comparison, however, enough is known of the potentialities of the deposit to place it in the category of one of the world's major oil resources.

The mineral aggregate of the sand consists mainly of quartz particles of 100 to 200 mesh size or smaller, with traces of other minerals, including mica, rutile, ilmenite, tourmaline, zircon, pyrite and garnet. Clay embedded in the bituminous sand is also a constituent. The sand over wide areas has only a very light overburden. In some parts of the area, where the beds are deep, a yield of 100,000,000 barrels or more per square mile has been estimated, while there are a few square miles which probably contain up to twice as much.

The physical properties of the bituminous sand vary considerably from one part of the deposit to another. From the large number of sampling bores made throughout the field it would appear probable that the specific gravity of the undisturbed sand ranges from about 1.95 to 2.1, the porosity from 35 to 40 per cent., the oil saturation 80 per cent. or less to approaching 90 per cent., and the water saturation from 3 per cent. upwards. As the

water saturation increases, the oil saturation decreases correspondingly.

The water naturally present in the sands is extremely important. Its quantity and distribution have been extensively studied. The position which it occupies in relation to the sand particles, apparently as a film on the quartz surface, is the key that permits application of the principle of simple water separation of the bitumen from the sand, while its universal distribution has made the application of this principle practical.

Two other groups of components in the sand are of major importance. One is the sulphur, which is present in such abnormally large quantities that it defines the type of plant and processes required for treating. The other important component is the group of minerals and metals. The immediate significance of these lies in their effect upon the refining plant and processes.

The most pronounced physical properties of the extracted bitumen are probably its gravity and viscosity. The specific gravities vary from about 1.027 for the bitumen in the vicinity of Fort McMurray to 1.005 in the Ells River district (Fig. 2). There is a general tendency for the bitumen in the north to be lighter than that in the south. The importance of the gravity of the bitumen is readily appreciated in connection with any form of recovery or separation dependent on the use of water. The viscosity of the unaltered bitumen has been shown to be much greater in the southern part of the area than in the north. Thus, at the Abasand quarry, samples have shown a viscosity of 600,000 poises at 50 deg. F., whereas in the Ells River and Bitumont district it is only 6,000 to 9,000 poises. The differences in the viscosity of the bitumen between district and district has a marked effect on the ease with which the sands can be excavated.

The amount of sulphur in the raw bitumen also varies appreciably throughout the area, but in general can be considered as being between 4.5 and 5.5 per cent. by weight of the dry bitumen. A few commercial crude oils contain between 2 and 3 per cent. sulphur, but the great bulk of even sour crudes have less than 1.75 per cent. The sulphur in the bitumen is in chemical combination with it. When the bitumen is distilled, the sulphur is found to be more or less uniformly distributed throughout the whole range of distillates. A small percentage of the lowest boiling distillates have a sulphur content of about 1.75 per cent., while in the bulk of the lighter ends the content varies from 2.5 to 3.5 per cent. Thus, distillation and fractionation alone do not permit the segregation of any particularly high or low sulphur-carrying distillate. In view of the exceptionally high sulphur content of this bitumen and its effects on the value of the products, the refining processes for its removal have been closely studied. These studies have been successful to an extent which will allow the refined bitumen to compete on a normal oil market.

Less is known of the significance of colloidal minerals and metals in the bitumen. The most detrimental effects due to their presence is the danger of poisoning the catalyst used in refining, and creating excessive treating losses. Some distillates from the bitumen which have been produced show a metal content of the order of ten times those from other heavy crudes. The metal content also varies considerably from one point to another in the field. The extreme limits, in parts per million, of the various metals in distillates after settling, are iron, 1.0 to 14.0; manganese, 0.4 to 1.5; nickel, 3.0 to 12.0; vanadium, 7.0 to 40.0; lead, 0.2 to 1.0; copper, 0.3 to 3.0; zinc, 0.2 to 2.0; tin, 0 to 2.0; aluminium, 1.0 to 30.0; magnesium, 0.7 to 40.0; and calcium, 2.0 to 30.0.

Fig. 1, herewith, shows the position of Fort McMurray in relation to the city of Edmonton,

THE BITUMINOUS SANDS OF ALBERTA.

Fig. 1.
MAP SHOWING RELATION OF FORT McMURRAY
TO EDMONTON, ALBERTA.

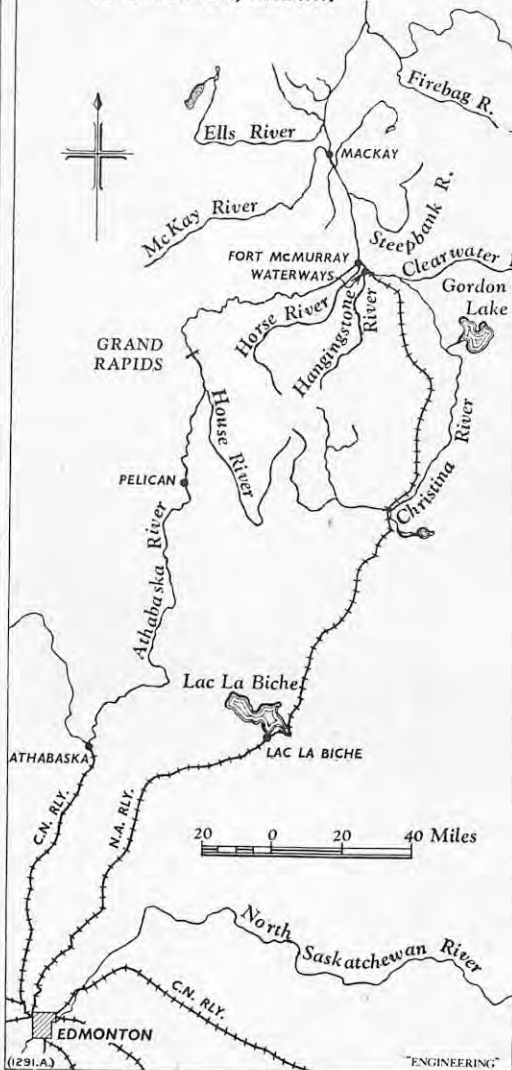
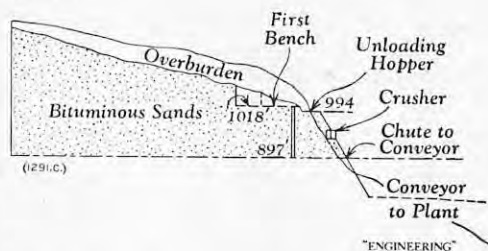
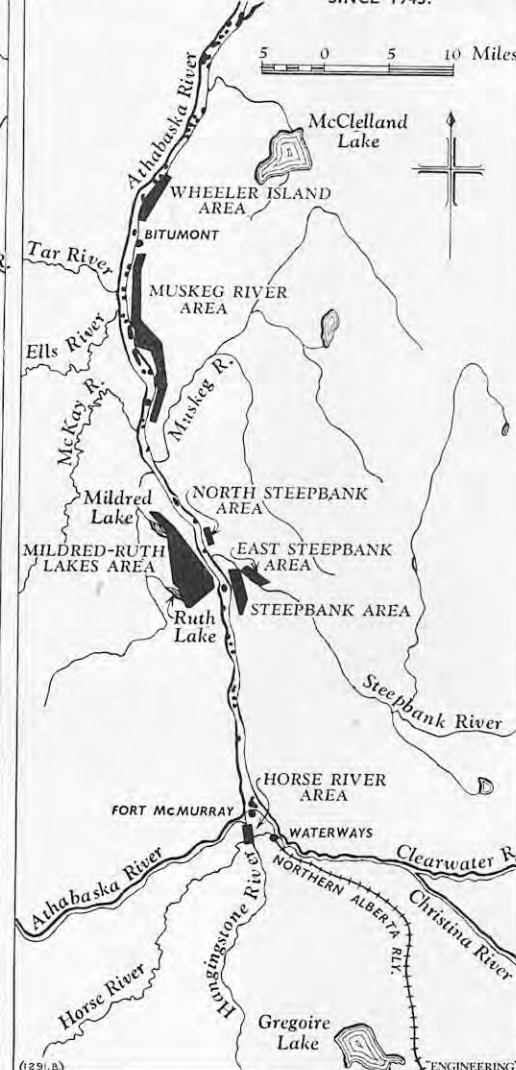


Fig. 3.



capital of the Province of Alberta, and the communication lines between the two points. Communication consists of the single-track line of the Northern Alberta Railway and the Athabasca River (which is navigable over most of its course) to Athabasca, and thence by the Canadian National Railway to Edmonton. In the absence of a pipeline and pumping stations, this paucity of communication and the costs of transporting the products of the sands to the available markets make commercial exploitation of the field on a profitable basis difficult, if not impossible. The construction of a pipeline is, however, under consideration and will doubtless be proceeded with as soon as prospective capital investment in development projects justifies the cost. Fig. 2, on this page, is a map of the district north of Fort McMurray, showing the areas which have been proved by drilling. A method of core-drilling in the bituminous sand strata has been developed, using diamond drills and a gell-mud drilling fluid. A dry compact core is obtained, which can be split for sampling and assaying.

Fig. 2.
MAP SHOWING AREAS EXPLORED BY DRILLING
SINCE 1943.



The mining of bituminous sand, and subsequent bitumen recovery, is essentially a large-scale operation. A project producing 20,000 barrels of oil per day requires approximately the same number of cubic yards of rich sand delivered to the separation plant. This results in handling over six acres of a 60-ft. bench per month. With the object of exploring the nature of the bituminous sand formation and determining actual volumes that would be available for large-scale operations, the Department of Mines and Resources at Ottawa initiated a drilling programme in the spring of 1943. In all, 291 holes were drilled through to the limestone. The holes averaged 185 ft. in depth, the deepest being over 300 ft. Further exploration since that date has indicated that the bituminous sand deposits are much more extensive than was originally estimated.

The result of the Federal Government's drilling programme was to prove that large areas of the sands would yield at least 20,000 cub. yds. per day for a period of 15 to 20 years, adjacent to a suitably located plant, so that the cost of transportation from mine to plant would be a minimum. For the purpose of a detailed survey, an area of one square mile was selected in the Mildred-Ruth Lakes district (Fig. 2) as being typical of the formation in this and other localities. Drillings showed an average depth of bituminous sand of 127.2 ft. and an average thickness of overburden of 32.2 ft., giving a ratio of sand to overburden of 3.93 to 1. The amount of sand in this square mile was estimated to be about 227,000,000 tons.

Where the overburden is light, as in this and

many other areas, open-pit mining can be employed economically. Using a large walking dragline with a 20 cub. yd. bucket, 1,580,000 cub. yds. can be moved per month. Comprehensive investigation has been made of the cost of removing the overburden and excavating the sand for delivery to the treating plant. The general method employed in this type of mining is to strip the overburden piece by piece. As each piece is removed, the underlying sand is excavated and the overburden is then dumped into the resulting space. This eliminates any long haulage and reduces the costs to a minimum. With 30-ton haulage equipment, the costs should not exceed 12 cents per cubic yard.

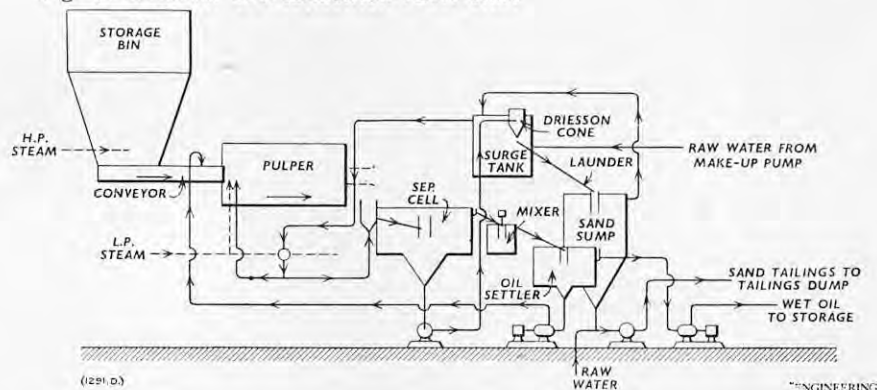
For mining large tonnages and carrying on winter operations it would appear essential to loosen the banks by blasting before beginning to load. In the typical open-pit layout, shown in Fig. 3, herewith, with 50 ft. to 60 ft. benches, blast holes drilled 30 ft. apart and 50 ft. back from the face would probably be adequate to loosen the mass sufficiently to permit of easy loading with either large electric shovels or walking dragline excavators. For large-scale mining operations in the Mildred-Ruth Lakes area, it was estimated that drilling and blasting costs would not exceed 12 cents per cubic yard, and as experience was gained in actual operations the cost might be materially reduced.

the limestone to the bottom of the bituminous sand. These would be equipped with jacketed metal liners through which steam could be introduced and allowed to come into contact with the over-lying sand. The liners and raises would extend low enough to discharge the oil sand as it dropped directly on to a belt conveyor feeding the treatment plant. It is expected that the space above each raise would gradually enlarge until it would break through to the space round the adjoining raises, in a manner somewhat similar to the block caving in large underground mining operations.

It has been estimated that, with a suitable steam plant, a volume of approximately 18,000,000 cub. yds. of the sand could be delivered to a treatment plant for 6,878,000 dols., or less than 4 cents per cubic yard. The percentage of the total sands which could be recovered by this method is uncertain, but, in view of the vast extent of the deposit, this consideration is of minor importance. Of greater moment is the fact that, in areas in which the overburden is too heavy to permit of economical open-pit mining, this method can be employed.

The separation of the bitumen from the sand has been the subject of exhaustive research during the past decade. It has been found that, when an intimate mixture of the bituminous sand and water is heated, the oil separates from the sand and

Fig. 4. ELEVATION OF A SEPARATION PLANT UNIT.



As the bituminous sand is known to contain, in places, some shale, gravel and boulders, the material, as excavated, should be dumped over a "grizzly" with openings of a suitable size for screening out all large pieces of foreign material. The material passing the grizzly would fall into a hopper and thence through a feeder and suitable crusher to a 36-in. conveyor leading to the treatment plant. With a site within 1,000 to 1,200 ft., the total cost of crushing and conveying should not exceed 8 cents per cubic yard. The open-pit mining costs per cubic yard, based on the data obtained from the square mile investigated, and based on a throughput of 20,000 cub. yds. per day, amount to 55 cents per cubic yard delivered at the plant, which would probably be reduced with experience.

Another method of recovering the bituminous sands, and one which might lower the cost, has been suggested, and the necessary experimental work has been carried out. It has been found that, when exposed to temperatures of from 45 to 90 deg. F., depending upon the location of the deposit, the viscosity of the sand changes and the exposed surface is softer and easier to dig. This characteristic has indicated that, if steam were exhausted into a closed chamber under the bottom of the deposit and the sands were exposed to a slow continuous heat, they might begin to loosen and drop. Experiment has confirmed this supposition. On a commercial scale, this method of mining would involve driving a 10 ft. by 10 ft. haulage way some 1,000 ft. long into the underlying limestone. Cross-cuts would then be excavated at intervals of 100 ft. extending 250 ft. on either side of the main adit. Raises, spaced 100 ft. or so apart, would then be driven from the grid of galleries so formed through

disperses in small flecks that lie among the sand grains. The oil in this pulp can be collected by flooding it with an excess of hot water. The larger flecks readily associate with air and water vapour, and float to the surface, where they form a fairly stable froth which can be conveniently removed. Under suitable conditions, a froth can be produced which does not carry more than 5 per cent. of mineral matter, and it usually has about 30 per cent. of water. From 90 to 95 per cent. of the total bitumen can be recovered by this process.

The quartz sand falls to the bottom of the separating zone. It is clean and white in appearance and carries only a trace of oil. When agitated with about an equal volume of water, it can be readily removed by pumping. The separation plant employed is shown diagrammatically in Fig. 4, herewith.

(To be continued.)

B.O.A.C. "COMET" COMPLETES 10,000 HOURS FLYING.—A de Havilland Comet air liner of the British Overseas Airways Corporation fleet has recently completed 10,000 hours of flying, 60 per cent. of this time having been flown since May 2, 1952, on passenger services, and the remainder on training, development and test flights, etc.

ENGINEERING CONFERENCE IN AUSTRALIA.—The 23rd Engineering Conference of the Institution of Engineers, Australia, will be held at Melbourne, Victoria, from Monday, March 16, to Saturday, March 21, 1953. "Power and Water" has been chosen as the theme for the conference, in recognition of the fact that these are two of the most important factors in the development of Australia. Further information may be obtained from the honorary conference organizer, the Institution of Engineers, Australia, 55, Collins-place, Melbourne, C.I.

INJURY CAUSED BY BREAKAGE IN MACHINERY.

A LARGE number of the cases in which workmen seek to recover damages for personal injuries appear to be based on some alleged breach of the Factory Act or of regulations made thereunder. Though the victim of an "industrial injury" can now prefer a claim for compensation from a fund which is derived in part from the taxpayer, it would seem that, in many cases, he likes to take his chance of getting something more if his employer is bound to observe the Factory Act. Many such claims have been successful in recent years; but there is no ground for assuming that the employer can be made liable for all accidents which occur in his factory. The case of *Dickson v. Flack* (1953) (1 W.L.R.236) serves to show that the judges are inclined to regard the Factory Act as a penal measure which must be strictly construed. The plaintiff in this case was operating a vertical-spindle moulding machine when one of the cutters flew off and he was struck in the eye by its bolt. The Shaw guard fitted to the machine was the most effective guard to protect an operator from coming into contact with the cutters, but another type of guard would have been more efficient to protect him against the danger of pieces flying out from the machine. In an action for damages for personal injuries it was alleged that the employer had committed a breach of Reg. 17 of the Woodworking Machinery Regulations, 1922 which provides that "The cutter of every vertical-spindle moulding machine shall, when practicable, be provided with the most efficient guard, having regard to the nature of the work which is being performed." Mr. Justice Havers held that the obligation was to guard against contact with any dangerous part of the machine, that is to say, the cutters, and not against dangerous materials ejected from it. "It has to be observed," he said, "that the regulation specifies the cutters as being a part of the machine which has to be provided with a guard. It does not require that the machine as a whole is to be provided with a guard; nor does it require that the spindle or any other part of the machine which may throw off a detached or broken part is to be provided with a guard." He, therefore, gave judgment for the defendants. The question might almost be said to have been decided in the earlier case of *Carroll v. Andrew Barclay & Sons, Ltd.* ((1948) A.C.477). In that instance, a man was injured by a broken belt part which flew out of a machine. In an action for damages it was alleged that the employer was in breach of S.13(1) of the Factories Act, 1937, which provides that every part of the transmission machinery shall be securely fenced. When the case reached the House of Lords, Lord Porter said: "It was, no doubt, the duty of the respondent (the employers) to fence the transmission machinery, but . . . fencing, in my opinion, means the erection of a barricade to prevent any employee from making contact with the machine—not an enclosure to prevent broken machinery from flying out." It is interesting to notice, however, that he also said: "If machines exist, or are hereafter invented and used, which are dangerous because fragments or loose parts of machinery are sometimes ejected from them, then I am not prepared to say that the employer is not bound to fence such machines for the purpose of protecting workmen against that damage." In so expressing himself, he was, in effect, approving a principle laid down in *Hindle v. Birtwistle* (1944) 1 K.B.337, where a man who had been injured by a flying shuttle was held to be entitled to recover damages. It was pointed out that, as there is always a danger of a shuttle flying out, the employer must take steps to prevent it from doing damage.

"METEOR" AIRCRAFT BARTERED FOR COTTON.—Seventy Meteor aircraft (60 standard Mark 8 fighters and ten Mark 7 trainers), constructed by the Gloster Aircraft Co., Ltd., Hucclecote, Gloucestershire, have been sold to the Brazilian Air Force for 4,000,000l., payable in raw cotton. It is believed to be the first barter deal of its kind. The British Raw Cotton Commission, who are establishing a credit for payment of the aircraft, will receive 15,000 tons of cotton from Brazil.

THE ENGINEERING OUTLOOK.

IV.—COAL-MINING, STEAM-RAISING AND HEAVY ELECTRICAL PLANT.

SINCE the end of the war, the fuel and power industries have enjoyed high priority for their investment programmes. Even so, the permitted level of investment has been far from adequate, and progress towards meeting national fuel and power requirements has been slow. The Report of the Committee on National Policy for the Fuel and Power Resources (Cmd. 8647), generally termed the Ridley Report, which was published in September, 1952, concludes that, "in the next few years, it is likely that the country will continue to face a shortage of coal, electricity generating capacity at peak hours, and (in some areas) gas-making capacity; it will be difficult to accelerate greatly the increase in supplies of fuel oils." Moreover, no great relief to fuel shortages can be expected within the next decade from sources other than coal and oil, though the seriousness of the coal supply position calls for great efforts to accelerate the development of new sources of energy. This, at a time when the buyers' market makes essential continuous and rapid advance in productivity, is a matter of the utmost gravity. High productivity has been achieved in the United States partly because power has been plentiful and (unlike labour) relatively cheap. In the United Kingdom, on the other hand, according to the Ridley Committee, fuel supplies in the next decade will not be as plentiful in relation to demand, or as cheap in terms of other commodities, as they were before the war.

Inflationary conditions and shortages of materials have been major factors in restricting investment in the British fuel and power industries; there are, however, good grounds for believing that, despite these, a higher level might have been possible. The wisdom of continuing, in the immediate post-war period, to export on a large scale mining machinery and power equipment urgently required at home is very questionable, even though manufacturers of that equipment have been enabled thereby to build up considerable goodwill which will stand them in good stead in the difficult marketing conditions which lie ahead. To some extent, the present shortage of fuel and power is due simply to unfortunate delays in the constructional engineering work and to bad co-ordination, and, though the public boards concerned have done much in the past two years or so to improve matters, they might still, with profit, consider ways and means of effecting further improvement. Certainly, there seems still to be considerable difficulty in matching demand with production targets, and planned investment with the levels actually achieved.

The engineering industries which supply the equipment for the fuel and power industries can now, in most cases, meet whatever demands the fuel and power authorities may lay upon them, and can still make a very substantial contribution to the export drive. Overseas orders, however, are becoming increasingly hard to secure, though order books are still fairly full. While British prices are generally competitive and the standard of equipment is high, the orders on hand may run down rapidly in 1953 unless sales effort is intensified and skilfully directed. The level of home sales in 1953 and for many years to come should be rather higher than in 1952, but this will depend upon the ability of the public authorities to carry through their investment programmes. This is more in question in the case of coal mining than in the electricity supply industry, but the electricity programmes are based on certain assumptions about the future available coal supplies, and therefore can be hampered by difficulties in the coalfields.

INVESTMENT IN COAL MINING.

According to the Ridley Committee, the output of coal in the United Kingdom is about 15 to 20 million tons below the demand at current prices. The Committee estimate that, by 1959, the demand for coal (including exports and bunkers) will be 257 to 267 million tons, whereas in the *Plan for Coal*, 1949, the Coal Board planned originally for

an output of only 240 million tons by that date. The Committee point out that their estimates are based on certain assumptions which may not be fulfilled. It is assumed, for example, that the production of iron and steel will increase at an annual rate of 4 per cent. per annum. The consumption of coal would be 15 per cent. less if iron and steel production increased at only 2 per cent. per annum. The estimate would also be changed significantly if fuel efficiency varied by a half per cent. from the 1 per cent. allowed. Nevertheless, the National Coal Board appear now to have accepted the Ridley forecast as being more realistic than their own earlier estimates, and they have announced that they are now planning to raise production above the level of 240 million tons, though the amount of the increase has not been stated. This is a most important decision, since the Ridley Committee pointed out that large increases above the level originally planned would mean steeply rising costs.

It is now clear that great difficulties are being met in the execution of the programmes outlined in the *Plan for Coal*. According to the Plan, investment in the mines was to rise from 30l. millions in 1950 to an average of 38l. millions for the years 1951 to 1955, thereafter declining to 32l. millions for 1956 and 1960 and later to an average of 28l. millions for 1961 to 1965. These figures are all at 1949 prices, so that, allowing for a rise of about one third, investment at current prices in 1952 should have been about 50l. millions per annum. This, moreover, probably underestimates the level of planned investment, since it seems to have been intended that investment in 1952 and 1953 should have been above the average for the period 1951 to 1955, because some large projects for coal cleaning and other ancillary equipment have been concentrated into the early years of the period. The total capital outlay in 1952 has not, in fact, exceeded 40l. millions, or 20 per cent. below the planned level; and in real terms it was only about the same level as in 1949. Investment also fell well below the projected levels in 1950 and 1951; over the first three years of the Plan, the deficiency does not seem to have been much less than one-third. In view of the Coal Board's declaration that two-thirds of the investment was required merely to sustain output at the 1950 level, this is very disturbing.

The reasons for the failure to carry through the planned investment are probably manifold. The record of contractors and constructional engineers in other industries since the war has not always been entirely happy, and the Coal Board may now be encountering the same sort of difficulties as have faced the British Electricity Authority in the construction of power houses. It is possible also that, with the improvement in recruiting for mines, it may have been decided that the need for re-equipment and re-organisation was not quite so urgent. There is little doubt, however, that the reduction in investment has been involuntary, and that the scarcity of skilled mining engineers capable of carrying through the work is largely responsible. Too few mines have staffs of their own who can prepare and cost the development programmes in the detail required; consequently, much of the work has to be left to contractors and to the engineering companies who supply the equipment. Many of these companies have too many of their staff tied up in this work; others have no one with the necessary specialised experience, though they would have no difficulty in producing the equipment if they were given detailed specifications. The delays are serious, and are unlikely to be eliminated until the Coal Board succeed in building up an adequate planning staff with the necessary skills and experience.

The *Plan for Coal* took no account of the extent to which coal output might be increased through the development of revolutionary types of machinery. In 1949, machines of the "Continuous Miner" type were still at a fairly early stage of development, and several years of rigorous testing in the mines were thought to be necessary before their general adoption was likely to be feasible. The A.B. Meco-Moore cutter-loader, which is the most successful machine in general use at the coal-face to-day, took ten years

to develop. It is possible, however, that a more rapid general introduction of the new types of mining machinery, despite the risks involved in shortening the period of testing, would be justified. The present chairman of the Coal Board, Sir Hubert Houldsworth, while he was still chairman of the East Midlands Division, expressed his conviction that the quickest way to raise productivity and output was to introduce new machines, like the Samson Stripper and the coal plough, as quickly as possible. It seems probable that the Coal Board are now thinking more in terms of the new machinery as a means of achieving their revised production target. They have announced that they hope to achieve the increased output by keeping in existence a number of marginal or uneconomic pits, by continuing opencast mining and, above all, by increasing the yield of the East Midlands Division to 56 million tons, 8 million tons more than originally contemplated. The East Midlands Division is distinguished from the others by the extent to which the new machinery has been introduced. In 1951-52, the output per man-shift was about 36 cwt. (in one mine, Thoresby, nearly 54 cwt.) compared with a national average of 24 cwt.

The rate at which mechanisation by the ordinary traditional machines has been carried out is beyond criticism. About 81 per cent. of the coal mined in the United Kingdom is mechanically cut, and 88 per cent. is mechanically conveyed. The newer mechanical loading equipment, however, is still very little in evidence; less than 5 per cent. of the coal mined is power-loaded. The number of Samson Strippers in use has only increased from three in 1949 to nine at present, though the amount of coal cut by strippers has increased from 73,000 tons to 500,000 tons per annum. The older style Meco-Moore cutter-loader has been established for many years, but there has not been a large increase in the number in use. In 1947, 25 were at work, compared with 99 to-day. Other cutter-loaders are still in a fairly early experimental stage. The Coal Board report that the Gloster Getter shows most promise, and that trials with the Uskside Mechanical Miner and Grassmoor Goblin are being extended. The widespread use of these and similar machines should eventually make available plentiful supplies of coal at low prices. They make it possible to win coal in two shifts instead of three, fuller use can be made of winding and haulage equipment, and large numbers of underground workers are freed for work at the coal-face; but even if the general introduction of the new machines were accelerated as much as is reasonably practicable, it will take much more than a decade before power-loading is in general use wherever possible. Moreover, full advantage will not be gained from its employment until the work of re-organising and improving physical conditions in the mines under the Coal Plan is complete. Because of the increasingly difficult conditions encountered, the average output per man-shift obtained from Meco-Moore machines has declined from 6.7 tons in 1947 to 5.8 tons at present, and the output per man-shift from the Samson Strippers has declined from 7.8 tons in 1951 to about 5.3 tons. This is not, of course, an argument against introducing the new equipment into relatively unfavourable areas; even there, the savings in manpower may be considerable.

The trend of deliveries of coal-mining machinery from 1948 onwards is shown in Figs. 1 to 6, opposite, which bring out the slow progress which the Coal Board are making with their capital investment programme. Figs. 7 to 12, on page 234, show the deliveries by quarters in 1951 and 1952. It is true that deliveries of all the types of machinery shown, with the exception of power loaders, were higher in 1952 than in 1951 or in 1950. The comparison with 1949, however, is much less favourable. The 1949 delivery figures for coal-preparation plant and for winding and haulage equipment are not available, and undoubtedly it is true that the output of coal-preparation plant, at least, was substantially higher in 1952 than in 1949; delivery of the other types of equipment, however, certainly did not regain the 1949 level. This is not entirely due to defective home demand; deliveries for export have fallen off considerably and in all cases, with the exception of coal-preparation and winding and

haulage equipment, deliveries in 1952 were substantially less than in 1951.

The fall in the export demand for coal-mining machinery, which was to be expected as the re-organisation and rehabilitation of the coal mines in Continental Europe neared completion, has been partly compensated, so far as the mining-machinery industry has been concerned, by an increased demand for other types of equipment in other parts of the world. As will be seen from Tables I and II, herewith, which are taken from the *Trade and Navigation Accounts*, exports of mining machinery were about the same in value, but some 9 per cent. lower in volume, in 1952 than in 1951. Exports to South Africa, the largest market for British mining machinery, continued to increase, as also did exports to India, Australia (despite the import restrictions which have hampered sales of most types of engineering equipment) and other Commonwealth countries. In 1953, the decline in prices for mining products are likely to affect adversely the demand for mining machinery, and foreign competition, particularly from Germany, may accentuate the downward trend of exports outside the Commonwealth.

INVESTMENT IN ELECTRICITY SUPPLY.

As the Ridley Committee pointed out, the rate at which electricity generating capacity can be installed depends upon how much of the country's investment resources are devoted to its provision. They were unable to estimate the number of years

needed to close the gaps between demand and supply, but they made it clear that only greatly accelerated construction would yield any appreciable relief to the shortages in the next few years. The British Electricity Authority, in their Report and Accounts for 1951-52, appear to take a rather more favourable view, observing that "Current uncertainties make it impossible to give any firm promise as to when generating capacity will be sufficient to meet all demands; and if the growth in demand accords with expectation and all goes well with the programmes, power cuts should be comparatively infrequent by the winter of 1954-1955." It is claimed that, in 1951-52, the increase in generating capacity exceeded the increase in demand, but this was due largely to a fall in the rate of increase of the basic demand, arising chiefly from a slackening of industrial activity.

The rate of installation of new generating plant has been increasing steadily; each successive year since 1950 has established a new record for the amount of plant installed. Despite this, the total amount of post-war plant installed is still far below the level originally planned. New generating plant brought into commission in 1951 amounted to 1.1 million kW, but 2.9 million kW of plant projected for the years 1947 to 1951 still outstanding. In 1952, the amount of plant brought into service is estimated at 1.4 million kW, but the arrears from previous programmes are probably still about 2.5 million kW. The revised plant programmes of

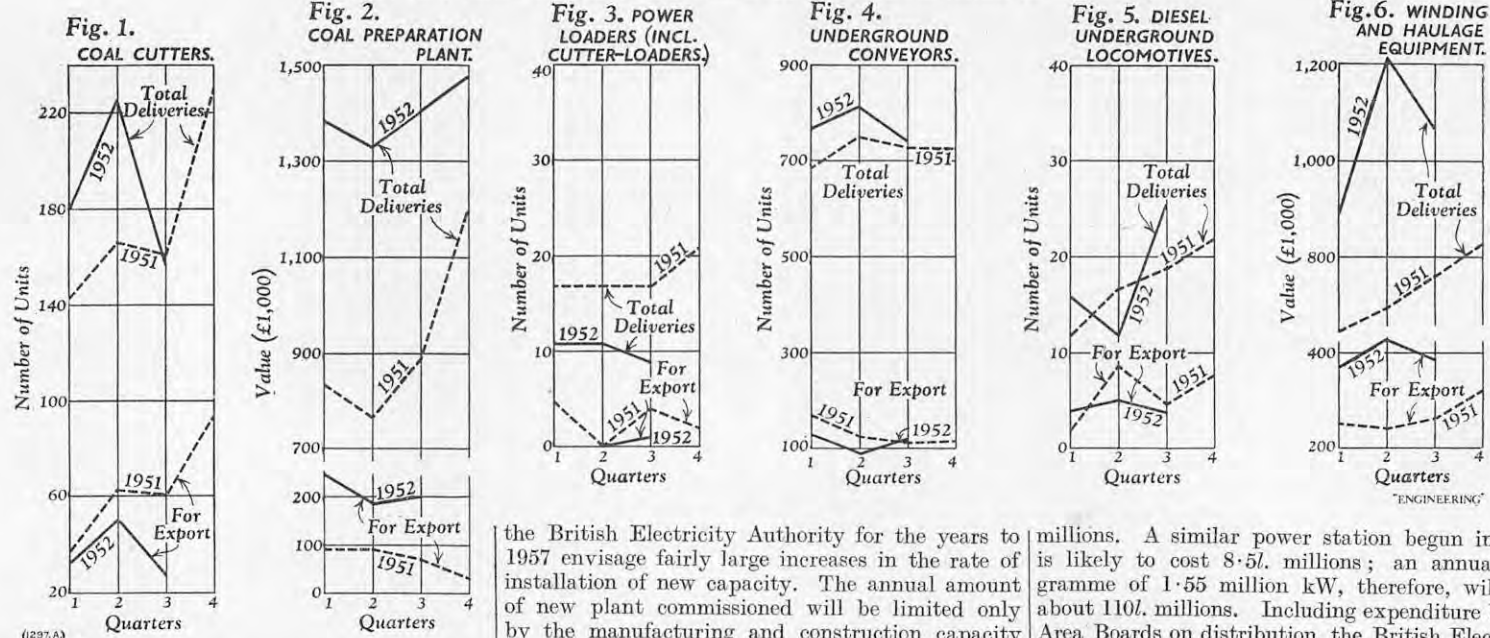
likely to be available and is expected to rise from 1.3 to 1.5 million kW in 1953, to between 1.7 and 1.9 million kW in 1957.

The Authority consider that these programmes are capable of achievement, provided that they are not affected by such national considerations as re-armament or restriction on capital investment. The possibility that they may be restricted (according to Government proposals of 1951) to 1.55 million kW per annum is deplored. The B.E.A. recognise the onerous and difficult nature of the Government's responsibility for ensuring the best use in the national interest of scarce materials, production capacity and labour; but they protest that restricted investment in electrical generating plant is not in the national interest, because it would hinder mechanisation and the extended use of power in industry.

The Productivity Teams who visited the United States have pointed out that the workman in the United States has at his command three times the amount of electrical power available to the British workman. Even if the B.E.A. programmes are carried out to the full, British industry will still be far short of parity with the American. Nevertheless, the cost of installing new generating capacity is so high that, in the opinion of some economists at least, even the B.E.A. programmes may well prove to be beyond the national means.

The total cost of a power station of 120,000 kW, begun in 1948, has turned out to be about 6.75/.

FIGS. 1 TO 6. UNITED KINGDOM DELIVERIES OF COAL-MINING MACHINERY (BY QUARTERS.)



the British Electricity Authority for the years to 1957 envisage fairly large increases in the rate of installation of new capacity. The annual amount of new plant commissioned will be limited only by the manufacturing and construction capacity

millions. A similar power station begun in 1952 is likely to cost 8.5/ millions; an annual programme of 1.55 million kW, therefore, will cost about 110/ millions. Including expenditure by the Area Boards on distribution, the British Electricity Authority have estimated their current and prospective annual capital expenditure at 150/ millions. An outlay of this order might be justified if it achieved a satisfactory return in terms of increased industrial productivity or improved fuel efficiency. A high proportion of the electricity generated at present, however, is used for ordinary heating purposes—an estimate by the National Coal Board is 40 per cent. While industrial power consumption since the war has been growing at the rate of about 6 per cent. per annum, the domestic consumption has been growing at about 11 per cent. per annum.

At present, nearly 15 per cent. (2.3 million kW) of installed capacity is represented by plant more than 25 years old, and in five years' time further plant of about the same capacity will have become over 25 years old. This plant consumes about 2 million tons of coal more than its modern equivalent. The thermal efficiency of much of the plant under 25 years old is very low. The thermal efficiency of all plant in use is rather more than 22 per cent. and half of the total capacity, accounting for 37 per cent. of total output, has a thermal efficiency of less than 22 per cent. The efficiency of modern plant is about 28 per cent. During the next five years, it is proposed to commission about 8 million kW of new capacity; if, at the same time, it were possible to retire (or to retain only to meet peak demand) 7 million kW of older plant, the annual saving in coal would be 5 million tons.

TABLE I.—UNITED KINGDOM EXPORTS OF MINING MACHINERY OTHER THAN PORTABLE POWER TOOLS.

	1950.		1951.		1952.	
	1,000 cwt.	Value (£1,000).	1,000 cwt.	Value (£1,000).	1,000 cwt.	Value (£1,000).
Power-operated coal cutters	37	830	30	766	20	626
Power-operated winders	64	654	59	677	80	1,081
Underground conveyors	109	941	105	704	113	945
Others	188	2,212	220	2,730	166	2,366
Total	398	4,637	414	4,967	379	5,018

TABLE II.—UNITED KINGDOM EXPORTS OF MINING MACHINERY OTHER THAN PORTABLE POWER TOOLS, BY COUNTRIES OF DESTINATION.

	1950.		1951.		1952.	
	1,000 cwt.	Value (£1,000).	1,000 cwt.	Value (£1,000).	1,000 cwt.	Value (£1,000).
British West Africa	28	228	18	212	12	195
Union of South Africa	98	1,063	77	1,023	91	1,275
India	18	294	26	388	28	418
Malaya	32	258	65	469	42	350
Australia	45	463	50	556	64	624
Other Commonwealth Countries and the Irish Republic	44	489	49	601	58	688
Poland	37	577	17	373	2	61
France	12	255	5	119	9	186
Other Foreign Countries	84	1,010	107	1,226	73	1,221
Total	398	4,637	414	4,967	379	5,018

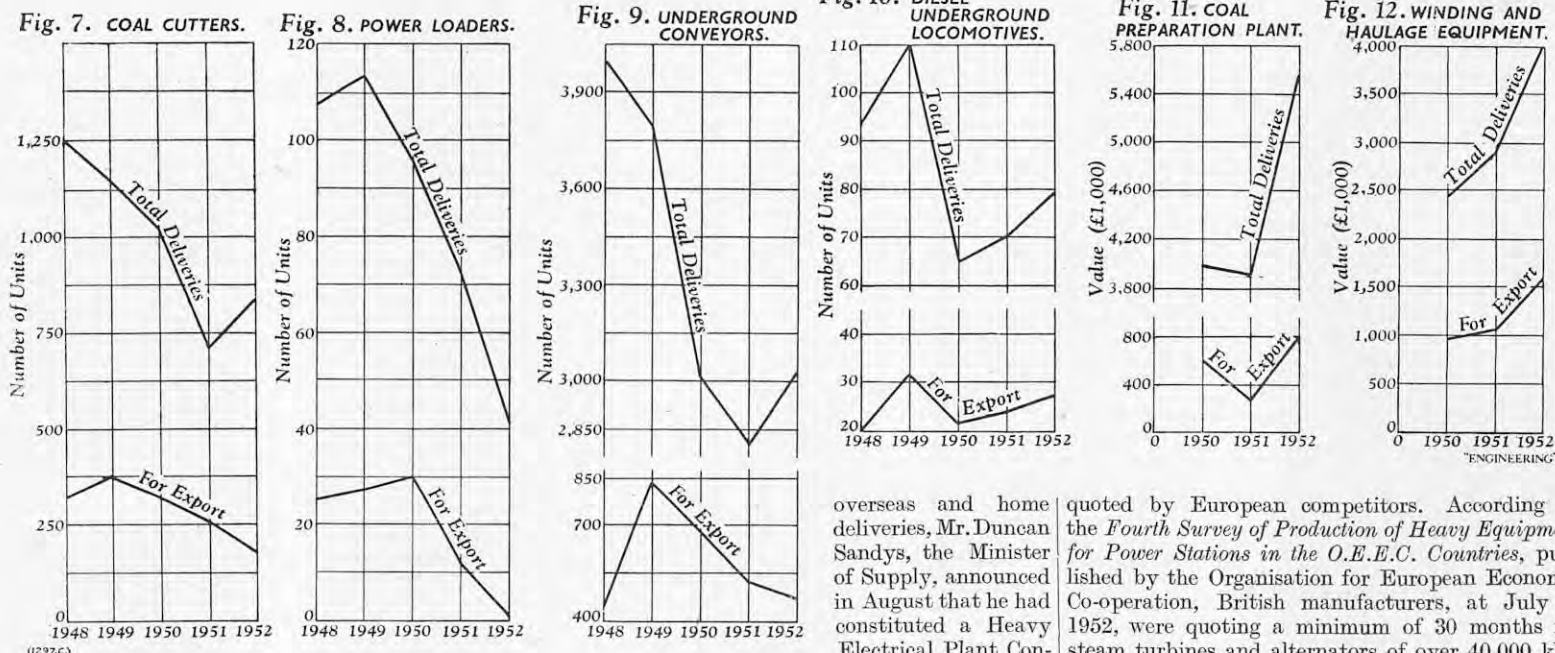
According to present plans, the consumption of coal by the B.E.A. will, in fact, rise by about 13 million tons to a total of 50.2 million tons per annum by 1959. The total increase in coal production envisaged over this period in the *Coal Plan* was only 30 million tons.

Although, at first glance, it would seem to be possible to withdraw much of the older plant by

ages for 1951 and 1952. Export deliveries as well as home deliveries of steam turbo-alternators of 10,000 kW and above were substantially higher in 1952 than in 1951. Makers of heavy electrical plant, however, cannot be expected to increase their contribution to the export drive and, at the same time, to meet the demands of the B.E.A. In view of the pressing need to fix the relative priorities of

generating sets could be excluded, the Customs figures would show very large increases in exports of electrical plant since 1950. The order books of British manufacturers are still very lengthy, though the buyers' market is beginning to affect even this branch of engineering, and new orders are becoming increasingly difficult to secure. Delivery periods quoted by British makers are well in excess of those

FIGS. 7 TO 12. UNITED KINGDOM DELIVERIES OF COAL-MINING MACHINERY.



transferring elsewhere the heating load at present carried by electricity, there are great practical difficulties in doing this and, as the B.E.A. have been quick to point out, it may not be desirable. The B.E.A. make the forthright statement in their report that those who claim that the direct use of coal gas or coke for domestic heating, etc., instead of coal could greatly reduce "the demand on coal and other national resources," base their conclusions on "incomplete and, in some instances, misapplied information." The amount of electricity used for domestic space-heating is comparatively small. About 92 per cent. of domestic living rooms have no alternative means of heating to the coal fire. Gas or coal could not be easily substituted for domestic comfort heating, water heating and cooking without heavy capital investment by the carbonisation industries. So far as the electrical supply industry is concerned, the cost of providing extra capacity to meet the needs for domestic space heating, etc., is merely marginal, and there is no practical alternative to electricity for the provision of light, radio and small power. Because of the need to balance the load, curtailment of domestic supplies might even result in increased industrial power costs. The B.E.A. claim that, since domestic supplies are usually given oversystems which cater for both industrial and commercial consumers, the costs per consumer are greatly reduced by the diversity of demand between the different classes, which allows a more balanced load.

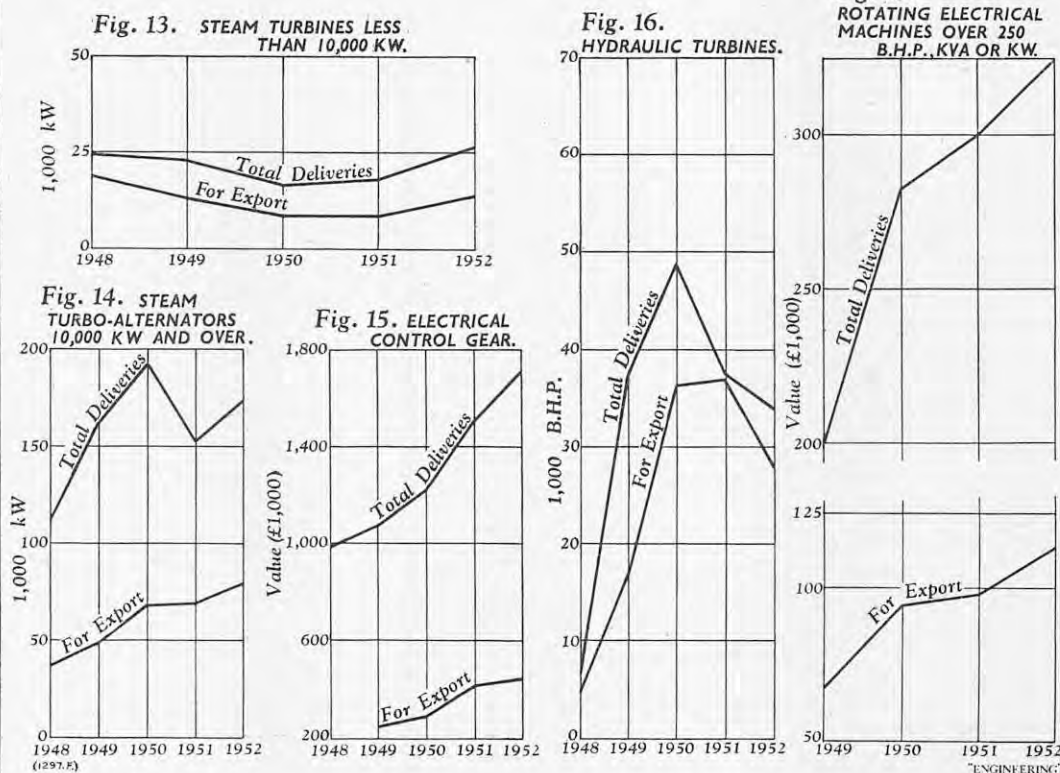
As appears from the evidence given in the Ridley Report, the views of the B.E.A. are not entirely shared by the National Coal Board or by the Gas Council. Disagreement among these bodies, however, is healthy, and probably is in the best interests of the consumer. The Ridley Committee have urged the continuance of competition among them with the recommendation that the consumers' freedom of choice should be guided by bringing prices closely into accord with the relevant costs. They do not consider that there is any waste of coal or capital resources in the present balance between the use of the different fuels. If this is so, the investment programmes of the B.E.A. are fully justified, and it will be a pity if they have to be restricted.

Figs. 13 to 17, herewith, show the trend of deliveries of electrical generating plant from 1948 onward, and Figs. 18 to 22 show the monthly aver-

with himself as chairman, to replace the Heavy Electrical Plant Committee, whose meetings were discontinued in July, 1950.

overseas and home deliveries, Mr. Duncan Sandys, the Minister of Supply, announced in August that he had constituted a Heavy Electrical Plant Consultative Council, quoted by European competitors. According to the *Fourth Survey of Production of Heavy Equipment for Power Stations in the O.E.E.C. Countries*, published by the Organisation for European Economic Co-operation, British manufacturers, at July 1, 1952, were quoting a minimum of 30 months for steam turbines and alternators of over 40,000 kW, while German and Swiss manufacturers were quoting 20 months and Italian manufacturers 15 months. Power transformers of 5,000 kVA and over could not be supplied by British manufacturers in less

FIGS. 13 TO 17. UNITED KINGDOM DELIVERIES OF HEAVY ELECTRICAL PLANT, (MONTHLY AVERAGES.)



EXPORT DEMAND FOR HEAVY ELECTRICAL PLANT.

Exports of heavy electrical plant, as will be seen from Table III, opposite, taken from the *Trade and Navigation Accounts*, were substantially higher in 1952 than in 1951. The totals include Diesel-driven generators of less than 200 kW, which are not heavy electrical plant; exports of these were only about half as great in 1951 as in 1950, and have again declined slightly in 1952. If small

than 24 months, but German firms could give delivery in ten months, French firms in eight months and Italian manufacturers in six months.

At a time when competition is increasing, British manufacturers are losing valuable orders through their inability to quote sufficiently prompt delivery; otherwise their competitive ability is high, as may be judged by recent successes in the United States market. In July, the Department of the Army of the United States Government announced that they

had accepted the tender for nine 33,000-kVA transformers, to be made by Ferranti, Limited, for the Garrison Dam project in North Dakota. The Ferranti tender of 1.138 million dollars was more than 200,000 dollars below the lowest bid by any of the

United States manufacturers. Acceptance of the British tender in this case is of great significance, since it is indicative of the growing awareness within the United States of the responsibility which that country has of admitting more freely imports

of foreign goods as the only means of alleviating the world-wide dollar shortage. In the case of the Ferranti tender, the British offer could have been rejected under the provisions of the "Buy American" Act, but, in fact, this Act was not invoked.

FIGS. 18 TO 22. UNITED KINGDOM DELIVERIES OF HEAVY ELECTRICAL PLANT, (MONTHLY AVERAGES).

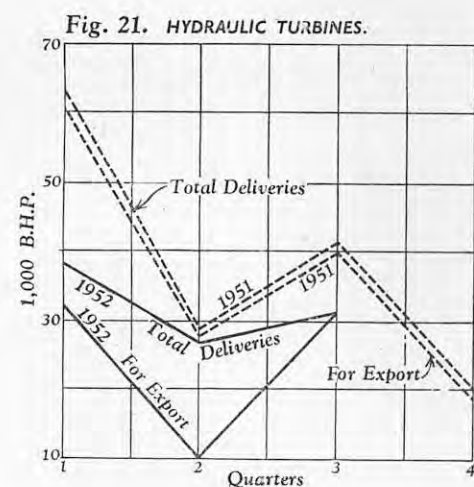
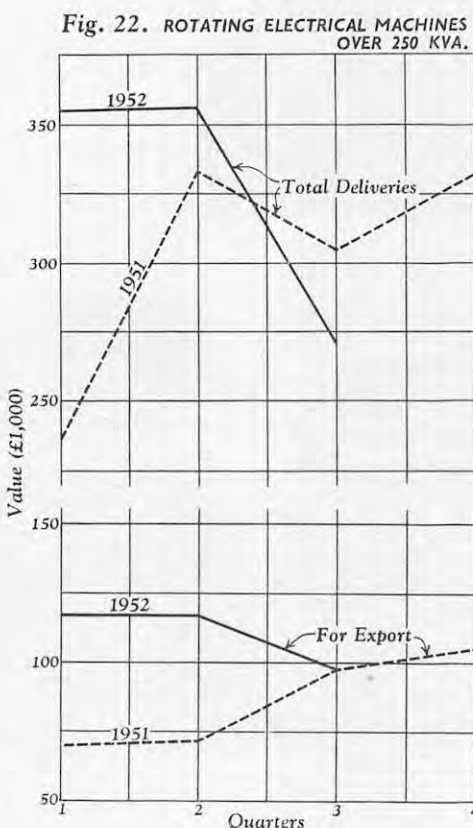
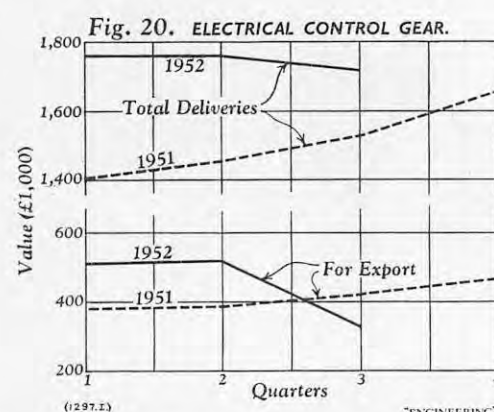
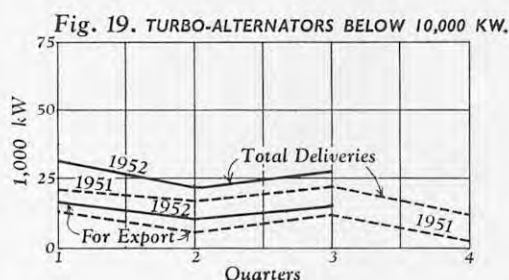
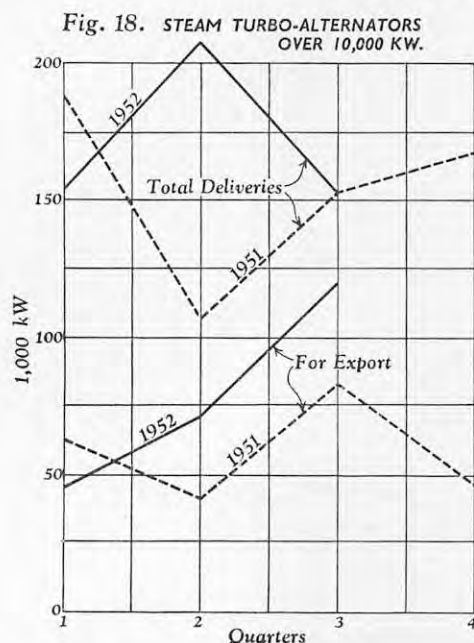


TABLE III.—UNITED KINGDOM EXPORTS OF ELECTRICAL MACHINERY.

	1950.		1951.		1952.	
	1,000 cwt.	Value (£1,000).	1,000 cwt.	Value (£1,000).	1,000 cwt.	Value (£1,000).
Generators complete:						
Driven by Diesel engines:						
Not exceeding 200 kW	396	8,690	195	4,523	181	4,891
Exceeding 200 kW	79	1,432	92	1,864	117	2,571
Other generators	174	4,080	93	2,487	77	2,387
Generators without prime movers and parts ..	108	2,174	217	5,611	243	7,065
Total	757	16,376	597	14,485	618	16,914
Converting machinery	7	154	11	211	16	485
Transformers	514	7,310	550	8,587	606	10,460
Rectifiers for powerhouse use	19	579	23	667	21	755
Starting and controlling gear	76	2,205	68	2,110	78	2,802
Switch gear and switchboards	396	10,789	415	12,395	468	15,461
Steam turbines	89	2,728	119	3,626	113	3,846
Grand total	1,858	40,141	1,783	42,081	1,920	50,723

TABLE IV.—UNITED KINGDOM EXPORTS OF BOILERS AND BOILER-HOUSE PLANT.

	1950.		1951.		1952.	
	1,000 cwt.	Value (£1,000).	1,000 cwt.	Value (£1,000).	1,000 cwt.	Value (£1,000).
Water-tube boilers	782	6,173	821	6,877	770	7,030
Lancashire and Cornish boilers	48	284	28	188	17	115
Vertical boilers	56	444	51	428	41	395
Other boilers	166	1,057	136	1,184	160	1,433
Economisers, feed-water heaters, and steam superheaters	152	914	129	994	146	1,346
Other boiler-house plant	320	3,459	301	3,393	413	5,054
Total	1,534	12,331	1,466	13,064	1,547	15,373

The English Electric Company have also recently achieved major successes in the United States market. In December, they received from the city of Seattle their second large American order of the year. This order, which is for two high-voltage transformers which will cost about 700,000 dollars, comes three years after another tender from the English Electric Company, for transformers for the same city, was turned down, though considerably below those put in by the United States manufacturers.

The principal British markets for heavy power plant continue to be the Dominions. Exports to Australia have suffered little from the import restrictions and were slightly higher in value in 1952 than in 1951. Exports to South Africa, Australia and New Zealand also continued at a high level. Orders received from these markets guarantee a high level of exports in 1953. Among the largest is an order worth 4l. millions for turbo-alternators and boilers, placed with the General Electric Company and Babcock and Wilcox, Limited, for the new Kelvin power station at Johannesburg. The three new 30-MW turbo-alternators are scheduled to be in use by 1955. The total orders for power equipment placed by the municipality of Johannesburg with the General Electric Company now amount to 547.5 MW. Other orders received by the General Electric Company in 1952 include a 60-MW turbo-alternator set for Wilge power station, in the Transvaal, and two 1.2-MW sets for Port Lincoln power station, also in South Australia. The Metropolitan-Vickers Electrical Company received an order for two 30-MW sets for the Salt River station, South Africa; a 25-MW set for the Halifax station of the Nova Scotia Light and Power Company; and a 20-MW set for the Electricity Supply Commission of Southern Rhodesia. Orders in hand with the Brush Electrical Engineering Company include three 15-MW Brush-Ljungström sets for Queensland and two 8.25-MW sets of the same type for Bangkok.

The shortage of boiler-making capacity since the war has been one of the principal factors in the slow rate of commissioning of new generating plant. There has now been considerable improvement, however, as a result of the policy of bringing new companies into the industry. There are now nine companies supplying boilers to the B.E.A., and the output in 1952 was a record. There are no official statistics of output of water-tube boilers, but it is reported by the Water-tube Boiler Manufacturers Association that the output in 1952 was considerably higher than in 1951, due to the high priority which the industry has received in the supply of steel and components. As will be seen from Table IV, herewith, taken from the *Trade and Navigation Accounts*, exports in 1952, though somewhat lower in volume, were slightly higher in value than in 1951. The number of new boilers put into service for the B.E.A. (59) was a record, but, to bring the programmes up to date, it would have been necessary to build 70 boilers in 1952.

CUTTING AND FORMING MACHINE FOR SHEET AND PLATE.

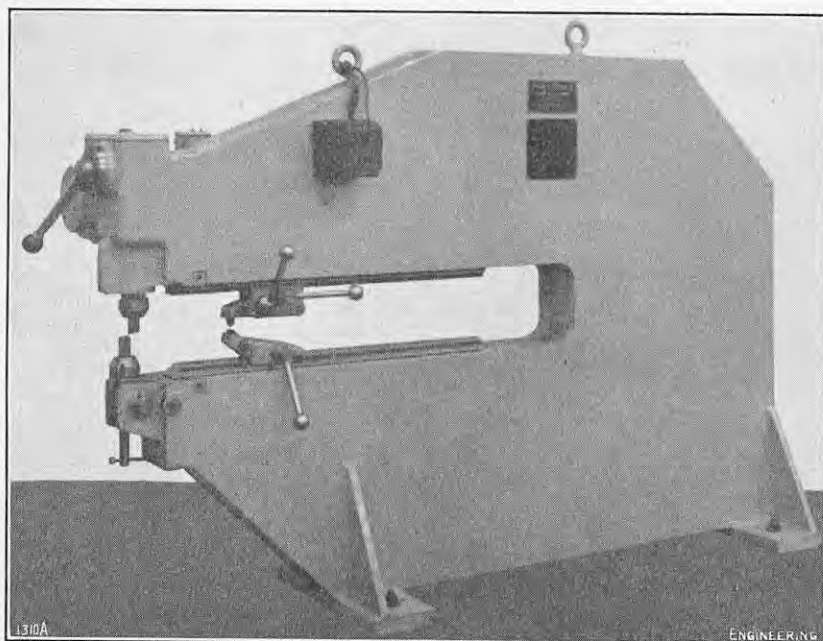


FIG. 1. "PULLOMAX" UNIVERSAL MACHINE.

UNIVERSAL MACHINE FOR CUTTING AND FORMING SHEET AND PLATE.

THE machine illustrated in Fig. 1, above, is designed for cutting and forming—in a wide variety of shapes—sheet and plate of mild and stainless steels, brass, copper, aluminium and magnesium, as well as wire mesh, fibre boards and certain plastics. For cutting purposes it works on the principle shown in Figs. 2 and 3: that the edges of two shearing cutters need not pass each other in order to shear the metal.

The depth of penetration through the thickness of a sheet which is necessary to effect shearing varies with the type, strength and thickness of material. To quote an example, in mild steel it may be as much as 70 per cent. of the thickness for a thin sheet, decreasing to only 30 per cent. for material of heavier gauge. In either case, however, complete penetration is not necessary. In this machine, therefore, the shearing cutters never pass each other. They are comparatively narrow, as shown in Fig. 3; the lower cutter is fixed and the upper cutter reciprocates vertically at a maximum speed of 2,800 strokes per minute, the operator guiding the sheet or plate along by hand. The possible cutting operations include edge cutting, circle and square cutting, straight and irregular slot piercing, and louvre cutting. For forming operations, which include beading, doming, and folding or joggling, appropriate tools are inserted in the machine, the lower one again being fixed and the upper one reciprocating, but both are arranged with their vertical axes in line, instead of being offset as in cutting. For free-hand work, where the required shapes are neither straight nor circular, the possibilities of the machine are limited only by the skill of the operator. Though the tools do not pass each other, they leave a clean square edge which requires no further finishing. The simplicity of operation of the basic machine, the versatility of the various attachments and tools, and the ease of changing from one type of operation to another, are outstanding features of the Pullomax machines. The speed of production is thus particularly valuable on "one-off" jobs or on small-batch work where the quantity does not warrant the manufacture of expensive tools.

The machine illustrated is one of a range of Pullomax universal plate and sheet-metal working machines of Swedish design and manufacture. The range consists of eight sizes, two of which—the P5 illustrated and the Pullomax AM—are also built in this country by the associate company, Pullomax (Great Britain), Limited, Blackpool. The sole agents in the United Kingdom are Alfred

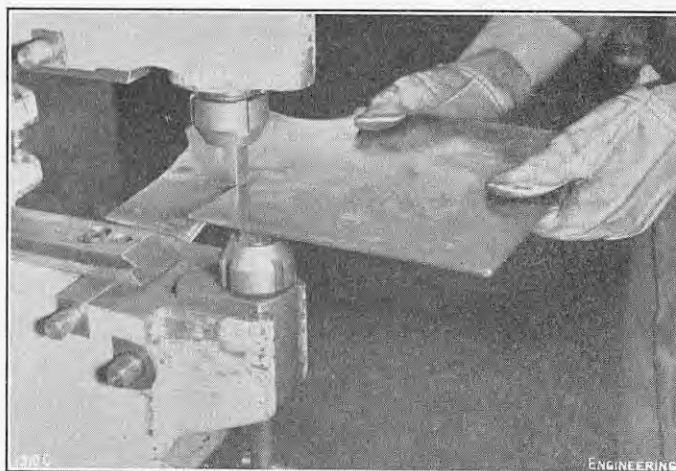


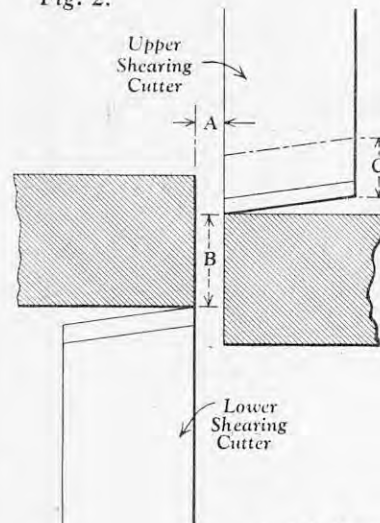
FIG. 4. STRAIGHT CUTTING.

Herbert, Limited, Factored Division, Red Lane Works, Coventry. The maximum capacity of the eight machines ranges from 16 s.w.g. to $\frac{1}{2}$ in. thick, and the cutting speed varies between 2 ft. to 16 ft. per minute on the largest machine, and 4 ft. to 20 ft. per minute on the smallest. The greatest throat depth is 48 in. and the least, 15 in.

The cutting tools are extremely simple, being made from high-grade steel of square section, ground on the ends to provide clearance so that the shearing action takes place on one corner only, as shown in Figs. 2 and 3. The upper tool is reciprocated by a pair of toggle links operating in oil, with the whole mechanism enclosed in a crankcase and driven by a motor mounted on the side of the frame. The power of the motor ranges from $\frac{1}{4}$ h.p. for the smallest machine to 4 h.p. for the largest. The stationary lower tool can be adjusted for height and lateral position to suit the requirements of the various operations and materials. As the shearing takes place along a limited length at each stroke, the production of intricate shapes, whether external or pierced, is facilitated. For ordinary straight or circle cutting, as shown in Figs. 4 to 7, the lower tool is held in a reversible offset tool block so that it can be located either behind or in front of the upper tool, depending on the operation being performed.

The length and frequency of stroke can be varied by means of a three-position pivoting lever, the movement of which changes the link-gear setting. When the lever is in its top position, the upper tool is clear of the work for loading and unloading purposes. Movement of the lever anti-clockwise lowers the tool and engages the link gear to give, in

Fig. 2.



(1/10 B)

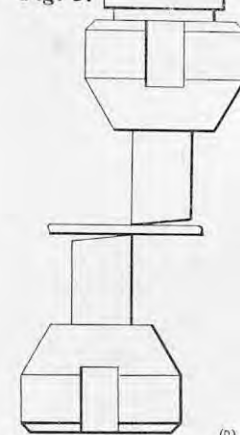
Fig. 3.



A Side Spacing
B Minimum Height Spacing
C Length of Stroke

"ENGINEERING"

Fig. 5.



(D)

the P5 machine, a stroke length of 0.04 in. at 2,800 strokes per minute. Movement of the lever clockwise also lowers the tool to the operating position, but engages a different link-gear setting, which then provides a stroke of 0.1 in. at 1,400 strokes per minute.

CUTTING OPERATIONS.

Work-holding attachments are available for straight and circle cutting; they can be fitted or interchanged in a few seconds. The straight-cutting attachment is shown in Fig. 17, opposite, but in use for folding. It consists of a cast-iron L-section guide rail carried on an adjustable block clamped to a dovetail slide on the lower jaw of the machine. The guide rail is accurately set in relation to the tool edges by lining up an index mark on the sliding block with a rule which is permanently attached to the lower dovetail slide. The guide rail is also adjustable vertically. When a hole is being cut, it is not necessary to provide a starting hole as the reciprocating upper tool cuts only a very short length at each stroke. The P5 machine will pierce $\frac{3}{16}$ -in. mild-steel plate without distortion, and as it works on a true shearing principle there is no loss of metal.

The circle-cutting attachment, shown in Fig. 6, consists of two units, carrying male and female centres, which are mounted on the dovetail slides of the upper and lower jaws, respectively. Each can be adjusted along its slide and can be locked in position at any required distance from the tool edges within the capacity of the machine. The centre in the upper unit is adjusted vertically by a cam-operating ball-ended lever, and in operation the

CUTTING AND FORMING MACHINE FOR SHEET AND PLATE.

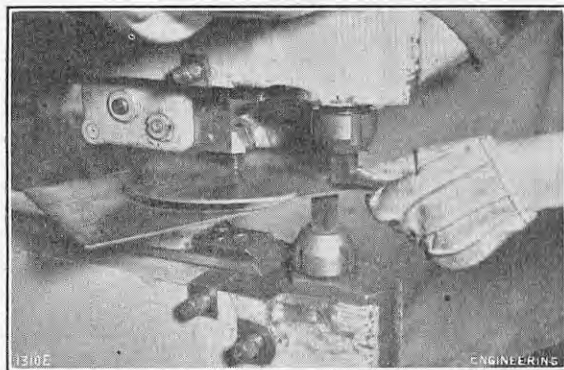


FIG. 6. CIRCLE-CUTTING.

Fig. 7.

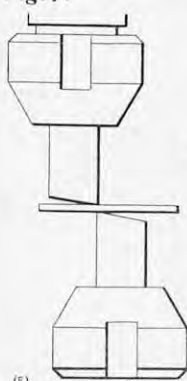


Fig. 12.

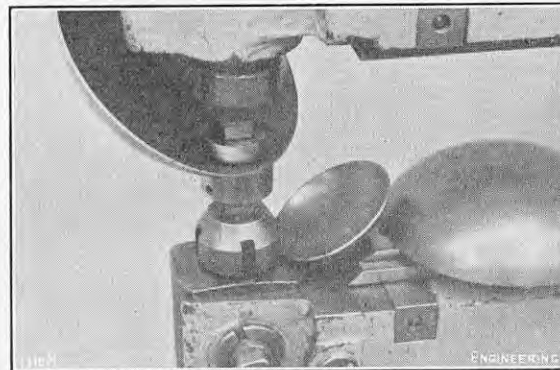
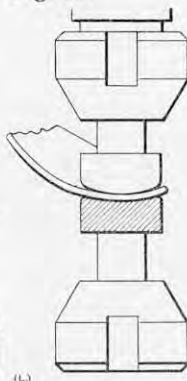


FIG. 13. DOMING.

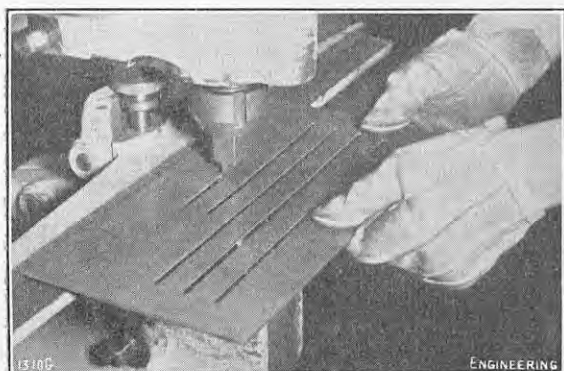


FIG. 8. SLOT-CUTTING.

Fig. 9.

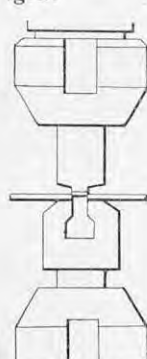


Fig. 14.

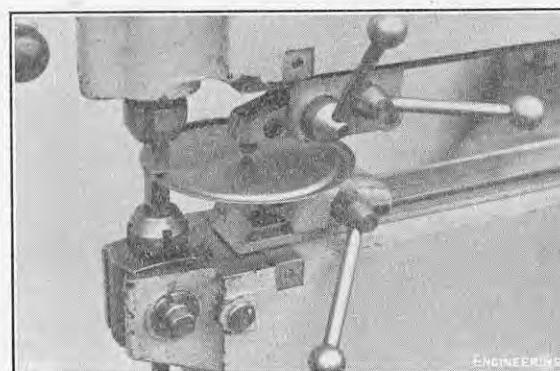
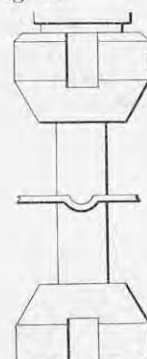


FIG. 15. BEADING.

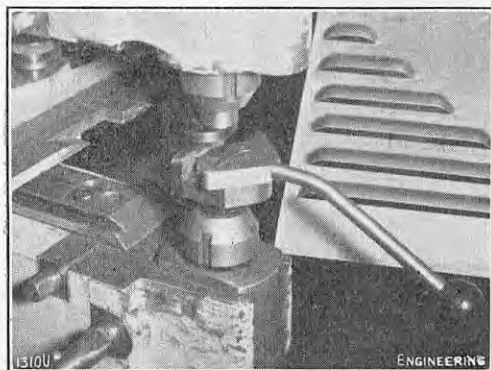


FIG. 10. CUTTING AND FORMING LOUVRES.

Fig. 11.

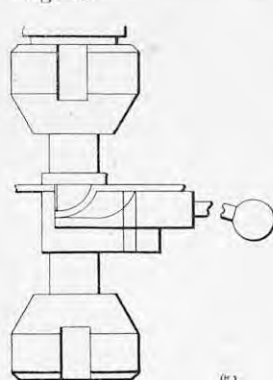


Fig. 16.

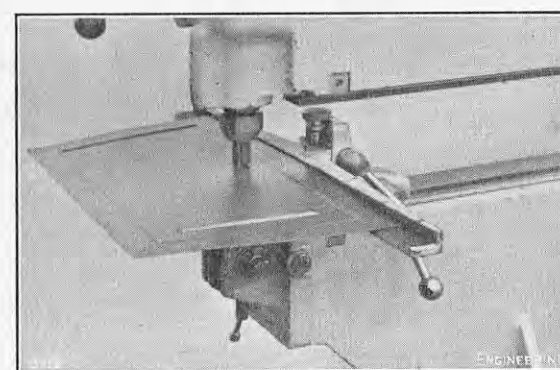
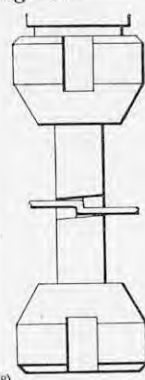


FIG. 17. FOLDING.

sheet-metal blanks are held by this centre against its mating centre in the lower unit. Both dovetail slides have a limited amount of screw-operated pivoting movement about their rear attachment screws, and this movement is used to provide cutting clearance when producing circular blanks or when circle-piercing at less than 4-in. radius. The straight-cutting and circle-cutting attachments can also be used for the wide variety of bending and forming operations of which the Pullomax machines are capable of performing.

The principle of slot-cutting is shown in Figs. 8 and 9, which need no further explanation. Standard pairs of slot-cutting tools are available for the following widths of slot: 3 mm., 5 mm., 7 mm. and 10 mm. Other sizes are readily made, and straight or curved slots can be cut by using the appropriate attachment.

The method of cutting louvres is illustrated in Figs. 10 and 11. The straight-cutting attachment and special combined cutting and forming tools are used. The reciprocating upper tool shears the metal and forms the louvre in one operation. It will be seen that the lower tool consists of a swivelling block having the required concave form cut radially from the pivot. Thus, in forming the ends of the louvre, the swivelling block is swung round in the appropriate direction until the "run-out" of the profile and the fixed cutting edge of the lower tool forms what is virtually a closed die. This

arrangement ensures that the ends of the louvre are clean-cut and undistorted. Louvres of any length can be formed.

FORMING OPERATIONS.

Doming on the machine is a free-hand operation, the circular sheet being hammered to the required radius by means of a ball-nosed punch and a concave die, as shown in Figs. 12 and 13. Accurate work can be produced with very little practice, and a good surface finish is assured by the relatively large area of contact between the metal and the two hammering tools.

Beading is illustrated in Figs. 14 and 15. It can be performed with either the straight-cutting or circle-cutting attachments, while irregular shapes can be produced by working to scribed lines. The upper tool, or punch, reciprocating rapidly, hammers the sheet into the form determined by the fixed lower tool, or die.

Folding or joggling is illustrated in Figs. 16 and 17, which show clearly the shapes of the two tools and the principle of operation. There are practically no limitations to the shapes that can be produced; a number of standard tools are available for straight, circular or irregular folds, but in any event the design of the tools is so simple that special tools can easily be made. As with some of the other operations, both the straight-cutting and circle-cutting attachments can be used for folding.

MOND NICKEL FELLOWSHIPS.—The Mond Nickel Fellowships Committee now invite applications for fellowships of an approximate value of 900*l.* to 1,200*l.* for 1953. Fellowships will be awarded to selected candidates of British nationality, having degree or equivalent qualifications, to enable them to obtain wider experience and additional training in industrial establishments, at home or abroad, thus making them more suitable for employment in senior technical and administrative positions in British metallurgical industries. Each fellowship will cover one full working year. Applicants will be required to state details of the programme they wish to carry out. Particulars and forms of application are available from the secretary, Mond Nickel Fellowship Committee, 4, Grosvenor-gardens, London, S.W.1. Applications should be lodged by June 1, 1953.

COURSE ON ELECTRONICS AT HARWELL.—Applications are invited by the Atomic Energy Research Establishment, Harwell, from physicists and electronic engineers holding a degree, or equivalent qualification, who wish to attend a specialised course on the design, use, and maintenance of electronic instruments used in nuclear physics, radiochemistry, and in work with radio-isotopes. The course, to be held at the Isotope School, Harwell, will be from Monday, March 16, to Friday, March 20. The fee for the course is 12 guineas, and living accommodation at Buckland House, near Faringdon, one of the A.E.R.E. senior staff hostels, transport and morning and evening meals will be provided at a charge of 7 guineas. Application forms may be obtained from the Electronics Division, A.E.R.E., Harwell, near Didcot, Berkshire.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

ELECTRICITY SUPPLY IN KINTYRE.—Owing to the increased demand for electricity in Kintyre, the North of Scotland Hydro-Electric Board have decided to extend the Glen Lussa project in Argyre. The scheme, which has been confirmed by the Secretary of State for Scotland, will increase the annual output of the generating station in Glen Lussa from 8.5 to 10.75 million kilowatt-hours. The necessary power will be provided by water diverted from the upper tributaries of the River Barr.

FUEL EFFICIENCY MEASURES.—The Scottish Fuel Efficiency Committee have recommended that the Fuel Efficiency Department of the Ministry of Fuel and Power should be retained on its present basis and the personnel increased four-fold. This would mean a minimum of 800 on the staff for the United Kingdom, and an increase of the Scottish staff from 24 to 100. If no Government funds are available to finance the scheme, this should be done by imposing a levy of 3d. a ton on coal. The committee also recommend that all expenditure on fuel-saving plant installed on the recommendation of Ministry engineers, or with their approval, should be exempt from taxation.

LAND-DEVELOPMENT EQUIPMENT.—The Scottish Land Development Corporation, Glasgow, have inaugurated a sales department, while continuing their function of hiring out land-development equipment. Hitherto most of this came from the United States, but the Corporation have now become sole Scottish agents for Fiat equipment. A parallel development is the adaptation by Albion Motors, Ltd., of their EN 286 four-cylinder direct-injection engine for use with the American Bucyrus-Erie excavator.

OPENINGS FOR BOYS IN SKILLED TRADES.—Difficulty in securing sufficient openings for boys in skilled trades is referred to in the annual report of the directors of Ponton House Lads' Residence, Edinburgh. Of the 75 boys in residence at the end of the financial year, 31 were apprenticed to 18 different trades.

CLEVELAND AND THE NORTHERN COUNTIES.

THE BLAYDON TO CARLISLE ELECTRICITY TRANSMISSION LINE.—At a conference at Hexham, Northumberland, to discuss the route of the proposed high-voltage overhead transmission line from Blaydon to Carlisle, it was decided that farmers, landowners, amenity societies, etc., should meet the Northumberland County Planning Authority to discuss a proposed deviation of the line. The general route of the line has been approved by the Government, but farmers are still opposing it on the ground that it will interfere with good farming land in the Hexham area. They propose a route farther south, but this is objected to by amenity societies because it will bring the line too close to the Roman Wall. It is understood that the British Electricity Authority are not averse to a slight deviation.

THE PRICE OF GAS.—In a statement to the Northern Regional Board for Industry, Alderman J. Hoy, chairman of the Northern Regional Gas Consultative Council, stated that prices for gas were lower in the north than the average for the country, namely, 6.32d. for industrial gas and 9.22d. for commercial gas per therm, against a national average of 10.44d. and 14.22d., respectively.

ELECTRICITY LOAD-SPREADING SCHEME.—Load-spreading arrangements for the Northern Area ended on February 13. Sir Mark Hodgson, chairman of the Northern Regional Board for Industry, in a letter to about 2,500 firms co-operating in the scheme, said that power cuts had been narrowly averted by the co-operation of all concerned. Load-spreading had been limited to 10 per cent. for three months, compared with 20 per cent. in previous years.

HEAD, WRIGHTSON & CO., LTD.—Mr. Richard Miles, chairman and managing director of Head, Wrightson and Co., Ltd., Thornaby-on-Tees, presided at a dinner on February 11 when presentations were made to 145 employees of more than 40 years' service. Thirty-four men with over 50 years' service received chiming clocks and gold watches, and those whose service was between 40 and 50 years were given gold watches. Mr. A. Chilton, director and general manager of Head Wrightson Stampings, Ltd., announced that the firm had decided to establish an office in Canada.

STEEL EXPORTS FROM WORKINGTON.—During 1952, the Workington Iron and Steel Co., Ltd., Cumberland, exported 39,402 tons of rails and railway material worth more than £1,500,000. In the same period orders were obtained for over 80,000 tons of railway-track material from overseas. The firm have obtained recently an order for 4,800 tons of steel rails and sleepers for East Africa.

WORKS EXTENSION AT GATESHEAD.—Messrs. Clarke, Chapman & Co., Ltd., Gateshead, are about to begin production in a new boiler shop which has cost the firm about 250,000l. According to Mr. T. Thompson, a director of the firm, the new shop will enable them to double their export trade and to increase the number of their employees.

THE LATE MR. JOHN MCCONWAY.—The death has occurred at South Shields, at the age of 84, of Mr. John McConway, managing director of the Anglo Foundry Co., Ltd., Templetown, South Shields. Mr. McConway began as an office boy with the Bede Metal and Chemical Co., Ltd., Hebburn, and eventually became general manager. He was connected with the Hebburn firm for about 50 years.

LANCASHIRE AND SOUTH YORKSHIRE.

IRON AND STEEL PRODUCTION.—Sheffield district producers of steel ingots and castings achieved a new record in January, with an output of 5,200 tons a week more than the average weekly production last year. The average weekly output of 48,500 tons was about 14 per cent. of the national total. Compared with January last year it was an increase of 4,100 tons a week. Steelmakers in North Lincolnshire produced 5,100 tons a week more than in the January average in 1952, and increased the production of pig-iron by 2,000 tons a week.

HEAVIER FUEL BILL.—It is estimated that, in the area of the North Eastern (Yorkshire) Divisional Coal Board, the increase in coal prices necessitated by the rise of 6s. a week in miners' wages will bring in about 250,000l. a week. About 210,000 tons of coal are conveyed by rail into Sheffield every week and the main burden of the higher charges will fall upon industry. Two large Sheffield firms have estimated that the price rise will cost each firm about 35,000l. a year. Smaller firms in the lighter trades express the view that the indirect effect of the rise, through electricity, gas and transport costs, will be worse than the direct effect upon their coal bills.

UNEMPLOYMENT IN SHEFFIELD.—On account of quieter times in the lighter trades of Sheffield, the number of workless has increased by 534. The largest increase in unemployment is among men, with a total of 1,309 wholly unemployed. The number of men temporarily stopped or on short time has risen by 51 to 266. There are 158 more women unemployed, the increase being to 1,061, and the number on short time or temporarily stopped has risen from 81 to 173.

THE LATE MR. A. K. WILSON.—Mr. Arthur Kingsford Wilson, who died at his home, Beauchief Hall, Sheffield, on February 10, was governing director of Spear and Jackson, Ltd., Sheffield, and was the fourth in direct succession from his great-grandfather to occupy the chair of the company. He was also a director of Newton, Chambers & Co., Ltd., until ill-health caused him to resign in 1951. He was the third member of the family to hold the office of Master Cutler, and as President of the Sheffield Chamber of Commerce did much for local and international trade. He headed a trade mission to South America while President. He was 67 years of age.

THE MIDLANDS.

PROPOSED ENGINEERING CENTRE AT BIRMINGHAM.—The scope of the Birmingham Exchange, in Stephenson-place, Birmingham, 2, is to be widened to include the organisation of a permanent Engineering Centre, similar to the one at Glasgow, but adapted to local needs and conditions. The project has been approved by the Public Works Committee of the City and the Regional Controller of the Ministry of Supply, and has the support of numerous prominent industrialists. It is intended that the Centre shall provide a constantly changing exhibition, representative of light and medium engineering, a capacity register, and an information bureau. Students and apprentices will be encouraged to make use of the Centre as a means of keeping informed of developments in the industry. The Centre will be run on a non-profit making basis, and no goods will be sold.

POOLING OF SMALL FIRMS' RESOURCES.—Two schemes have been proposed by the Dudley area branch of the National Union of Manufacturers to

assist small firms in the district to engage in export work. The Union's plans are based on the fact that there are many firms in the area which are too small individually to have the necessary experience and resources to engage directly in exporting. It is proposed, therefore, to supply nearly 250 firms with details of the two schemes for co-operation. Under the first plan, firms making component parts only will be invited to market a finished product collectively, by arranging for one firm in the group to assemble parts produced by the others. The second plan is for producers of finished goods on a small scale. In this case, it is suggested that a group of firms should arrange for one export agency to handle in bulk the entire output of the group.

PROPOSAL TO CLOSE MIDLAND CANAL BRANCHES.—The British Transport Commission have a private Bill before Parliament which seeks power to close to navigation certain branch canals in the Midlands. They are all, with one exception, short disused canal arms in the Black Country area. The exception is that part of the Dudley Canal from its junction with the Worcester and Birmingham Canal at Selly Oak, Birmingham, to a point near Halesowen. This section, though disused, is about 4½ miles long, and includes Lapal Tunnel, which is 3,795 yards long, and is the third longest canal tunnel in the country. The section of canal has been closed to traffic since 1917, when part of the tunnel collapsed.

TESTING PLANT FOR MATERIALS.—Solus-Schall (Non-Destructive Testing), Ltd., 18, New Cavendish-street, London, W.1, have opened a branch at Matlock, Derbyshire. The branch is able to undertake non-destructive testing by X-ray, gamma-ray, ultrasonic, and magnetic methods. It is intended to serve the Midlands, Sheffield and Manchester, and is claimed to be the first of its kind outside London.

DEFENCE CONTRACTS FOR COVENTRY.—The Government have lifted the ban on the placing of defence contracts in Coventry. Some contracts have been placed already, and others are in the negotiation stage. The decision has been taken in view of the slackening of trade in the motor industry, Coventry's principal employer of labour, and is a move to prevent redundancy. Several of the principal motor-vehicle manufacturers in Coventry have, in recent months, introduced short-time working.

SOUTH-WEST ENGLAND AND SOUTH WALES.

THE VELINDRE COLD-REDUCTION WORKS.—Work was due to commence on Monday, February 16, on the preparation of the site of the new cold-reduction plant to be built by the Steel Company of Wales, Ltd., at Velindre, Llangyfelach. Plans submitted by the company in respect of the plant, which will be similar to that erected at Trostre, have been approved by the Llchwyr Urban Council, whose engineer, Mr. Francis T. James, told the Council that the Ministry of Works had granted licences for several million pounds to carry out civil-engineering work and buildings. The new strip mill is to be the major development in the 40,000,000l. scheme. The main building will be more than a quarter of a mile in length. The plan includes a new bridge to span the proposed railway connection to the site and the diversion of the Velindre road for a distance of 600 yards.

SHORT-TIME WORKING IN THE TIN-PLATE INDUSTRY.—Another tin-plate plant, the Pemberton Works, Llanelly, has introduced the four-day working week in the mills department. This is a comparatively small plant. About 1,000 employees in the Old Castle tin-plate works, Llanelly, and the Ashburnham tin-plate works at Briton Ferry, were already on short time, although the number of operatives registered as wholly unemployed as the result of the steps taken in regard to these obsolete works is reported to be negligible.

SEA-DEFENCE WORKS AT BARMOUTH.—Mr. Harold MacMillan, Minister of Housing and Local Government, has announced in Parliament that he is prepared to consider an application by the Barmouth Urban Council for a Government grant in connection with their proposed 26,000l. sea-defence project. He rejected a proposal that the work should be accepted wholly as a national charge. Mr. T. W. Jones, M.P. for Merioneth, who raised the matter with the Minister, said that the Council had been crippled financially as a result of carrying out sea-defence work at a cost of 180,000l.

SILTING AT CARDIFF DOCKS.—Mr. Peter Scott, B.Sc., M.I.C.E., of Sir William Halcrow and Partners, consulting engineers, London, S.W.1, has been asked by the Cardiff Port Development Association to prepare a report on measures to overcome the silting caused by the River Taff at the entrance to Cardiff Docks.

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.

INSTITUTE OF ELECTRICAL ENGINEERS.—*Radio Section*: Monday, February 23, 5.30 p.m., Victoria-embankment, W.C.2. "Radio Aids for Airport Control," by Mr. G. W. Stallibrass. *North-Eastern Centre*: Monday, February 23, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. "Logical Approach to the Problems of Electric Space-Warming," by Mr. D. H. Parry. *London Students' Section*: Tuesday, February 24, 7 p.m., Victoria-embankment, W.C.2. "The Formation of the Electric Spark," by Dr. E. H. Cohen. *North Midland Centre*: Tuesday, February 24, 7.15 p.m., Offices of the Yorkshire Electricity Board, Ferensway, Hull. "Electrical Equipment of Battery Road Vehicles," by Mr. W. D. Sheers. *Supply Section*: Wednesday, February 25, 5.30 p.m., Victoria-embankment, W.C.2. "The Testing and Specification of Bushings in Relation to Service Conditions," by Mr. H. Barker and Mr. H. Davies. *Southern Centre*: Wednesday, February 25, 6.30 p.m., South Dorset Technical College, Weymouth. "The Manufacture of Reliable Valves," by Dr. E. A. Roberts. *Mersey and North Wales Centre*: Friday, February 27, 6.30 p.m., Electricity House, Llandudno Junction. "Domestic Electrical Installations: Some Safety Aspects," by Mr. H. W. Swann.

ROYAL SOCIETY OF ARTS.—Monday, February 23, 6 p.m., John Adam-street, W.C.2. "The Safety Factor in Construction," by Mr. G. Anthony Gardner. Wednesday, February 25, 2.30 p.m., Cadman Memorial Lecture on "Improving Coal Production," by Mr. E. H. Browne.

ILLUMINATING ENGINEERING SOCIETY.—*Leeds Centre*: Monday, February 23, 6.15 p.m., 24, Aire-street, Leeds, 1. "Lighting in Mines," by Mr. W. L. Potts. *Cardiff Centre*: Tuesday, February 24, 5.45 p.m., Offices of the South Wales Electricity Board, Cardiff. "Modern Airport Lighting," by Mr. J. W. Morse. *London*: Wednesday, February 25, 6 p.m., 2, Savoy-hill, W.C.2. Entries for Dow Prize Competition.

INSTITUTE OF PRODUCTION ENGINEERS.—*Manchester Section*: Monday, February 23, 7.15 p.m., College of Technology, Manchester. "Pressed Metal," by Mr. S. Cadman. *Luton Section*: Tuesday, February 24, 7.15 p.m., Town Hall, Luton. "Future Prospects of the Production Engineer," by Mr. W. C. Puckey. *Lincoln Section*: Tuesday, February 24, 7.30 p.m., Technical College, Gainsborough. Film Evening. *Wolverhampton Section*: Wednesday, February 25, 7.15 p.m., Wolverhampton and Staffordshire Technical College, Wolverhampton. "Automobile Production Methods in the United States," by Mr. D. Burgess. *South Wales and Monmouthshire Branch*: Thursday, February 26, 6.45 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "How the Metallurgist Can Help Production Engineers," by Dr. J. D. Jevons.

INCORPORATED PLANT ENGINEERS.—*West and East Yorkshire Branch*: Monday, February 23, 7.30 p.m., The University, Leeds. "Fuel Conservation in the United States," by Mr. W. A. Wordley. *South Yorkshire Branch*: Thursday, February 26, 7.30 p.m., Grand Hotel, Sheffield. Various short papers. *Birmingham Branch*: Friday, February 27, 7.30 p.m., Imperial Hotel, Birmingham. (i) "The Development of Mechanical Excavators," by Mr. L. V. Nelson; and (ii) "Modern Crawler Tractors," by Mr. G. H. Shaw.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Bournemouth Branch*: Monday, February 23, 8.15 p.m., Grand Hotel, Bournemouth. "Electrical Progress and Developments," by Mr. E. H. Turle. *York Branch*: Tuesday, February 24, 7.30 p.m., Creamery Restaurant, Pavement, York. "Rupturing Capacity of Switchgear," by Mr. J. Sykes. *Luton Branch*: Thursday, February 26, 8 p.m., George Hotel, Luton. "Applications of Heat Exchange," by Mr. H. E. Holt.

INSTITUTE OF BRITISH AGRICULTURAL ENGINEERS.—Tuesday, February 24, 2.15 p.m., Institution of Electrical Engineers, Victoria-embankment, W.C.2. "Recent and Present Work at the National Institute of Agricultural Engineering," by Mr. W. H. Cashmore.

ROYAL INSTITUTION.—Tuesday, February 24, 5.15 p.m., 21, Albemarle-street, W.1. "Behaviour of Engineering Structures.—II," by Professor A. J. S. Pippard.

INSTITUTE OF CIVIL ENGINEERS.—Tuesday, February 24, 5.30 p.m., Great George-street, S.W.1. "Application of Precast Concrete to the Construction of Acton Lane 'B' Power Station," by Mr. J. A. Derrington and Mr. A. G. S. Lance. *Yorkshire Association*: Friday, February 27, 7 p.m., Royal Station Hotel, York. "Claerwen Dam: Design and Construction of 200-ft. High Gravity Dam," by Mr. P. Scott.

INSTITUTE OF FUEL.—Tuesday, February 24, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "International Flame Radiation Trials at Ijmuiden, Holland," by Mr. M. W. Thring. *East Midland Section*: Thursday, February 26, 7.15 p.m., Electricity Showrooms, Derby. "The Railways and Coal," by Mr. R. G. Jarvis.

INSTITUTE OF MECHANICAL ENGINEERS.—*South Wales Branch*: Tuesday, February 24, 6 p.m., Mackworth Hotel, Swansea. "Exhaust Arrangements and Power Output of Internal-Combustion Engines," by Mr. T. J. Williams. *Institution*: Friday, February 27, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Developments in Steel Castings in the Heavy Power Plant Industry," by Mr. F. Buckley. *Western Automobile Division Centre*: Thursday, February 26, 6.45 p.m., Grand Hotel, Bristol. Centre Chairman's Address, by Mr. F. H. Kidd.

INSTITUTE OF STRUCTURAL ENGINEERS.—*Lancashire and Cheshire Branch*: Tuesday, February 24, 6.30 p.m., College of Technology, Manchester. "Developments in the Design of Sheet Pile Walls," by Mr. P. W. Rowe. *Institution*: Thursday, February 26, 6 p.m., 11, Upper Belgrave-street, S.W.1. "Soil Mechanics in Relation to Structural Engineering," by Mr. P. L. Capper. *Midland Counties Branch*: Friday, February 27, 6 p.m., James Watt Memorial Institute, Birmingham. "Experiences with Concrete," by Mr. N. T. Grant.

INSTITUTE OF HEATING AND VENTILATING ENGINEERS.—*Scottish Branch*: Tuesday, February 24, 6.30 p.m., 351, Sauchiehall-street, Glasgow. "Electrical Equipment for the Heating and Ventilating Engineer," by Mr. J. M. Hulley.

INSTITUTE OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, February 24, 6.30 p.m., 39, Elm-bank-crescent, Glasgow. "Inspection Problems in the Manufacture of Modern Jet Engines," by Mr. C. Garside.

SOCIETY OF INSTRUMENT TECHNOLOGY.—Tuesday, February 24, 7 p.m., 26, Portland-place, W.1. "Geophysical Prospecting for Oil," by Mr. D. T. Germain-Jones.

ROYAL STATISTICAL SOCIETY.—*Merseyside Industrial Applications Group*: Tuesday, February 24, 7 p.m., Radiant House, Bold-street, Liverpool. "A Study of Variations in the Strength of Concrete," by Mr. B. E. Roberts. *London*: Wednesday, February 25, 5.15 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "Sampling Design Used by the Ministry of Education," by G. F. Peaker.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*West Midlands Section*: Tuesday, February 24, 7.15 p.m., Wolverhampton and Staffordshire Technical College, Wolverhampton. "The Development of the Radio and Electronics Industry in India," by Mr. C. D. Clifford.

JUNIOR INSTITUTION OF ENGINEERS.—*North-Western Section*: Tuesday, February 24, 7.15 p.m., Engineers' Club, Manchester. "The Air and the Future," by Air Commodore F. R. Banks. *Midland Section*: Wednesday, February 25, 7 p.m., Technical College, Coventry. "Automatic Feed Pressworking," by Mr. C. H. Crawford. *Institution*: Friday, February 27, 7 p.m., Townsend House, Greycoat-place, S.W.1. "Electronics in Materials Handling," by Mr. L. Landon Goodman.

ROYAL AERONAUTICAL SOCIETY.—*Graduates' and Students' Section*: Tuesday, February 24, 7.30 p.m., 4, Hamilton-place, W.1. "Viscount Operations," by Captain R. Rymer. *Society*: Thursday, February 26, 6 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "New Materials and Methods for Aircraft Structure," by Mr. H. J. Pollard.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Birmingham Branch*: Wednesday, February 25, 7.15 p.m., James Watt Memorial Institute, Birmingham. "Operation of the Water-Cooled Cupola," by Mr. J. W. Dews. *London Branch*: Wednesday, February 25, 7.30 p.m., Waldorf Hotel, Aldwych, W.C.2. "Operating Experiences with Hot-Blast Cupolas," by Mr. F. C. Evans. *Falkirk Section*: Friday, February 27, 7.30 p.m., Temperance Café, Lint Riggs, Falkirk. "Light Castings Defects," by Mr. A. N. Sumner.

INSTITUTE OF WELDING.—*North London Branch*: Wednesday, February 25, 7.30 p.m., 26, Portland-place, W.1. Brains Trust Meeting.

ROYAL SOCIETY.—Thursday, February 26, 10.30 a.m., Burlington House, Piccadilly, W.1. Discussion on "The Floor of the Atlantic Ocean," opened by Dr. E. C. Bullard, F.R.S.

CHEMICAL SOCIETY.—Thursday, February 26, 7.30 p.m., Royal Institution, 21, Albemarle-street, W.1. Centenary Lecture on "Some Applications of the Separation of Large Molecules and Colloidal Particles," by Professor A. Tiselius.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, February 27, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. "Wake Studies of Plane Surfaces," by Dr. J. F. Allan and Mr. R. S. Cutland.

PERSONAL.

H.M. THE QUEEN has been graciously pleased to grant her Royal Patronage to the Institution of Gas Engineers, 17, Grosvenor-crescent, London, S.W.1.

SIR GEORGE P. CHRISTOPHER has been appointed chairman and managing director of the Union-Castle Mail Steamship Co. Ltd., 3, Fenchurch-street, London, E.C.3, in succession to the late SIR VERNON THOMSON, Bt., G.B.E. SIR CAMPBELL STUART, G.C.M.G., K.B.E., has been elected deputy chairman. Mr. J. S. BEVAN, an assistant manager of the company, has been elected a director and assistant managing director. Mr. R. J. BLOXAM, F.C.I.S., who is to continue as secretary, has been appointed an assistant manager.

MAJOR-GENERAL C. A. L. DUNPHIE, C.B., C.B.E., D.S.O., in addition to his existing duties as managing director, engineering and shipbuilding division, Vickers-Armstrongs Ltd., will act as managing director, aircraft division, during MAJOR SIR HEW KILNER's absence due to ill health. Other appointments are those of Mr. R. P. H. YAPP, as assistant to the managing directors; Mr. G. R. EDWARDS, C.B.E., B.Sc., F.R.Ae.S., A.M.I.Struct.E., as director of the company and general manager and chief engineer, aircraft division; Mr. B. STEPHENSON, A.F.R.Ae.S. as chief designer aircraft, Weybridge Works; Mr. H. H. GARDNER, B.Sc., F.R.Ae.S., as chief designer, guided weapons, Weybridge Works; Mr. T. GAMMON, O.B.E., M.I.Mech.E., as deputy general manager, aircraft division; and Mr. R. EDMONDS, M.B.E., as superintendent, Weybridge Works.

MR. G. E. BEHARREL, deputy chairman and managing director of the Dunlop Rubber Co. Ltd., has been nominated President of the Motor and Cycle Trades Benevolent Fund for 1953-4.

DR. R. J. MORLEY, hitherto at the Billingham Works of Imperial Chemical Industries Ltd., has been appointed Director-General of Carbonisation to the National Coal Board.

DR. DONALD C. PACK, of the Mathematics Department, University of Manchester, has been appointed to the chair of mathematics at the Royal Technical College, Glasgow.

MR. J. R. MUSGRAVE, A.M.I.C.E., A.M.I.Mun.E., has been appointed assistant deputy county surveyor of Staffordshire.

MR. ARTHUR HORNER, director and general manager, Darlington and Simpson Rolling Mills Ltd., Darlington, has been appointed managing director in succession to the late Mr. J. W. HARRISON.

MR. H. HOWE GRAHAM has been appointed deputy chairman of the Rover Co. Ltd., Solihull, Birmingham. Mr. L. G. T. FARMER, secretary of the company, has been elected to the board.

MR. A. A. MILLAR, electrical engineer for the Cumberland area, National Coal Board, has been appointed chief electrical engineer for the central west area, Scottish Division, of the Board.

MR. R. P. BROOKES has been elected a director of Beans Industries Ltd., Hurst-lane, Tipton, Staffs.

MR. W. J. FARRANT has relinquished his position as director of John Bolding & Sons, Ltd., Grosvenor Works, Davies-street, London, W.1.

MR. P. O. WITTEY, A.M.I.E.E., has retired after 16 years with the British Thomson-Houston Co. Ltd., and 50 years in the electrical industry.

MR. G. A. BURRIDGE, secretary and director of Burton, Griffiths & Co. Ltd., has also been elected a director of B.S.A. Tools Ltd. Mr. F. A. JAMES, sales manager for the B.S.A. Tools Group, has joined the board of Burton Griffiths & Co. Mr. J. L. PARKER has been appointed works manager of B.S.A. Tools Ltd., in succession to Mr. F. H. HARRIS, who has left the company.

MR. J. C. MILNE, M.I.E.E., has been appointed assistant general manager, Electric Construction Co. Ltd., Bushbury Engineering Works, Wolverhampton.

MR. H. W. BARNETT is to be manager of the newly-formed Oxygen Generator Division of the Butterley Co. Ltd., as well as act as the company's London manager, the post he now holds. Mr. A. A. C. ROBERTSON, A.M.I.Mech.E., will be chief engineer, and Dr. G. G. HASELDEN, D.I.C. A.M.I.Chem.E., consultant. The purchasing agent is Mr. H. P. WILLIAMS. The headquarters of the Division are at 20, Ashley-place, London, S.W.1. (Telephone: VICTORIA 8023.)

MR. J. S. CARR, M.B.E., has relinquished the post of commercial manager of E.M.I. Factories Ltd., to take up that of managing director of African Consolidated Sound Industries (Pty.) Ltd., Johannesburg.

MR. C. WILLIAMS has been made technical sales engineer, in the Liverpool district, of Higgs Motors Ltd., Witton, Birmingham, 6.

On February 23, THE ASSOCIATED ETHYL CO. LTD., will move to 20, Berkeley-square, London, W.1. (Telephone: GROSVENOR 6030.)

ELECTRICAL CONTROL OF FISH AT HYDRO-ELECTRIC POWER STATIONS.

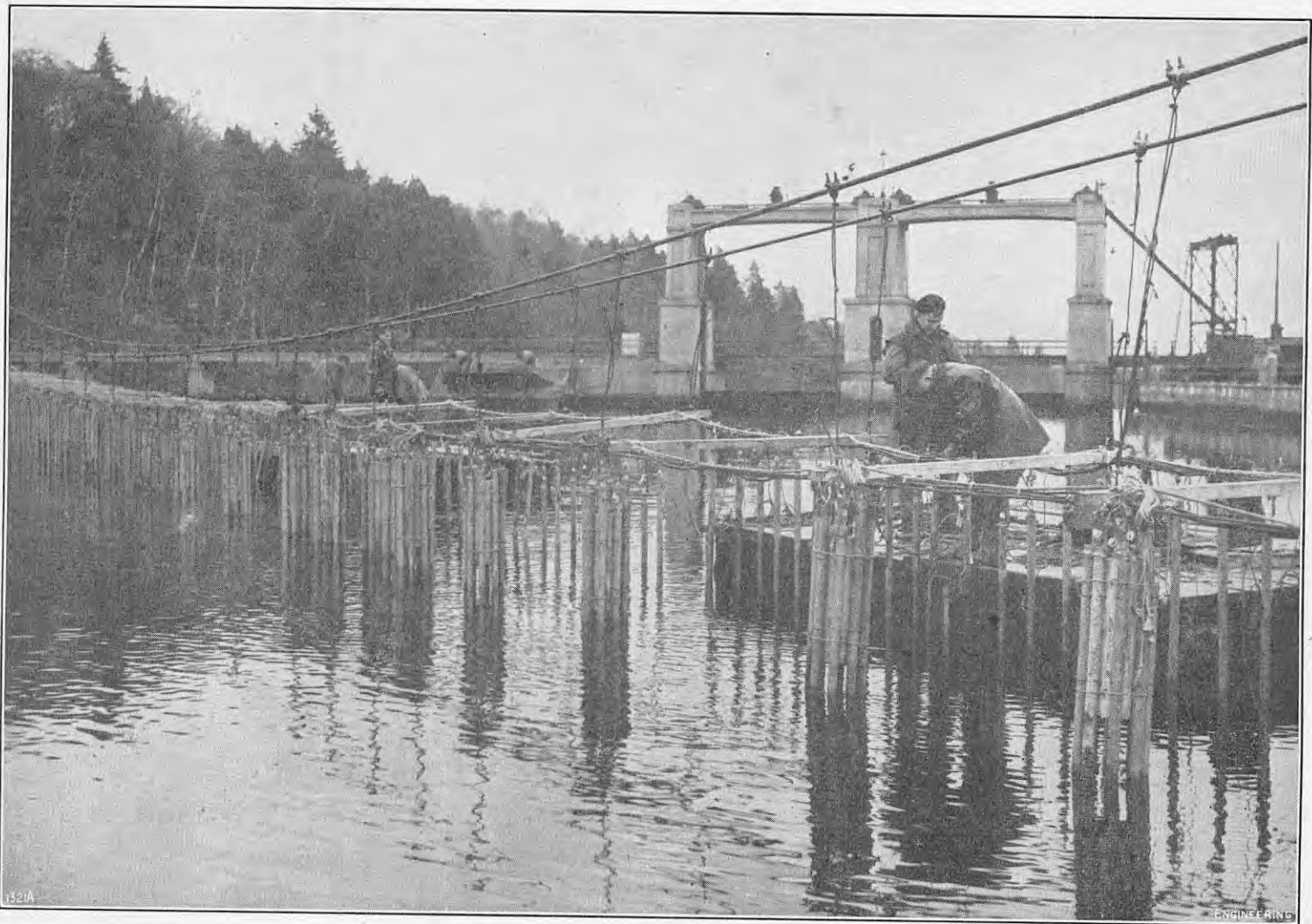


FIG. 1. ELECTRIC SCREEN AT DUNALASTAIR DAM.

ELECTRICAL CONTROL OF SALMON AND TROUT.

In our issue of February 13, on page 203, we printed a summary of a paper which was presented to the Royal Society of Edinburgh on February 2 by Mr. Norman G. Lethlean, of the research staff of the North of Scotland Hydro-Electric Board, in which he described some experiments with electrical methods of controlling the movements of salmon and trout in the vicinity of hydro-electric plants. It was stated that, following the initial experiments at Dundee, electrically-charged screens were tried at Morar and above the dam at Dunalastair, on the River Tummel, in Perthshire, as a means of diverting the fish into the fish pass and keeping them away from the intake to the power station.

As a supplement to the abstract of Mr. Lethlean's paper, we reproduce herewith two views of the experimental electrified screens. Fig. 1 shows the screen at Dunalastair Dam, which consists of two rows of aluminium tubes. The upstream row has the tubes arranged in groups, placed 8 ft. apart, and the downstream row is a single line of tubes, 1 ft. apart. Fig. 2 shows the screen at Pitlochry, which is of the same design as the one tested at Morar and has a row of aluminium electrodes, extending almost to the bottom of the channel, with two outer electrodes (not shown) about 7 ft. downstream from the screen. This type was found to be completely successful, whereas the type shown in Fig. 1, during last year's experiments, diverted only about 70 per cent. of the fish.

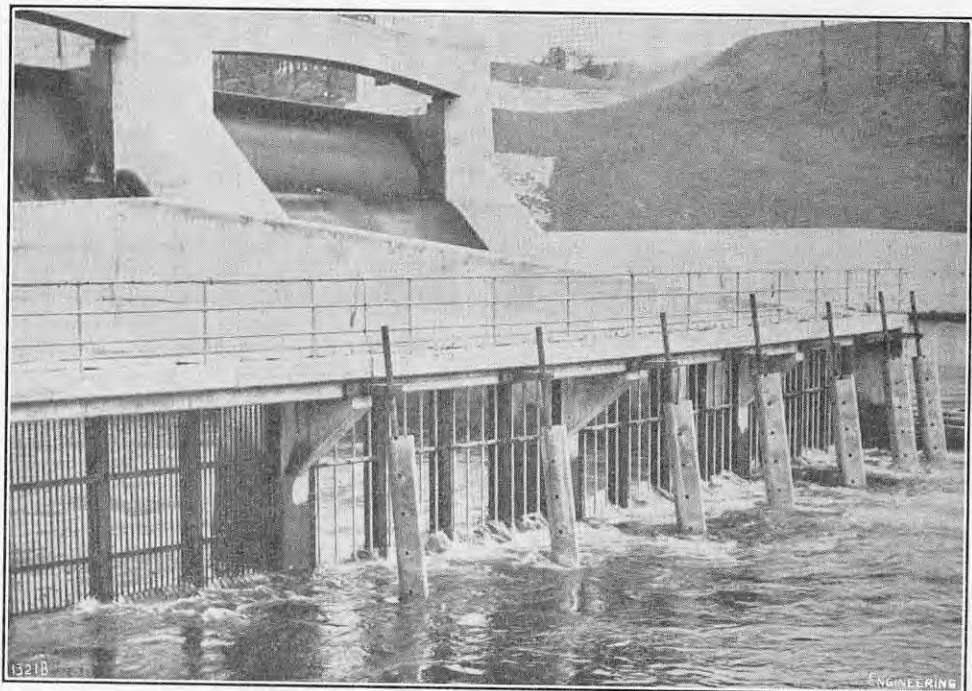


FIG. 2. SCREEN AT PITLOCHRY POWER STATION.

IMPERIAL COLLEGE EASTER SCHOOL IN RELAXATION METHODS.—Since 1945 a number of vacation schools in relaxation methods have been held at the Imperial College of Science and Technology. Their success has encouraged the provision of a similar course in the coming Easter vacation, and this is now planned for

the period April 9 to 23. This course will cover the numerical solution of linear algebraic equations, framework problems, Laplace's and Poisson's equations, the biharmonic equation, eigenvalue problems, the heat-conduction equation, three-dimensional relaxation, and other subjects. The course will consist of daily lectures at 10.15 a.m. and 11.30 a.m., with numerous examples to be solved under supervision in the afternoons. The fee for the course will be 10/., payable to the Imperial College. The College may be able to

provide accommodation in the hostel building; the daily charge for a room is 9s. Meals are obtainable in the College refectory. Applications to attend should be addressed to Mr. D. N. de G. Allen, Imperial College, of Science and Technology, Prince Consort-road, South Kensington, London, S.W.7. Separate application should be made by each individual, stating the amount of time that can be given to the course, whether accommodation is desired, and if so, whether for the whole period or for that period excluding week-ends.

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

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

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ENGINEERING

FRIDAY, FEBRUARY 20, 1953.

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No. 4543.

SCIENCE, INDUSTRY AND THE COMMONWEALTH.

THERE is a challenge to British industry in three factors which are operative in the Commonwealth to-day, namely, the undertaking given by the Government at the recent Commonwealth Conference to accelerate its investment in the Commonwealth, the fact that British industry itself is pressing for increased investment, and the steps that are being taken to ensure that the results of Government-sponsored research are made available freely to the other countries of the Commonwealth. The first two factors are to some extent antithetical, in that they will both intensify demands on the limited savings of this country, and the third implies that, in the years ahead, the developing countries of the Commonwealth will benefit from the application of the results of research which has been financed by the United Kingdom's industries. The flow of data is, of course, two-way—this journal, for example, has published recently several articles on research conducted in Australia—but, on balance, there is no doubt that the Department of Scientific and Industrial Research, and its laboratories, serves the Commonwealth as a whole as much as it serves industries at home. The ties which make the Commonwealth a power in the world are thereby strengthened and the modern liberal view of progress among a group of nations is affirmed.

In this broad picture, the challenge to British industry is clearly seen. The United Kingdom investment in the Commonwealth has averaged

about 160,000,000l. a year in the past three and a half years. At the Commonwealth Conference it was decided to increase the rate of investment, and as it will be necessary, at the same time, to invest more at home, the nation's ability to save is going to be crucial. It will be decided, in part, by the Budget, but whatever financial juggling takes place in the next few months, there is no gainsaying the fact that British industries, with a few notable exceptions, require first priority on re-equipment.

Meanwhile, the engineer may consider the implications of the third factor—the diffusion of the results of research among the nations of the Commonwealth. There are Scientific Liaison Offices in London and North America which act as centres for Commonwealth collaboration in scientific matters, and there is a considerable amount of direct communication and interchange of information between the research stations of the several countries. This kind of co-operation arose during the last war, when the impact of science on defence matters was paramount. After the war it was realised that similar co-operation could, with advantage, be continued in peace-time and in relation to the civil, as distinct from the military, requirements of science. At a conference held in 1946 and attended by large delegations from the independent countries of the Commonwealth, as well as from many of the Colonies, a comprehensive programme of scientific collaboration was worked out and the machinery to give effect to it was established.

A second conference was held in Australia early last year to review the functioning of these arrangements, and the recently-published report on its proceedings* reveals the several ways in which scientific knowledge is being spread throughout the Commonwealth. The chairman of the Conference was Dr. I. Clunies Ross (who is chairman of the Australian Commonwealth Scientific and Industrial Research Organisation), and the delegation from the United Kingdom comprised Sir Ben Lockspeiser, K.C.B., F.R.S., secretary of the Department of Scientific and Industrial Research; Dr. F. H. K. Green, C.B.E., principal medical officer of the Medical Research Council; Dr. Alexander King, C.B.E., head of the intelligence division of the D.S.I.R.; and Sir William K. Slater, K.B.E., secretary of the Agricultural Research Council.

From the engineering point of view, the deliberations of the committee on the application of the results of research in industry are of particular interest, since they evinced an appreciation of the significance of this aspect of science which is often stressed in this country. Certain features of the problem are now commonly accepted, though perhaps it is only lip service. Thus, it is known that improvements in the efficiency of production might be attained on the basis of existing knowledge. It was considered that the scientific organisations of the countries represented at the Conference had a duty to regard this problem as of the highest importance, and to advise their Governments accordingly. In agriculture, owing to the obvious difficulties confronting a farmer who wishes to apply the latest findings of research, "extension services" are provided; they are staffed by men who are engaged in advisory work with farmers, and in experimental and demonstration work to see that the findings of research are applied in practice.

The conditions are very different in engineering. Industrial research serves a wide variety of industries, some employing conventional materials and methods, while others are based on recent scientific discovery. Engineering firms themselves vary considerably in character, from large enterprises with their own qualified research and development staffs to small firms possessing little or no technical skill or experience. Thus, although the delegates

* British Commonwealth Scientific Conference, Australia, February-March, 1952: Report of Proceedings. H.M. Stationery Office, London. [Price 3s. net.]

were not in a position to lay down one infallible method of applying the results of research, they were able to review some of the approaches to the problem. They noted, for example, the tendency of research institutions to undertake too many projects in relation to their resources in research workers and equipment. It was therefore considered necessary to review research programmes periodically to ensure that effort was being concentrated on those projects of greatest significance to the industries served.

"Technological development," the report states, "is much more costly than scientific research." That statement, assuming it to be true—it is the opinion of a group of eminent leaders of research—raises a fundamental point. Considering the accountable expenditure on research in this country alone, it may be doubted whether anything like enough is spent on technological development, even though the amount spent is difficult, if not impossible, to compute with any pretence to accuracy. The committee recognised that it is best for development to be undertaken on the basis of research data by industrial firms themselves, but that, unless some help is given, many firms do not undertake developments even of processes or machines of economic significance to them. There appeared to be no easy way of surmounting this difficulty; the remarks in the report were confined to references to organisations such as the National Research Development Corporation in this country. All that this body can do, however, is to encourage the adoption of inventions and developments which for some reason have not already been exploited by commercial interests. That is quite different from, and much less fruitful than, the technical progress that springs from alertness in the board room, the design office and the shops.

Reduced to its simplest terms, the problem for this country, and for the Commonwealth as a whole, is to have the right people in the right places. At the Conference it was agreed that this can be facilitated by arranging for scientists to visit Commonwealth countries; by scholarships, of which there are now many; and by each country being prepared to accept for training in research selected graduates who are members of the staffs of government research organisations of another Commonwealth country. It was felt that the most permanent results would be achieved by the countries concerned sending their own nominees to appropriate centres for training. The resolution adopted at the Conference was that, in view of the possible adverse effect, on the research programme of individual countries, of the heavy demand for scientific and technical assistance to underdeveloped countries in implementing the Colombo Plan and other plans, a study should be made of the problems involved in the supply by the Commonwealth of scientific and technical personnel to help underdeveloped countries. By this and other means, industrial firms in all the countries will be able to understand and make use of scientific knowledge and technological advances. The proportion of scientists and technologists in industry to those in the research establishments will be raised. At the present time, the report states, "trained people of this character do not exist in sufficient numbers in any country of the Commonwealth, and the best stimulus to improving this unsatisfactory state of affairs lies in an effective demand by industry itself." The data and findings from research establishments are not sold to the highest bidder: for the most part, they are available freely to anyone who recognises the opportunity. In the United Kingdom, a very high percentage of the national income is now being invested in primary and secondary education. As other countries of the Commonwealth develop, firms at home will prosper only if they make good use of the young men and women who are presented to them in the future.

ELECTRONICS AND THE YOUNG ENGINEER.

Two papers in recent issues of *Electrical Engineering* raise some interesting points regarding developments in that increasingly important branch of the electrical industry, electronics, and discuss an aspect of the labour problems, which this progress has brought about. In the first of these communications, on "Electronics, Development and Industrial Growth," Mr. J. E. Hobson points out that, in not much more than a quarter of a century, the use of electronics (a somewhat vague and far from satisfactory term) has resulted in the establishment of an industry which has "reached proportions of major influence on American economy." It has, in fact, become essential in many fields of technical activity, a state of things for which there are several reasons, among them its versatility. This quality is exemplified in Mr. Hobson's statement that, in electronic applications, voltages varying from 10^{-8} to 10^6 volts, currents from 10^{-14} to 10^6 amperes, power from 10^{-12} to 10^7 watts, and frequencies up to 10^{12} cycles are commonly handled. The range of its practical uses is equally wide, because of the way in which knowledge gained during war conditions has been applied for peaceful purposes. This progress is, of course, largely dependent on the improvements that have been made in the original thermionic valves of Fleming, de Forest and other pioneers, as is clearly shown by the statement that, in the United States, 30 million valves of some 1,200 types can be produced per month. Of these, a high proportion are intended for use in radio or television receivers, while the telephone, police and fire services demand their quotas, as do military and aeronautical equipment.

That recent developments should initially have occurred in these directions is not surprising, since, in the first place, many of the latest uses of electronics are a natural extension of war-time activities, while the energy that has been displayed during the last few years in the United States in providing television facilities has also played a significant part. This is shown by the statement that 108 television stations are now in operation in that country, while some 2,000 are contemplated, a state of things which imposes some strain on the imagination. On the other hand, progress in the even more important industrial field has been slower, partly because of some natural doubt about the reliability of the essential valves, which it is feared may involve high maintenance costs and lead to the breakdown, without warning, of production lines. Although we feel sure that Mr. Hobson does not exclude improvements in this respect, it is interesting to note that he pins more faith on such newer devices as the transistor, the germanium diode and the magnetic amplifier. He points out in this connection that, while the transistor is only about five years old, it is already being produced at the rate of several thousand per month and that, since it is some 15 times as reliable as the average vacuum tube and has a lower power requirement, its influence on the design of electronic apparatus of all kinds may well be profound. In fact, he adds, it is considered "a real threat to the receiver tube business."

All this development, as Mr. Hobson rightly points out, has arisen, not from a "flash of genius of a single discoverer," but from well-organised team work, a position which still persists. In fact, of the 50,000 electronic engineers in the United States, it is estimated that 35,000 are working on improvements, a figure which in itself should provide some guarantee of future progress. A natural conclusion that may be drawn from these figures is that electronics offers a fruitful field of employment to the young engineer, a statement which leads to a consideration of the second paper mentioned above.

In this communication, which is entitled "The Man Power Shortage in Power Education," Mr. J. D. Ryder deals with the difficulty that electricity supply undertakings in the United States are experiencing in obtaining recruits from "engineering college graduates." This difficulty seems to be due to three reasons: an actual shortage in the number of recruits, owing to the greater financial attraction of other work (a point on which great emphasis is laid by Mr. Lee Cahn in another communication); the unenlightened policy of some of the undertakings concerned; and the competition provided by the electronic branch of the industry. The last of these reasons is supported by some interesting figures. As the result of a questionnaire circulated by the Education Committee of the American Institute of Electrical Engineers, it is calculated that, of the 5,930 Bachelor of Science degrees granted in that country in 1951-52, only 2,130, or 36 per cent., were "in power," while 3,800, or 64 per cent., were "in electronics." Moreover, it appears that the electronic courses were the more difficult, so that the poorer students tended to gravitate into power work. Similarly, exceptional students were attracted into the electronic field by the theoretical and mathematical features of the work, thus further upsetting the balance between the two.

Mr. Ryder suggests that the remedy for this state of affairs lies in the hands of the supply undertakings "since the schools cannot greatly influence the interests of the students." He warns those bodies that time will not bring a remedy, as some of them seem to think; and that to suppose that the electronic industry cannot continue to provide work for all graduates (an opinion which is also widely held) is to live in a fool's paradise. This argument would certainly seem to be supported by the evidence regarding the growth of the electronics industry which we have given above. In other words, "a dynamic 9,000 million dollar industry is not suddenly going to fade away." To meet this competition, it is contended, the supply undertakings must increase their salaries to attract better men, endow scholarships, and allow new entrants a higher degree of responsibility than has been common in the past. As it is, these undertakings seem unable to convince students that they are interested in "creative aggressive engineering," with the result that of the 90 candidates who received a science degree from one Mid-Western university in 1951-52, only one went to a power company.

These figures, and the arguments which are based upon them, deserve some attention from British electrical engineers, especially as regards the relative attractions of the electronic and power branches; and it would be interesting to have similar data to that we have just recorded from the training institutions in this country. At the same time, it is desirable that this statistical information should not altogether be accepted at its face value. It is admitted, in fact, that to divide students into "power" and "electronics" is too rigid a classification, and that the training in the American schools is not so narrow as to preclude a change from one field to the other. That it might be possible to make this change without sacrificing the undoubted glamour of electronics is shown by a recent statement by Mr. W. Borgquist that, with the growth of transmission systems, and the consequent increase in protection and stability problems, the Swedish Power Board mainly requires electrical engineers who are familiar with "weak current" work. He also added that, for the erection and maintenance of these systems, it is those with civil engineering training that are necessary. There seems to be a lesson in this for those who are willing to learn it, and perhaps also a solution of the general problem—to concentrate a little more on the cultivation of adaptability.

NOTES.

SYMPOSIUM ON ELECTRICAL INSULATING MATERIALS.

SINCE in almost every branch of electrical work, insulation sets the limit to what is practicable, as distinct from what is wanted, it is perhaps a little surprising that a conference on this subject has not previously been held by the Institution of Electrical Engineers. This omission is now, however, to be remedied by a symposium which is to take place, under the auspices of the Measurements Section, in London, from Monday, March 16, to Wednesday, March 18. The papers, all of which will contain a substantial proportion of hitherto unpublished material, will be considered in five sessions, during which most of the time available will be devoted to discussion. At the session at 5.30 p.m. on the first day an opening address will be delivered by the President (Mr. B. H. Leeson), and six papers will be presented under the heading of "Permittivity and Dielectric Losses in Solids," with Professor Willis Jackson acting as rapporteur. On Tuesday afternoon, at 2.30 p.m., there will be five papers on "Permittivity and Dielectric Losses in Liquids," with Dr. L. Hartshorn as rapporteur, and on the same day at 5.30 p.m., the subject of "Electric Strength and Breakdown Mechanisms" will also be dealt with in ten papers, with Dr. S. Whitehead as rapporteur. On Wednesday afternoon, at 2.30 p.m., the "General Properties and Stability of Insulation" will be discussed in two papers, and "Current Problems in Insulation Design for High Frequencies and Lower Frequencies," in six papers, Dr. R. W. Sillars being the rapporteur for both these groups. At the final meeting on Wednesday evening, the subject will be "Classification, Specification and Testing," with Dr. T. E. Allibone as rapporteur for three papers.

LOAD CAPACITY OF SMALL ROAD BRIDGES.

It has been recognised for some time that the restrictions placed on the maximum weights of vehicles permitted to cross any given bridge were unduly conservative. This has arisen because the limiting loads have been calculated by the use of over-simplified methods which failed to take account of factors that contribute materially to the strength of the bridge. The discrepancy is most particularly marked on road and railway bridges of up to about 40-ft. span and of which the principal elements are either cast-iron girders or a masonry arch; many hundreds of such bridges are in existence in the United Kingdom at the present time, and a low permitted loading applies a severe restriction on the movement of traffic throughout the country. An investigation to determine the source of the unsuspected strength of these bridges was begun as long ago as 1936, when the Building Research Station, Garston, began an inquiry on behalf of the Ministry of Transport into the behaviour of various types of small highway bridges. A considerable part of the data that have been collected has been published already, particularly in the *Journal* of the Institution of Civil Engineers, but the inquiry is still being continued and a supplementary account, briefly covering material previously published, together with additional information which mainly concerns the tests that have been made on masonry arch bridges, has been issued in a report entitled *Tests on Road Bridges*, by Dr. Norman Davey, M.I.C.E. (National Building Studies, Research Paper No. 16, H.M. Stationery Office, price 3s. net.). The report describes in considerable detail the tests—three of which were continued until failure occurred—made on small bridges. Examination of a great variety of small masonry bridges showed that all of them differed in some respect from each other and no attempt has been made in the report to deduce a general formula for estimating the load capacity of such bridges; the data obtained, however, permit such an estimate to be made by measuring the spread and deflection of the arch and interpolating these measurements in the figures obtained in the tests described in the report. It has been possible,

however, to determine a more satisfactory method than this in the case of cast-iron girder bridges. Until recently, it had been customary merely to apply a limiting tensile stress to the combined effect of the dead and live load, but there had been a growing realisation of the unsatisfactory nature of using a permissible stress which, in effect, failed to distinguish between the factors of safety required for the dead-load stresses and for the live-load stresses. This has been particularly important with cast-iron bridges, where dead-load stresses form a high proportion of the total stress in the girder. By making a fundamental approach to the problem on the basis of the fatigue strength of cast iron, it has proved possible to devise a method, given in the report, of more accurately assessing the live-load capacity of this type of bridge. In addition to the graphical representation of the results of the tests, the report contains a series of half-tone illustrations of the bridges on which the tests were made, and it is concluded by an appendix describing the apparatus used, including acoustic and optical strain gauges, deflectometers and proving rings of 100 tons capacity.

THE INSTITUTION OF CIVIL ENGINEERS.

The contrast between the accuracy achieved by the modern survey instrument and the limitation on accuracy of general surveys undertaken on most sites was the theme of the discussion that followed the paper "Modern Developments in Surveying Methods and Instruments" by Mr. Alfred Stephenson, O.B.E., M.A., at the Institution of Civil Engineers on Tuesday, February 17. In his paper, the author described in some detail the improvements and refinements that have been made recently in theodolites, tachometers and levels, as well as in air surveying. Particular stress was laid on the advances made in tachometers and the greater use that was being made of them for the precision measurement of shorter distances for control surveys. This point was pursued further by Col. M. O. Collins, C.B.E., of the Ordnance Survey Department, who gave the results of an investigation made to determine the comparative costs of tachometric surveying and taping methods, to the standard required for his Department's 1/2,500 surveys; for town work, tachometry proved slightly less expensive, and it was further pointed out that, over rough country where taping would be more difficult, the difference in cost would be even more pronounced. The use to which modern mechanical computers could be put when dealing with the arithmetic involved in reducing the data obtained from air surveys was also discussed by the same speaker. Mr. E. W. S. Cockle, of the New Works Department, London Transport Executive, described how air survey work could be most usefully applied to railway work. The 40 ft. to 1 in. aerial surveys—the most accurate produced at present—were only sufficient for record purposes as a topographical picture; but if a control traverse was laid along the track, critical points could be picked up later with that degree of accuracy necessary for deducing co-ordinates for track calculations. Several speakers, including the author, emphasised the importance of each member of a survey team being clearly instructed in the purpose and requirements of the survey. Professor E. H. Thompson drew attention to the greater speed and, therefore, reduced cost with which surveys could be accomplished by using the modern optical instruments described in the paper, and he deprecated what he described as the engineer's reluctance to give up familiar instruments; Professor Thompson apparently overlooked the difficulty—even though it be demonstrably worthwhile—of finding the 800l. necessary to buy one of the new instruments.

RECONSTRUCTION IN THE COALFIELDS.

The spending of 635,000,000l. (at mid-1949 price levels) on capital-cost improvements in the coalfields managed by the National Coal Board was the subject of a lecture given by the Board's Director-General of Production, Mr. E. H. Browne, C.B.E., M.A., to the Yorkshire Branch of the

National Association of Colliery Managers, on Saturday, February 14. Before dealing in detail with the different aspects of modernising plant and buildings at existing collieries, Mr. Browne indicated that the national plan of reconstruction had envisaged the development of 22 new collieries, which included three cases where old mine workings were to be used for what would be virtually new collieries. The plan also proposed reconstruction of a major character at 70 mines and of a relatively minor character at a further 190 pits or smaller new drifts. The total cost of these schemes amounted to about 142,000,000l. (at the prices prevailing at the time of preparation), but of this only about 55 per cent. had been planned in sufficient detail to permit the authorisation of the actual expenditure. The difference was mainly due to the need to refrain from approving expenditure until the time for ordering approached. More significant, however, was the difference between the expenditure authorised and the work that had either been put in hand or let to contract; there was, in fact, at the middle of last year, 30,000,000l. worth of work outstanding. In reviewing the staff available to detail and supervise these schemes of reconstruction, Mr. Browne emphasised that the mining planning staff must be fully employed on the specialised work of examining proposals for underground reconstruction; it was essential that surface work and mechanical installations underground which could be undertaken by civil and mechanical engineering consultants should be allocated to them wherever possible. The lecturer also reviewed in some detail the present outlook in respect of winding equipment, washeries, wagon control and the use of Diesel or battery-driven locomotives, as well as mechanical handling generally; the mechanisation of the coalface itself, Mr. Browne reserved for a future address. The lecture was concluded by the showing of a number of slides illustrating layouts and installations adopted in recently completed works of reconstruction, and by two films illustrating the surface works at Kingshill Colliery and underground workings at Shilbottle colliery. These films were shown recently in London, and a notice of them appears on page 253 of this issue.

LETTERS TO THE EDITOR.

THE LATE MR. A. P. GOOD.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with a keen personal interest your obituary notice on Mr. Alan Paul Good, on page 212, *ante*. He was, as you said, a big man in every way. In height, he was 6 ft. 5 in.; in achievement, he built up an industrial empire and was called affectionately by his staff "The Emperor"; in self-confidence, no one could better him in getting the backing of the banks for his schemes, which, for the most part, were many years ahead of his time. His aim was to build a manufacturing potential for Diesel engines and Diesel generators adequate to enable this country to supply the world, and particularly those nations which have a low standard of living. "We have a job to do in helping to develop those backward territories of the world," he declared, "and this job is something more than just the selling of our products in the most favourable markets. It is a job concerned with developments that can bring stability and prosperity to millions of people who have not experienced the opportunities and advantages of western nations." He was a man of high ideals. His membership of the Commonwealth Party—he was treasurer—with Sir Richard Acland, showed that he wished to extend to the social and political spheres the ideals which he displayed in his industrial activities. One of his closest associates described him as "a man of considerable drive and courage, luckily gifted with a sense of humour." The most likely epitaph of his choice would have been: "I have made a living for all of you, even if I made it killing myself."

His death at 46 is a tragedy for British industry and the direct result of his immense capacity for

work, which prevented him from giving any time to interests outside his group's affairs. Good's most obvious quality was his "drive." He applied it mainly to the problems of production, which, from 1937 to 1952, were foremost. When a company faced serious difficulties, as many did during that period, "A. P. G." would pitch his caravan outside the factory and work 16 hours a day until recovery had begun. The Brush staff will long remember his timely intervention when trouble with the Ljungström turbine threatened the company's future. Some have said that his drive sometimes obscured his companionship, but circumstances had to be faced, and he tackled production problems when these mattered most.

In April, 1952, he said that, "If the economic problems of the country are to be solved . . . and if the country is to be able to continue to support our increasing population, then the efficiency contained in all exported goods must be increased. If we look at this in terms of our own organisation, this will mean that, in each of our factories there must be higher output per man employed, and higher output in terms of horse-power for each ton of material used. This can only be done in so far as the first is concerned on the basis of complete mass-production in all our factories, namely, one type of engine of standard range in production in one particular factory; and, in so far as the second desideratum is concerned, by employing in our own organisation the best and most expert designers."

The greatest achievement of the Brush A.B.O.E. Group is, doubtless, the production of cheap Diesel power. This was done by designing an engine with a very high power ratio, such as the Petter AV and B engines, which range from 3 to 36 brake horse-power, with speeds of 1,500 r.p.m., and, later, by the very successful Mirreles J and K series of high-powered marine and industrial engines, with speeds around 900 r.p.m. The Admiralty's backing of the new Mirreles designs was also most encouraging, though the support of shipowners was much slower in manifesting itself. The unpleasant fact, from the manufacturer's point of view, is that users rarely like to be the first to use a new design, particularly in this country; on the other hand, very few users like to be the last, and in this lie the hopes of success. It is most unfortunate that "A.P.G." should have left the scene before his policy became generally accepted.

In an interview given in June, 1951, he said that, "Some 14 years ago, I set out to rationalise the Diesel engine industry. Give me another 14 years and in Associated British Oil Engines you will have an international power in world engineering." He was not granted his wish, but he achieved more than half his goal. A powerful group has been built up round ideas that were much in advance of his time—hence the continuous struggle that he had to face, to get sufficient financial backing.

The rationalisation of design and production had barely begun when illness forced "A. P. G." to retire from the activities of his Group. His aim was to produce a variety of engines which did not cover the same power range with the same speeds, and to concentrate the production of each main type in a separate factory. He left other new designs in preparation by J. and H. McLaren, Limited, National Gas and Oil Engines, Limited, and Henry Meadows, Limited; but some years will doubtless elapse before the rationalisation problems have been solved, because, as in all similar organisations, the problems are of personalities as well as of a technical nature.

"A. P. G." was handicapped to some extent by the fact that he was not a technical man, and he found it difficult, therefore, to make decisions concerning designs in the face of expert and often conflicting advice. Another very big problem of which he was aware, but which he did not have time to tackle, was that of distribution. Probably the only man who has a clear conception of this problem in this country is Mr. Harry Ferguson, who sells agricultural engineering and not merely a tractor, a plough, or a harvester. A considerable proportion of the cost of distribution lies in the operation of sales forces in the various markets. For example, the Brush A.B.O.E. Group may spend something under a million pounds on distribution services, but their products probably require four times

this expenditure before they reach the end users. A good case can be built up to show that our distribution methods are medieval, and this much "A. P. G." understood. What he might have achieved in this field cannot be assessed, but, had he made the same progress in it as he did in the field of production, the prices of his group's products would have fallen considerably below those of their competitors, both in this country and overseas.

"A. P. G." always insisted that one of the greatest shortages in this country was that of brains. By this he meant that "there are too few people who take the trouble to use their brains in trying to overcome those problems with which we have to deal." It is to be hoped that the foundations which he has laid will serve to build up, not merely a successful group of companies, but a basis on which his ideas can become the guiding principles of British industry in times which are likely to be difficult, but rewarding, for the enterprising and courageous.

Yours faithfully,
ONE WHO KNEW HIM.

London, S.W.1.

February 13, 1953.

THE UNIVERSITIES AND INDUSTRY.

TO THE EDITOR OF ENGINEERING.

SIR,—May I begin a comment on your leading article on "The Universities and Industry," on page 178, *ante*, with a mild protest at your opening remarks? The idea that the universities are an "invisible overhead" on industrial costs is not entirely novel. On the contrary, all the professors of engineering of my acquaintance are constantly pre-occupied with the problem of how best to discharge their acknowledged responsibility to industry and to the community generally.

As you point out later in your article, there is no agreement on the best method of training engineers. After a period when American methods were being praised to the skies and our own roundly condemned, more reasonable views are beginning to prevail. It is admitted that the Americans themselves are by no means satisfied with their methods, even in their own context. Probably we shall settle down to the view that, within broad limits, the details of engineering courses are comparatively unimportant, so long as they stimulate the inquiring and critical mind.

It is of first importance, however, that the supply of good students be maintained, and, in this respect, the present situation has some disturbing features. The number of places in our engineering schools is now such that no student of honours calibre is refused entry, though he may not get into the university of his first choice. Indeed, this year, there are signs that professors are competing for students, who are being accepted long before they have sat for the examinations on which selection should properly be based. Many universities, including my own, are still in the process of expanding their engineering schools, and it is clear that the problem of filling these with adequate students will become increasingly acute. At the same time, the demand for good graduates grows each year as more and more organisations start graduate apprenticeship schemes.

On the other hand, the demand for places in the pure science departments seems to be unabated, and one is left with the impression that engineering is not getting its fair share of the output of the Science Sixth Forms of the grammar schools. In order to test this idea, I am going to make inquiries from headmasters in this area, but it would be interesting to know if my view is shared by others.

If engineering is really being starved of recruits, then the firms which now send information about themselves to engineering students are addressing the wrong audience. It is the schoolboy, just choosing his career, who needs information about industry to set alongside that given about pure science by his masters.

Yours faithfully,
J. A. LOUIS MATHESON,
Professor of Engineering.

University of Manchester.

February 13, 1953.

ELECTRIC-TRACTION BRAKING.—I.

By T. F. WALL, D.Sc., M.I.E.E.

ELECTRIC-RAILWAY systems may be distinguished according to the method used for supplying their power requirements, as follows: (i) those which obtain their supply from a stationary power-station by means of a third rail, or an overhead line; (ii) those which carry their own power-generator, which is usually some form of heat-engine; and (iii) those which take their power from a storage battery. For main-line railway systems with an overhead line or with a third-rail, direct-current, single-phase and three-phase current are all used. The three-phase system, however, has not achieved any great importance, on account of its poor control characteristics, and also owing to the complications introduced by the necessity of providing three lines. In Germany, the main-line electric railways use single-phase current at 15,000 volts, and this type of operation is also used in Scandinavia and Switzerland, as well as on some sections of the railways of the United States.

The frequency is selected by the requirements of commutation, as well as for reasons of pressure drops in the supply lines. In view of these considerations, the frequency chosen is usually 16½ cycles per second. For the operation of suburban-line express trains, direct current is used. The use of direct current for main-line trains is chiefly confined to Great Britain, France, Italy and the United States.

The departure from the normal frequency of 50 cycles per second for the supply of electric main-line railways has necessitated the provision of special power-stations, or of some type of converter station, in order to transform the power from 50 cycles to 16½ cycles per second. This conversion could be avoided if the normal frequency of 50 cycles could be agreed upon for railway-traction work, and a large-scale investigation has been carried out in Germany, for which a stretch of a track was used for operation at 50 cycles; 300 km. of urban and suburban systems in Hamburg and Berlin were also used for this experimental test. The results obtained showed that there is good reason to believe that a frequency of 50 cycles will eventually be employed.

A notable characteristic feature of electric railway traction is the excessively fluctuating and irregular nature of the motor load. The output power required from the motor, as defined by the tractive effort and the speed, is dependent on the physical features of the track, such as the curves and gradients. It also depends upon the running schedule, as well as on the periods of heavy load and of no-load. Under the drastic requirements of railway service, it is not sufficient for constructional specification purposes to know the continuous-load rating as would be the case with most stationary machines; it is necessary to know also what power the motor can develop momentarily, as, for instance, at starting. The most comprehensive survey as regards the power possibilities of a traction motor is obtained from a power-chart showing the relationship between the speed and the available power. The limitation to the power which the vehicle can support is determined by the adhesion between the rail and the wheel, and if this limit is exceeded, the wheel will slip. As far as may be reasonably possible, the power limit of the motor should correspond to the adhesive limit of the wheel and rail.

The chief advantage of electric-traction, as compared with other systems, is the high overload which electric-traction can sustain. This is particularly noticeable on those routes which include steep gradients. For express-train services, it is important that the motors should be able to operate at suitable

overloads, in order that acceleration may be obtained at high speed.

Of the two types of motor characteristics, namely, series and shunt, it is only the series motor which has become established as being suitable for traction work. The characteristic feature of the series motor is that the speed falls sharply as the load increases; and other advantages of this type of motor are its simple and reliable construction features, its large starting-torque, its insensitivity to the large pressure fluctuations which are characteristic of railway work, its high efficiency and the simplicity of its control system.

In principle, a direct-current series motor (see Fig. 1) could also be operated when supplied with single-phase current, since the direction of rotation will remain the same when the current is reversed. In practice, however, the pulsating magnetic flux in the massive iron structure of the poles and yoke would generate eddy currents of such magnitude that excessive heating would result with a correspondingly heavy loss of efficiency, as well as a throttling of the flux. It is, therefore, an essential feature of the alternating-current motor that the whole of its magnetic circuit must be laminated. In addition to these features, it is necessary to ensure that there shall not be too great a phase displacement between the current and the pressure vectors; that is to say, the power factor must not be too low. It follows, therefore, that the total inductance of the motor must be kept small, and this is achieved by neutralising the armature-reaction field; that is to say, the cross field, since this field is not required for power conversion. For this reason, compensating windings are provided on the magnet frame system. In this way, it becomes possible to eliminate the field-distortion in the air-gap, in consequence of which the length of the air-gap can be reduced to the limit of mechanical safety. By thus reducing the length of the air-gap, a relatively small number of field-coil excitation turns can be used, and a corresponding reduction in the inductance of the field circuit is obtained.

Dynamics of Electric Braking.—As a preliminary numerical example of the practical significance of electric braking, the following simple relationships will be considered. An electrically-operated vehicle of mass M kg., is running on a level track at a speed of V metres per second. If the vehicle is braked by a constant retarding torque, the relationship between the speed and the time can be derived as follows. When a constant braking torque is applied, the retardation will also be constant, so that the speed-time relationship will be given by the straight line ABC in Fig. 2, and at any given moment during the braking period the kinetic energy of the mass will be

$$\frac{1}{2} M V^2 \text{ joules,} \quad (1)$$

where V metres per second is the speed, and M kg. is the mass of the braked vehicle. If the magnitude of the kinetic-energy is plotted as a function of time, the resultant graph will be the parabola ADC , Fig. 2.

If, then, the total time for bringing the vehicle to rest is t_0 seconds, then in $0.8t_0$ second the speed will have fallen to 0.2 of its original value, so that the kinetic-energy still stored in the moving vehicle will be,

$$\frac{1}{2} M (0.2 V)^2 = \frac{1}{2} \times 0.04 M V^2 \text{ joules,}$$

that is to say, when the speed has fallen to 20 per cent. of its original value, the kinetic-energy will be only 4 per cent. of its original value. If, then, electric braking is applied to reduce the speed to about 22 per cent., and if the vehicle is then brought to rest by mechanical braking, the demand on the mechanical brake will be extremely small. If, however, mechanical brakes were used exclusively, the wear on the friction surfaces would be very great

and the cost of maintenance would be high; also the powder or dust resulting from the frictional wear might penetrate into the rotor structure and seriously impair the insulation.

As a further numerical example, the following conditions will be assumed: A train of mass G metric tons is travelling at a speed of v km. per hour. If it be assumed that the kinetic-energy of the rotating parts of the train is 25 per cent. of the kinetic-energy of translation, then the total kinetic-energy can be found as follows:

(i) The kinetic-energy of translation, viz., $\frac{1}{2} M V^2$ joules, where M kg. is the mass and V metres per second is the speed, and 1 joule = 1 watt-second = 0.737 ft.-lb.

Fig. 1.

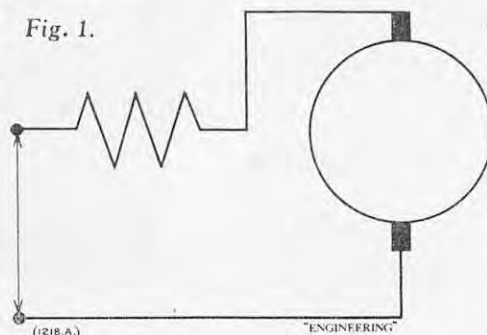


Fig. 2.

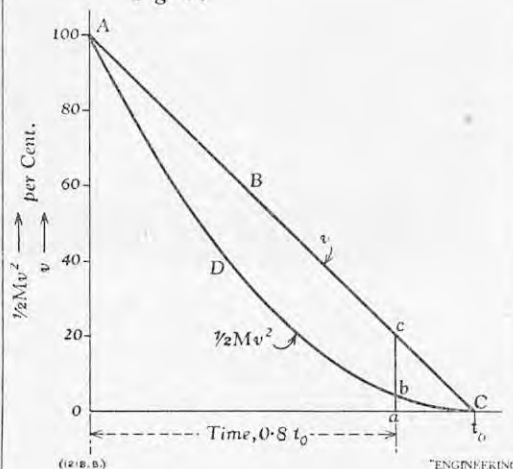
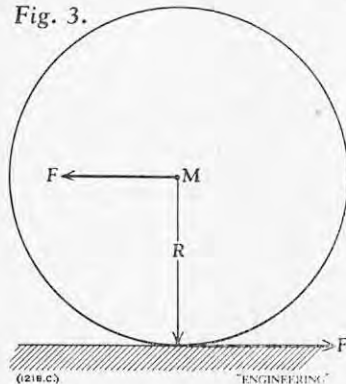


Fig. 3.



Then, since G metric-tons is equal to 1,000 G kg.m. and v km. per hour is $\frac{1,000 v}{3,600}$ metres per second, the kinetic-energy of translation will be,

$$\frac{1}{2} 1,000 G \left(\frac{10^3 v}{3,600} \right)^2 \text{ joules,}$$

which reduces to

$$\frac{1}{2} v^2 G 77 \text{ joules,}$$

or

$$\frac{1}{2} v^2 G \frac{1}{10^3} \frac{1}{3,600} \text{ kWh.} = 10.6 G v^2 10^{-6} \text{ kWh.}$$

(ii) The kinetic-energy of rotation is given as 25 per cent. of the energy of translation; that is,

$$0.25 \times 10.6 \times G \times v^2 \times 10^{-6} \text{ kWh.} = 2.65 \times G \times v^2 \times 10^{-6} \text{ kWh.}$$

The total kinetic-energy of the vehicle is therefore,

$$(i) + (ii) = 13.2 G v^2 10^{-6} \text{ kWh.}$$

If, for example, the factor G is 50 metric tons, and $v = 100$ km. per hour, then the total kinetic-energy of the moving train is,

$$13.2 \times 50 \times 10^4 \times 10^{-6} = 6.7 \text{ kWh.}$$

Tractive Effort.—The tractive effort F is the force at the rim of the driving wheel; that is, the total driving force of all the driving wheels. The tractive-effort F will operate as a drive against the adhesion of the rails, and an equal force F will act at the centre M of the wheel, as shown in Fig. 3. The driving torque τ will then be given by the expression

$$\tau = F \times R$$

where R is the radius of the wheel.

If n r.p.s. is the speed of the driving wheel, then the power developed will be,

$$W = \omega \tau = 2 \pi n \tau \text{ kg.m. per sec.,}$$

where $\omega = 2 \pi n$ radians per second, and τ is the torque in kg.-metre units.

Numerical Example.—Tractive effort $F = 23,100$ lb. = 10,600 kg. Diameter of wheels = 4 ft. 5.1 in. = 1.35 m. Radius of wheels $R = 0.675$ m., and speed of train $V = 28.5$ miles per hour = 12.6 m. per second.

Then,

$$2 \pi n R = 12.6 \text{ m. per sec.}$$

and

$$\omega = 2 \pi n = \frac{12.6}{0.675} = 18.8 \text{ radians per sec.}$$

The power developed will then be

$$\begin{aligned} W &= \omega \tau = 18.8 \times F \times R \\ &= 18.8 \times 10,600 \times 0.675 \text{ kg.m. per sec.} \\ &= 135 \times 10^3 \text{ kg.m. per sec.} \\ &= \frac{135 \times 10^3}{102} \text{ kW.} \end{aligned}$$

or,

$$\begin{aligned} W &= \frac{135 \times 10^3}{102} \times 1.34 \text{ h.p.,} \\ &= 1,770 \text{ h.p.} \end{aligned}$$

Consideration of the foregoing treatment will show that the following simple relationships will hold.

$$\left(\begin{array}{c} \text{Tractive effort} \\ \text{in kg. m.} \end{array} \right) \times \left(\begin{array}{c} \text{Speed of train} \\ \text{in m. per sec.} \end{array} \right) = \left(\begin{array}{c} \text{Power developed in} \\ \text{kg. m. per sec.} \end{array} \right)$$

or

$$\left\{ \begin{array}{c} \text{Horse-power} \\ \text{developed} \end{array} \right\} = \left\{ \begin{array}{c} \left(\begin{array}{c} \text{Tractive effort} \\ \text{in kg. m.} \end{array} \right) \times \left(\begin{array}{c} \text{Speed in} \\ \text{m. per sec.} \end{array} \right) \times 1.34 \\ 102 \end{array} \right\}$$

If the numerical data of the above example are inserted in this expression,

$$\text{horse-power} = \frac{10,600 \times 12.6 \times 1.34}{102} = 1,770.$$

REFRESHER COURSE FOR WORKS AND PLANT ENGINEERS.—The Extra-Mural Department of the University of Sheffield is holding a refresher course for works and plant engineers, at the University, from Monday, April 13, to Friday, April 17. The course is intended to be of particular interest to engineers employed in the iron, steel and kindred industries. Lectures, followed by discussions, will cover such subjects as the economics of fuel selection, combustion control, heat balances, compressed-air appliances and practice, furnace plant, waste-heat recovery, works handling problems in relation to fuel economy, and lessons of American and Continental practice. The fee for the course will be 2l. 10s. Accommodation is available in one of the University halls of residence at an inclusive fee of 6l. 10s. Inquiries should be addressed to the Director of Extra Mural Studies, University of Sheffield, St. John's, Crookes Valley-road, Sheffield, 10.

FAN PERFORMANCE TESTS.

A NEW code on fan performance tests,* prepared by the Fan Manufacturers Association, disposes of the previous limitation of the test methods to fans developing pressures not exceeding 1 lb. per square inch (27.74 in. of water), which was the limit set up by B.S. 848, because it has been found that there is really no sharply defined boundary between fans and compressors. Also, any machine may be used for pressures well above or well below 1 lb. per square inch, depending on its speed of operation and the density of the gas handled. This change makes it possible for a manufacturer whose products included a small proportion of high-pressure machines, to use the same test methods and apparatus throughout the test methods adopted are suitable for fans in which the pressure rise exceeds 28 in. w.g. The code contains methods of correction for compressibility for use where the pressure rise exceeds 10 in. w.g., and the corrections cover a range up to 200 in. w.g. (7 lb. per square inch). A chart is included for the correction of the efficiencies of high-pressure fans on an adiabatic basis. The definitions of terms relating to fans, pressures and instruments have been revised to bring them into line with accepted terminology. A distinction is made between axial fans and propeller fans, and terms such as "cased" or "open" fan have been dropped. Under "Fan Performance," the term "intake volume" has been introduced to define the measured volume and avoid ambiguity, since the volume flow at outlet differs from that at the inlet, due to compression of the air. The use of the term "total head" has also been dropped in favour of "fan total pressure."

The instructions on measurement and computation are basically the same as in B.S. 848:1939, although the information has been re-written in parts and rearranged to meet present needs. In the section dealing with the division of rectangular air-ways into areas for measurement purposes, the code gives two separate tables applying to the use of a pitot tube or anemometer. The information on measuring average static pressure by the use of side tappings is dealt with in detail, and the method of finding intake volume is extended to include reference to differential pressures produced on either side of an orifice. Included in this part of the code are the details of the instruments to be used for measuring air flow; a clause on speed measurement is also given. General instructions for performance tests are dealt with, and a statement of fan laws is given, including formulae for calculating the performance and size of geometrically similar fans from those of a known machine. In the clause on tolerances, a limit for maximum power absorbed is given and it is stated that the tolerances apply only when the eventual fan drive operates at the specified design speed. A table of the test methods required for different types of fans is given to assist selection of the correct method. B.S. 848 provided for testing axial-flow fans on the outlet side, but this proved inaccurate because the fan performance was altered by the presence of the air straighteners required for obtaining satisfactory readings. The method now given is for testing on the inlet side, employing an entry nozzle, which gives a more reliable and simpler method of volume measurement. The nozzle recommended has the same dimensions as that proposed in the forthcoming revision of B.S. 726, the title of which is to be "Measurement of Air Flow for Compressors and Exhausters." The test method given for small fans, where pitot-tube traverses for volume measurement would be unsatisfactory, employs a duct on the inlet side of the fan, incorporating an orifice plate in accordance with the rules laid down in B.S. 1042:1943 (Flow Measurement), together with an auxiliary supply fan to overcome the resistance of the test system. The volume flow is calculated from the pressure differentials on either side of the orifice. This method of volume measurement provides for testing fan performance under free intake and discharge conditions as well as against a resistance.

* *Fan Performance Tests*. Code No. 3. Fan Manufacturers' Association, Limited, Copthall House, Copthall-avenue, London, E.C.2. [Price 9s. 6d. net., 10s. post free.]

H. M. AIRCRAFT CARRIER "HERMES."

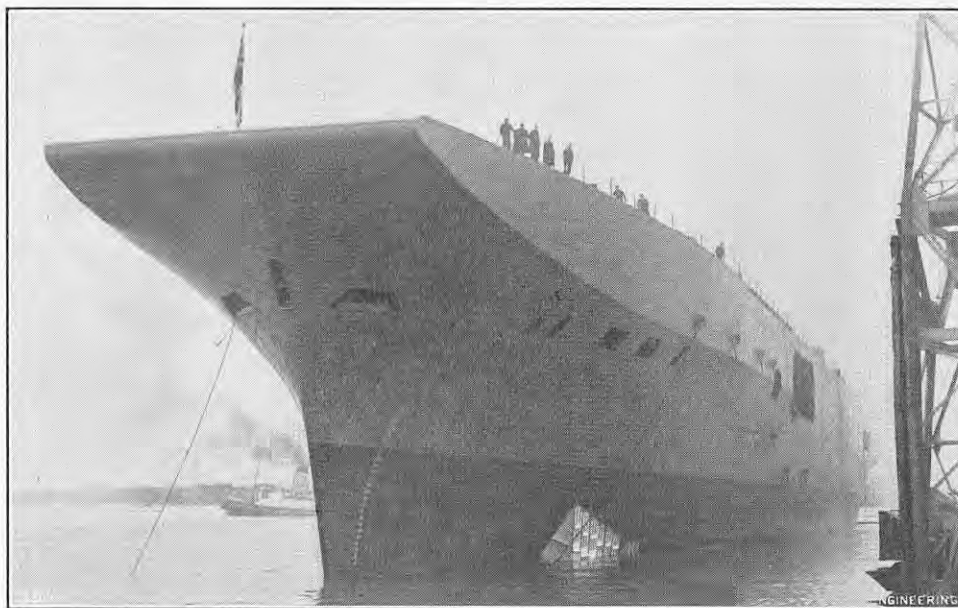


FIG. 1. VESSEL AFLOAT.

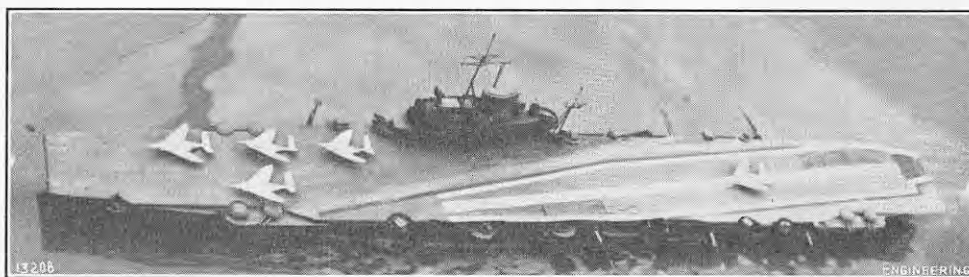


FIG. 2. MODEL SHOWING ANGLED DECK.

H.M.S. "HERMES".

THE light fleet aircraft-carrier Hermes, illustrated above, in Fig. 1, was launched at the Barrow-in-Furness shipyard of Vickers-Armstrongs Limited on Monday, February 16, the naming ceremony being performed by Mrs. Churchill, the wife of the Prime Minister. H.M.S. Hermes is the tenth naval vessel and the second aircraft carrier to bear the name, her predecessor having been sunk by the Japanese in 1942. The present Hermes, which will have a displacement of 18,300 tons, was laid down in June, 1944, but work on her was suspended for some years after the cessation of hostilities. She has now been largely redesigned to incorporate the most modern equipment for launching and handling aircraft, including the new "angled deck," a model of which is shown in Fig. 2. With this layout, the aircraft will fly on at an angle of about 8 deg. to the centre line of the ship instead of in line with it. The flight deck of a carrier is divided into three main areas: at the after end are the arrestor wires which are hooked by an aircraft when coming in; forward of these is the barrier area, in which a machine is stopped if it fails to hook the arrestor wires; and at the forward end is the deck park and also the launching mechanism. With the approach made at an angle, there is less need for the barrier area, as, should an aircraft fail to hook the arresters, the pilot opens up to full throttle and flies on and over the side of the ship at an angle, to make a further attempt; emergency barriers are provided, however, to halt an aircraft which has had its hooking mechanism deranged or shot away. The new layout, therefore, by virtually dispensing with the barrier area, makes more space available to take the "pull-out" of the arrestor wires and for parking, an important consideration as aircraft become progressively faster and larger.

A novel feature, so far as the Royal Navy is concerned, is that a side lift is to be fitted, to enable aircraft to be transferred from the hangar

to the flight deck while others are flying on or off. This device has been in use for some time in the United States Navy, where it is known as a "deck-edge elevator." The catapults are of the steam-operated type, in which a hook attached to a piston is driven along a slotted cylinder supplied with high-pressure steam. The method adopted to keep the slotted cylinder steam tight is the invention of Commander (E) C. C. Mitchell, O.B.E., R.N.V.R., of Messrs. Brown Brothers and Company, Limited, Edinburgh, who designed and built the prototype catapult fitted to H.M.S. Theseus, which has been demonstrating it to the United States naval authorities. This type of catapult is said to give a steadier acceleration than the pattern formerly used, and to be more tolerable physiologically, although the rate of acceleration is actually greater than with the conventional types, so giving a higher flying speed at the moment of taking off. The demand made on the steam supply is considerable, but it is not sufficient to interfere with the normal operation of a ship, even when used rapidly for successive launchings. Another advantage is that its power is such that aircraft can be launched while the carrier is stationary, so rendering it unnecessary to steam into the wind for long periods. H.M.S. Hermes is the last of four ships of her class. She has an overall length of 741 ft. 6 in. and a beam of 90 ft. Her main machinery is to consist of geared steam turbines by Vickers-Armstrongs Limited, and her speed will be about 30 knots.

TRANSPORT SERVICES TO NORTHERN IRELAND.—Discussions have recently taken place between the Northern Ireland Minister of Commerce, Mr. W. V. McCleery, and the chairman of the British Transport Commission, Lord Hurcomb, concerning the sea-ferry service between Larne and Stranraer. The proposals discussed involve the provision of two new additional ships and improved port facilities at both terminals. A suggestion made by British Railways (who operate the service) to transfer the Northern Ireland terminus from Larne to Belfast is to be re-examined, following representations made by local authorities at Larne.

OPERATING EXPERIENCES WITH TWO GAS-TURBINE LOCOMOTIVES.*

By A. W. J. DYMOND, B.Sc., M.I.C.E.,
M.I.Mech.E.

THE purpose of this paper is to refer briefly to some of the problems which emerged in the design of two gas-turbine locomotives for this country, and to give some details of the experience gained since they were put into service. The locomotives are the outcome of a decision by the directors of the former Great Western Railway to consider "... plans for the construction of a gas turbine locomotive based upon the experience obtained in connection with jet propulsion. . . ." The first practical result of this decision was a project jointly sponsored by the railway and the Metropolitan-Vickers Electrical Company, Limited, to build a locomotive incorporating a gas-turbine whose design and layout followed closely the aircraft jet engines developed by that firm. While preliminary discussions on this project were proceeding, the then chief mechanical engineer, Mr. F. W. Hawksworth, paid a visit to Switzerland to inspect the gas-turbine locomotive which had been designed and built for the Swiss Federal Railways by Brown, Boveri, of Baden, and S.L.M., of Winterthur. An order was placed with British Brown-Boveri, shortly after Mr. Hawksworth's return to this country, for a similar machine of slightly greater power.

Though the projects were designed and built to the requirements of the chief mechanical engineer, no influence was brought to bear from the railway side as to the details of the gas-turbine cycle, nor to the layout of the gas-turbine machine; neither was any considerable pressure exerted on the transmission and chassis design. In the case of the Brown, Boveri engine, which was the first to be delivered, most of the fundamental development work had been done on the first locomotive produced for the Swiss Federal Railways. Consequently, the design for the Great Western Railway followed broadly similar lines. The layout of the gas-turbine unit, main generator and controls was very little different from the first machine the firm had built, while the transmission and bogie design, though differing from that of the first engine, was very like bogies produced by S.L.M. for electric locomotives for the Swiss Federal, Berne-Loetschberg-Simplon and Rhaetian Railways. In the case of the Metropolitan-Vickers engine, while the essential characteristics of the gas-turbine unit were based on aircraft practice, it was necessary to tailor it to the fundamentally different needs of railway practice. At the same time, the high output envisaged for the prime mover involved special problems in bogie design, resulting in a proposal for an entirely new design of bogie suspension and attendant novelty in the accommodation for traction and braking forces. These factors, together with others, resulted in delivery of the Metropolitan-Vickers engine some months after the Swiss machine; the one being delivered in February, 1950, and the other in December, 1951.

No attempt will be made, and no comment implied or expressed, to compare the two locomotives with each other. So far as facts lead to obvious conclusions, they will speak for themselves. Another comment which should be made in this context is that, at the time of writing, the Swiss locomotive has been in service during nearly three years, and has completed 122,000 miles, whereas the Metropolitan-Vickers locomotive has been in service nearly one year and has run 42,000 miles; neither has yet had a general overhaul.

THE BROWN, BOVERI LOCOMOTIVE No. 18000.

The Brown, Boveri locomotive, after having had a few runs in Switzerland, was shipped to this country and was towed to Swindon, where it arrived on February 5, 1950. It first ran under its own power on British metals on February 13. From this date until May 19, 1950, when the locomotive hauled its first loaded passenger train,

many trips were run for the dual purposes of adjusting controls, etc., and training staff. During this period, and up to September, 1950, a Swiss engineer was permanently on the locomotive, and his services were supplemented by one or more additional members of the firm's staff. The period of initial adjustment and training was unfortunately extended by some weeks owing to a failure of the blading of the compressor on March 9, 1950, when hauling a train of empty stock between Swindon and Bristol. The failure, which consisted of the shedding of the first three rows of blades in the compressor, was adjudged to be due to "flutter," caused by some differences, as compared with the Swiss Federal locomotive, in the nature of the flow of the ingoing air, due to the incorporation at the intake of water-jet nozzles provided for blade cleaning.

The new blading fitted at the repair was equipped with damping rings, and since that date the compressor has given completely trouble-free service. After about a week's service on passenger trains between Paddington and Swindon, following the initial run on May 9, the locomotive went into service between Paddington and Plymouth on May 22. It continued in this service until June 14, taking the 3.30 p.m. from Paddington on one day, returning with the 7.15 a.m. from Plymouth on the following day. This period was interrupted for four days at the beginning of June while a temporary lining for the combustion chamber was replaced. Subsequently it has been the experience that these liners have needed frequent changing, and a further comment will be made when summing up the whole experience. On June 12, 1950, a series of trials was arranged to ascertain the maximum trailing load that could be safely hauled up the gradient from Plymouth to Hemerdon in South Devon. It was assumed at that time that this should be fixed at the maximum load that could be restarted on the steepest part of the bank (i.e. a 1 in 42 rising gradient) and hauled to the top without overheating the electrical machines. The trials were rather disappointing in some ways, and the locomotive failed to restart with 350 tons gross trailing load, though on a previous occasion 290 tons had been restarted. A successful run was made without stopping with a load of 400 tons, the speed falling to 10 m.p.h. at the summit after entering the gradient at about 50 m.p.h. The generator and the traction motors were examined and there was no evidence of excessive heating.

It was therefore a sad blow when the locomotive failed while hauling a passenger train on June 13, due to serious defect in No. 2 traction motor. This was due to a loose binding coil thrashing around among the brushes, completely wrecking these and the ends of the field coils on the stator, and subsequently being caught between the armature and the pole-pieces and being reeled right through the machine. Despite considerable damage to the windings, however, no sign of overheating was apparent, all the damage being entirely mechanical. The defective motor was removed for repair and the locomotive put into service temporarily with three motors. In this state a demonstration run took place from Paddington to Westbury via Newbury, returning via Swindon. Following this, the engine did a few days duty with passenger trains between Paddington and Swindon, at the end of which it was withdrawn for the repaired traction motor to be installed. At this date (July 15, 1950), the locomotive had some 8,500 miles to its credit. After its restoration to service, still on the Swindon run, it ran without further interruption until towards the end of August, and in the last week of that month was restored to the Plymouth service, doing the round trip in two days as before. This continued until the end of October; it was then necessary to withdraw the engine for work on the train-heating boiler. This work unfortunately precluded further service until the end of January, with the exception of a few days on the Paddington-Plymouth service early in December. The locomotive had covered 23,200 miles and the turbine had given 530 hours. During this period, apart from the major incidents referred to, there were various stoppages due to smaller defects, such as leaking roof tank, broken details in thermostats, oil-pump bearing overheated.

Ignoring the heavy stoppages due to the traction-motor failure and the difficulties with the train-heating boiler, the only serious items concerning the gas turbine as such were the compressor-blading failure and the frequent necessity to change the combustion-chamber liner. Considering the novel nature of the locomotive, this constitutes a fair record for the first year's working.

During the second year's working the only serious stoppage was a disastrous fire which broke out in the heat exchanger, completely wrecking the whole unit. This was deemed to be due to heavy accumulations of soot in the interior of the tube nest, which were ignited by a short period of high-temperature running followed by a lay-by period. A new heat exchanger was quickly built in Switzerland and fitted to the locomotive immediately on its receipt in this country. In order to minimise future risk of such fires, the access doors to the interior of the heat exchanger were increased in size to permit more perfect washing-out of the interior. The combustion-chamber lining had to be changed on a number of occasions, being replaced as convenient by repaired liners or by new spares. Other minor troubles also occurred to the light-fuel tank, the Diesel-engine radiator, some of the thermostats and the heavy fuel-oil pressure system.

During this year, until the end of April, the engine was kept on short runs between Paddington and Swindon. From the beginning of May it worked a daily trip from Paddington to Bristol and back, and this was supplemented at the end of the month by an additional daily trip to Swindon and back, the weekly mileage then reaching just over 2,200 miles. The heat-exchanger fire put it out of service until the middle of August, when it again took up the 2,200 miles weekly schedule between Paddington and Bristol and Swindon. It was then put on a series of runs between Paddington and Plymouth for dynamometer-car testing. The engine continued on the Paddington-Bristol-Swindon schedule throughout the remainder of the second year of its operation, and had completed 72,590 miles up to February 2, 1952. The turbine hours to that date aggregated 1,913 hours. Throughout the third year of running, to the time of writing, the engine continued on the same schedule. It had to be withdrawn from traffic, however, in mid-September, owing to slight cracking in the first and second rows of blades of the turbine stator. These cracks, of which there were two or three on a blade, extended from the trailing edge across the width of the blade by amounts varying up to half the width. Immediate arrangements were made by the builders to manufacture replacements, and at the time of writing the engine was in the shops for the reblading to be carried out. The cause of this cracking was attributed, at the time of writing, either to bad temperature distribution at the turbine inlet, due probably to an excessively long flame, or to delayed ignition. The blades exhibited no evidence of scaling. As the enforced stoppage caused by this defect coincided very nearly with the programmed date for the installation of a larger train-heating boiler, opportunity was taken to do this at the same time. The mileage at the date of the stoppage was 122,118, and the total turbine hours had reached 3,296 hours.

Maintenance.—There have been three major incidents since the locomotive went into service: the compressor failure, the traction-motor failure and the heat-exchanger fire. Each has been very efficiently repaired by the firm and the component has given no further trouble. The most persistent trouble has been the short life of the combustion-chamber lining. In all, seven linings have been made and fitted. The first and second were of $\frac{1}{8}$ -in. alloy steel (25 per cent. chromium, 20 per cent. nickel) and gave only a single life each, one of 215 hours and the other of 100 hours. Subsequently, liners were manufactured of thicker material (20 per cent. chromium with titanium), the latest $\frac{1}{4}$ -in. thick, and most of these have given additional service after repair. One aggregated over 1,000 hours in four lives, and another 980 hours in three lives. The distortion and wasting which have characterised this liner deterioration have pointed consistently to the difficulty of ensuring satisfactory combustion of residual fuel over the entire range of operation. Development work by Brown, Boveri and the

* Paper presented to the Institution of Locomotive Engineers, in London, on February 18, 1953. Abridged.

Railway Executive, in conjunction with the Shell Petroleum Company, is being pursued.

On the subject of the train-heating boiler, whose inadequacies and difficulties have been fruitful of considerable lost time and restriction in use, little need be said in this paper. The problem is not peculiar to gas-turbine locomotives, and its solution appears always to follow that recently adopted in this instance—the installation of a larger boiler. The locomotive has been stabled throughout the period at Old Oak Common, and has had servicing each Sunday. This includes washing out compressor and heat exchanger at approximately 600 hours and 200 hours respectively. The wash-out is carried out with a detergent solution in the compressor and with plain water in the heat exchanger.

(To be continued.)

COATING ALLOY FOR PETROL-ENGINE POPPET VALVES.

THE use of leaded fuel and other measures to increase efficiency in aircraft internal-combustion engines impose severe conditions on the poppet valves, and present-day flight schedules demand complete reliability and a maximum period between overhauls. To a lesser extent, these conditions apply also to modern engines in land vehicles, where efficiency and long hours of hard and trouble-free running are expected. Many of the alloys used for valves, valve-seat faces and for coating the heads of valves, eventually fail from lead oxybromide attack when the valve temperature exceeds a critical figure. Alternatively, the valves may fail as a result of mechanical weakness at the elevated temperatures encountered, or from the effects of a combination of both factors. During the past few years Rolls-Royce have developed and introduced into flying services a new coating alloy which is now being used regularly on valves in civil-aircraft engines. It is claimed that the use of the alloy on the valve head and seating has increased the period between scheduled overhauls to 1,000 hours. It is added that even after this time only a small proportion of the valves are withdrawn from service.

The new alloy is known as C.26 and the manufacturing and marketing rights have been acquired by Deloro Stellite Limited, Highlands-road, Shirley, Birmingham. It has a nickel base and contains chromium, aluminium and molybdenum; other minor constituents are added as has been ascertained by an investigation of the alloy systems of the four main constituents. Although hard, the alloy is stated not to be brittle under repeated impact, and it does not crack radially under the time/temperature stresses imposed by high-power engines. While the temperatures of inlet valves are somewhat lower than those of exhaust valves, the new alloy has been adopted in their case also, owing to its excellent resistance to the abrasive action of the products of combustion of leaded fuel. The alloy is claimed to possess excellent resistance to oxidation at all temperatures up to 1,250 deg. C., and, provided that the iron content is maintained below 1 per cent., it is highly resistant to lead oxide and lead oxybromide at temperatures up to 800 deg. C. The melting range of the alloy is from 1,280 to 1,360 deg. C., and it is deposited on to engine valves by means of an oxy-acetylene torch. The alloy has a fine structure and fracture, and is machinable without undue difficulty. At 20 deg. C., it has an ultimate tensile strength, in the aged condition, of from 60 to 70 tons per square inch, and at 800 deg. C., of from 42 to 48 tons per square inch. The diamond-pyramid hardness of the alloy in the as-cast state, under a 30-kg. load at 20 deg. C., is 390, and, after ageing for 16 hours at 700 deg. C., from 490 to 525. At 600 deg. C., the hardness is given as 420, at 700 deg. C., as 395, and at 800 deg. C., as 350. These last three hardness figures are the average of five impressions, each of 15 seconds duration, obtained with tungsten carbide and using a new pyramid for each test. Under an alternating-bending test, in contact with lead oxybromide at 700 deg. C., a safe stress of ± 12.8 tons per square inch was obtained for 40×10^6 reversals.

LABOUR NOTES.

A SETTLEMENT of the wage dispute in the coal-mining industry took place at a meeting in London between the National Coal Board and officials of the National Union of Mineworkers on February 12, as a result of which miners employed on a day-wage basis are to receive an extra 6s. a week. It was arranged that this rise in pay should take effect as from last Monday. About 320,000 men are expected to benefit from the concession, which, it is estimated, will add approximately six million pounds to the Board's annual wage bill, equal to an increase of about 6d. a ton on the price of coal at the pithead. The new national minimum wage rates are 6l. 7s. 6d. a week for miners employed on surface work and 7l. 6s. 6d. a week for those working underground. The increase will not apply to some 17,000 day-wage men whose wage rates were already well in excess of these amounts.

On its side, the National Union of Mineworkers agreed to recommend that its members should continue the working of voluntary shifts on Saturdays during next winter and also, where local arrangements can be made, during the coming summer. In addition, the union pledged itself to co-operate with the Board in securing improvements in production and efficiency in the industry, and to take part in joint committees for the improvement of relationships between managements and miners, to be set up in each of the Board's eight divisional areas. It was also agreed that the two bodies should collaborate in a campaign for the instruction of all sections of the industry in its economy and organisation.

No doubt these promises by the union had much to do with the widening of the Board's wage offer. The negotiations on the claim had been in progress for some months and on more than one occasion seemed likely to break down completely. The Board offered an increase of 1s. a shift (equal to 6s. a week) for a limited number of day-wage men and, later, when that was rejected by the union, put forward an alternative offer of 8d. a shift (equal to 4s. a week) for all day-wage men. After refusing this offer, likewise, the union held a ballot throughout the coalfields on the question of re-opening negotiations. The ballot resulted in a vote of 447,000 in favour of a new approach being made to the Board, to be accompanied by an offer of Saturday work, and of some 226,000 against. Scotland, South Wales, Northumberland, Cumberland and Somerset were the areas where voting against Saturday working was heaviest. Saturday working in the past has sometimes had to be abandoned because, although there was a good attendance of day-wage men, there were too few pieceworkers present to allow work at the coalface to proceed. This will presumably be one of the earliest problems to be tackled by the new joint committees.

Increases of from 7s. 6d. to 10s. a week were granted to draughtsmen in the engineering and shipbuilding industries by an award of the Industrial Disputes Tribunal made on February 11. The Tribunal approved increases of 7s. 6d. a week for draughtsmen aged 21 and 22, of 9s. a week for men aged 23 and 24, and of 10s. a week for those aged 25 and above. Qualified tracers aged 19 and over will receive an extra 6s. 6d. a week. About 30,000 members of the Association of Engineering and Shipbuilding Draughtsmen will benefit from the award, which will come into operation immediately.

The original demands of the Association were presented to the Engineering and Allied Employers' National Federation on November 25, last year. Increases of 10s. a week for members aged 21, with proportionate advances for older men up to the age of 25, were then demanded. Minimum rates of pay at that time, for draughtsmen aged 21, were 6l. 14s. in the provinces and 6l. 19s. in London. The two sides were unable to come to terms, however, and the dispute was referred to the Tribunal a short time ago for arbitration.

Preliminary consideration was given by the economic committee of the Trades Union Congress General Council last week to the memorandum which it is suggested the General Council should submit to Mr. R. A. Butler, the Chancellor of the Exchequer, in connection with the forthcoming Budget. It is understood that, among the proposals under review by the trade-union leaders, are recommendations that there should be no reduction in food subsidies or in the social services, and that post-war credits should be refunded at earlier ages than at present. Other suggestions are that the purchase tax on household goods and other necessities should be abolished or much reduced, and that income tax should be maintained at its present level. Any memorandum presented to Mr. Butler by the General Council seems certain to emphasise the importance of preventing further rises in the cost of living. It may be recalled that, prior to the 1952 Budget, the General Council asked for an increase of income tax, higher subsidies on food, and the institution of a tax on capital gains.

A strike of some 2,000 members of the National Union of Vehicle Builders, employed by the Austin Motor Company, Limited, at their Longbridge works, Birmingham, was called on Tuesday by the union's district committee. The dispute is stated to be due to the firm's refusal to re-engage a former senior shop steward, who was among 700 employees discharged on redundancy grounds last September. More than 17,000 persons employed at these works are likely to be thrown out of work.

Arrangements were made earlier this week for wages in the engineering and shipbuilding industries to be discussed at some length at the quarterly meeting of the general council of the Confederation of Shipbuilding and Engineering Unions, which took place at York on Wednesday last. It was announced on Wednesday that a general statement on wages in these industries would be made at the council meeting by Mr. H. Brotherton, the chairman of the Confederation, and that there would probably be demands for the presentation of new wage claims to the employers. Increases of 7s. 4d. in the engineering industry and 7s. 6d. in the shipbuilding industry were granted last November and these were followed shortly afterwards by suggestions in the Amalgamated Engineering Union that a further claim should be made. It was decided, however, that no action should be taken until after Wednesday's meeting of the Confederation's council.

A number of fresh demands on the engineering employers were put forward by the "engineering and allied trades shop stewards' national council" at a conference last week-end. This unofficial organisation decided to press for an extra 15 per cent. on all wages, the immediate introduction of a 40-hour week, and a three-months' time limit for the negotiations. It also demanded that redundant employees should be retained and that overtime for each operative should be strictly limited to 30 hours a month. As an alternative to a claim for a general wage increase, the National Union of General and Municipal Workers is in favour of priority being given to negotiations for a new wage structure for the engineering industry.

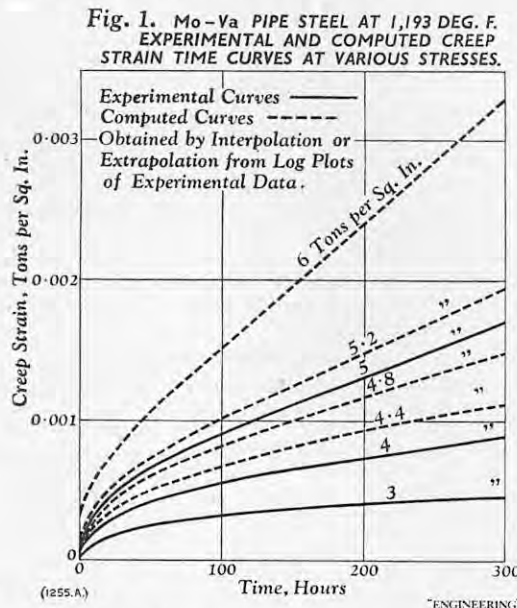
Assurances of the Government's intention to maintain full employment in the iron and steel industry were given by Mr. Duncan Sandys, the Minister of Supply, during a debate in the House of Commons on February 12, on the committee stage of the Iron and Steel Bill. He stated that full employment would be affected by prices and developments in the industry. The Bill gave the Government power to intervene, and override the Iron and Steel Board in the national interest on questions of price fixing. If developments in the industry in a particular locality caused unemployment, the Government could use other powers to fulfil its policy of full employment. Earlier, Mr. A. R. W. Low, the Parliamentary Secretary to the Ministry of Supply, had declared that the best contribution that the Board could make to the maintenance of full employment was to be successful in helping the industry to produce efficiently at prices which were competitive in world markets.

CREEP PROPERTIES OF STEELS FOR POWER PLANTS—II.*

By A. E. JOHNSON, D.Sc., M.Sc.Tech.,
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A.M.I.Mech.E.

In Part I of this report † it was concluded that the analytical treatment put forward by Dr. R. W. Bailey was not completely adequate (at any rate, in its original form) to represent the experimental results, particularly at the highest stress and temperature peaks involved. Consideration has since been given to the possibility of providing alternative means of analysis; if possible, upon some fundamental basis. It has been concluded, reluctantly, that the present knowledge of creep of steels under generalised conditions of stress and temperature is insufficient to provide such a fundamental basis; nevertheless, the work that is being done on general loading systems may provide an answer in due course.

Two lines of approach to the problem are, however, still available, the first being to extend the applicability of analysis of the Bailey type by possible generalisation; and the second, to examine whether some reasonably simple means can be found of deriving the creep behaviour in cyclic tests directly from the normal families of creep curves.



With regard to the first alternative, it will be recalled that Dr. Bailey regarded the exponents of his equation as two constants only in restricted stress and temperature ranges, and, for example, anticipated changes of values in the tertiary creep range. Unfortunately, the conditions corresponding to the high stress and temperature peaks in the current problem are those of a transition state between primary-secondary and fully-developed tertiary creep and, while differing exponent values may be admitted in the two stages, the problem of how to combine them to satisfactorily represent a transition region may be of some complexity. It is possible that, if the Bailey equation be generalised to give the form

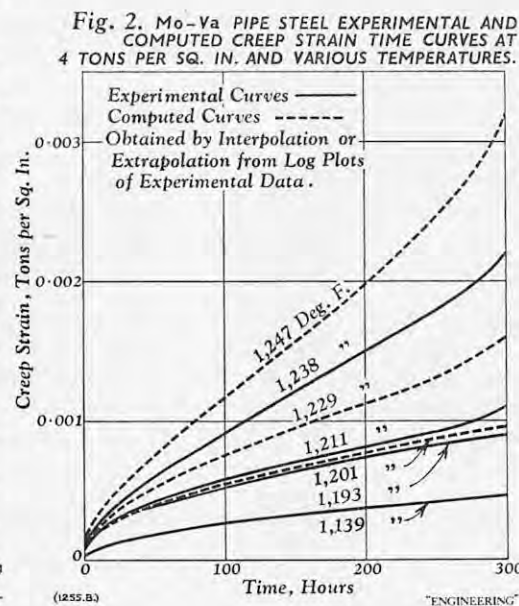
$$x = [B_1 (p_1 + 1)]^{\frac{1}{p_1+1}} \frac{1}{f(p_1+1)} \frac{a_1}{e^{(p_1+1)}} \theta^{\frac{1}{p_1+1}} + [B_2 (p_2 + 1)]^{\frac{1}{p_2+1}} \frac{1}{f(p_2+1)} \frac{a_2}{e^{(p_2+1)}} \theta^{\frac{1}{p_2+1}}$$

where the suffix 1 refers to primary-secondary and 2 refers to tertiary creep, such an equation, with suitably-chosen constants, might satisfactorily represent the transition region. However, this presupposes a complete knowledge of the primary-secondary and tertiary creep characteristics of the material which is not available in the present case, and might only infrequently be available to designers.

Data of this nature are necessary in any case to establish that such superposition methods of use of functions of the type indicated are justified in the case of normal constant-stress and temperature families of creep curves. Accordingly, apart from the relative inherent complexity of the treatment, it was felt that the bases of such an approach were insufficiently established to make further exploration along these lines remunerative, and a consideration of the direct use of the creep curves themselves seemed likely to be more profitable, though the methods arising therefrom might be of a purely empirical nature.

DIRECT USE OF NORMAL STRESS AND TEMPERATURE CREEP STRAIN TIME CURVES.

One means of using normal creep curves directly to estimate behaviour in cyclic tests, which has occurred to several investigators, is to take the various curves concerned in the cycle, divide the total strain by the total period of test, obtaining average rates of strain, and combine these to represent the cyclic behaviour by simply multiplying the appropriate rates by the proportionate cyclic times during which the particular stress or temperature condition prevailed and adding to obtain the complete cyclic condition. Obviously, this particular means would be expected to be more accurate at stress and temperature levels where a relatively prolonged linear portion of the creep strain time curves was exhibited.



This procedure has been used by the Americans Guarnieri and Yerkovitch,* who expressed a total cyclic creep ϵ in time t by the relation $\epsilon = V_o(kt) + V_n(1 - kt)$ where V_o and V_n were determined as the ratio of total creep to total time for overload and normal stresses, respectively, and kt and $(1 - k)t$ are the respective time fractions for which overload and normal stress were applied. This method is considered later in relation to available data.

Apart from methods involving averaging of data, it is obvious that, in looking for reasonable means of combining an overload or excess temperature curve with a basic stress curve, two predominantly important matters to be considered are, firstly, the nature of the stress increase and decrease steps from normal to overstress or excess temperature curve; and, secondly, the modification of portions of the overstress or excess temperature curve and the normal condition curve corresponding with successive part cycles of the cyclic test by reason of the fact that they have been preceded by part cycles of the normal condition or overstress or excess temperature curve, respectively, instead of by the portion of the creep curve of which they normally form part.

On the matter of the stress increase or decrease steps, it is possible to say that the unloading action is completely anelastic and balanced in a con-

sideration of total strain by an equal amount of anelastic loading strain of reversed sign. Again, experience has shown that, in raising the stress or temperature of the creep curve for intermittent periods, plastic strain and irrecoverable creep occurs mainly on the first increase, and in subsequent increases diminishes relatively rapidly, or disappears altogether. Thus, although in the cyclic tests discussed it may not be possible to make an explicit assessment of this factor, it would seem that some likely limits to the behaviour can be set.

In regard to the second factor mentioned, the effect here is even more obscure, but again some reasonable bounds may be suggested to the behaviour. Firstly, one obvious extreme is to make the assumption that neither curve affects the other; the sum total of cycles of a cyclic test would then be represented by simple addition of the total strain in part of the total time of the overstress or excess temperature curve to the corresponding quantity for the normal condition curve. Consideration of available data shows, however, that such a proceeding gives strains much too high in the vast majority of cases, and therefore it may be dismissed.

Some appreciable effect of one test on the other must therefore be allowed for, and, since this effect must be expressed in terms of strain hardening, it can obviously be most easily represented by shift of the cyclic part-period along the axis of increasing time. In the absence of anything like precise information, two reasonably likely possibilities suggest themselves, indicating two differing degrees of effect.

In the first place, a method in which considerable strain hardening of the curves may be expressed might be obtained by combining, for the cyclic curves concerned, the first part-period from the normal condition with the second part-period from the upper stress or temperature conditions, the third part-period from the normal conditions with the fourth part-period from the upper stress or temperature condition, and so on. (This is referred to later as Method 1.)

Alternatively, complete cycles of the cyclic test may be compounded by sums of odd part-cycles of each of the overstress or excess temperature and the normal curves; thus in a 24-hours cycle of 50 per cent. period overstress, the complete cycles would be 12 hours of each of the periods 0 to 12, 24 to 36, 48 to 72 hours, etc., for each curve. This method envisages appreciably less modification of the upper stress or temperature curve than the first method. (This is referred to later as Method 2.) These arrangements of the cycles are, of course, purely arbitrary, but they seem likely to be not too remote from actual fact.

The two variations of cycle should now be considered in relation to the second factor of stress-raising or temperature-raising increment. The first method obviously assumes anelastic loading throughout the duration of test, while the second method virtually assumes that the whole of the plastic and irrecoverable creep shown in the first part-cycle of the virgin curve for overstress or excess temperature is included in the final total strain summation, but that, thereafter, loading is anelastic.

These two methods, apart from expressing varying degrees of strain hardening effects of the two varieties of part-cycle on each other, also incorporate not unreasonable bounds for the effect of stress or temperature increase. The writers accordingly suggest that it is worth while to examine the degree of application of such methods of coupling the two curves in question to available experimental data. In the following paragraphs the American averaging method is termed Method 3.

THE USE OF METHODS 1 TO 3.

Ideally, to examine the usefulness of the above-mentioned methods, a complete set of normal stress data, at constant stress and variable temperature, and vice versa, is necessary, since cycles of combined stress and temperature variation as well as simple stress or temperature variation are involved. However, such complete data were not available for any material concerned, but, in the case of the Mo-Va pipe steel, data at several stresses and one temperature, and also at several temperatures and one stress, were available (Figs. 1 and 2). From

* Communication from the Mechanical Engineering Research Laboratory. Abridged.

† Part I appeared on pages 25 and 58, ante.

* "The Influence of Overstressing on the Creep Properties of Several Heat-Resistant Alloys." A.S.M.E. preprint No. 72 (1952.)

these data, by interpolation or extrapolation, it was possible to construct creep curves corresponding to the overstress or excess temperature values, and these were used in the subsequent trials of Methods 1 to 3.

In Table I, herewith, the averaged rates corresponding to the American method are given. In Table II, the total strains computed for four pure stress cycles and three pure temperature cycles on the basis of the three methods are given; and in Table III the equivalent steady temperature increments corresponding to these strains, computed by methods discussed in Part I, are given.

TABLE I.—Method of Guarnieri and Yerkovitch: Values of ratio of Total Strain Time for a 300-Hours Period ($\frac{\epsilon}{t}$) for Mo-Va Pipe Material at 1,193 deg. F., and Various Stresses, and at 4 Tons per Sq. In. and Various Temperatures.

Stress, Tons per sq. in.	Total Strain at 300 Hours.	Value of $\frac{\epsilon}{t}$ on Basis of 300 Hours.
5	0.00168	0.0000056
4	0.00089	0.000003
3	0.00046	0.0000015
Temperature, deg. F., at 4 Tons per sq. in. Stress	Total Strain at 300 Hours.	Value of $\frac{\epsilon}{t}$ on Basis of 300 Hours
1,238	0.00219	0.0000073
1,211	0.00109	0.00000364
1,193	0.00089	0.00000296
1,189	0.00045	0.0000015

TABLE II.—MO-VA PIPE MATERIAL: COMPARISON OF TOTAL STRAINS MEASURED EXPERIMENTALLY WITH THOSE COMPUTED UPON THE BASIS OF THREE SUGGESTED METHODS FOR SEVERAL CYCLES OF STRESS AND TEMPERATURE, RELATIVE TO BASIC CONDITIONS OF 4 TONS PER SQ. IN. AND 1,193 DEG. F.

Variety of Cycle.	Stress Peaks.				Temperature Peaks.		
Cyclic period of test, hours	24	24	24	24	24	24	24
Per cent. of cyclic period under overstress	50	25	5	5	—	—	—
Value of overstress, per cent.	10	20	30	50	—	—	—
Per cent. of cyclic period under increased temperature	—	—	—	—	25	50	25
Value of temperature increase, deg. F.	—	—	—	—	8.1	36	54
Experimentally measured creep strain at 300 hours	0.00095	0.00089	0.00098	0.00144	0.00089	0.00129	0.00163
Creep strain at 300 hours, computed by Method 1	0.00098	0.00102	0.00093	0.00099	0.00092	0.0012	0.0013
Creep strain at 300 hours, computed by Method 2	0.00115	0.00125	0.00109	0.00124	0.00099	0.00133	0.0016
Creep strain at 300 hours, computed by Method 3 (Guarnieri and Yerkovitch)	0.001035	0.00105	0.000955	0.00098	0.000905	0.00128	0.00134

TABLE III.—MO-VA PIPE MATERIAL: COMPARISON OF EQUIVALENT STEADY TEMPERATURE INCREMENTS OF EXPERIMENTALLY MEASURED TOTAL STRAINS, WITH INCREMENTS COMPUTED UPON THE BASIS OF THREE SUGGESTED METHODS, FOR SEVERAL CYCLES OF STRESS AND TEMPERATURE, RELATIVE TO BASIC CONDITIONS OF 4 TONS PER SQ. IN. AND 1,193 DEG. F., AND ALSO WITH INCREMENTS BASED ON BAILEY ANALYTICAL TREATMENT.

Variety of Cycle.	Stress Peaks.				Temperature Peaks.		
Cyclic period of test, hours	24	24	24	24	24	24	24
Per cent. of cyclic period under overstress	50	25	5	5	—	—	—
Value of overstress, per cent.	10	20	30	50	—	—	—
Per cent. of cyclic period under increased temperature	—	—	—	—	25	50	25
Value of temperature increase, deg. F.	—	—	—	—	8.1	36	54
Equivalent steady temperature increment corresponding to experimentally measured total strain, deg. F.	6	10.8	10.8	23.4	2.7	23.4	30.6
Equivalent steady temperature increment computed on basis of Method 1	8	11.5	4	8	2	21	27
Difference from value based on experiment, deg. F.	+2	+0.7	-6.8	-15.4	-0.7	-2.4	-3.6
Equivalent steady temperature increment, deg. F., computed on basis of Method 2	21	26	18	25	9	28	35
Difference from value based on experiment, deg. F.	+15	+15.2	+7.2	+1.6	+6.3	+4.6	+4.4
Equivalent steady temperature increment computed on basis of Method 3, deg. F.	13	14	6	8	1	26	28
Difference from value based on experiment, deg. F.	+7	+3.2	-4.8	-15.4	-1.7	+2.6	-2.6
Value of equivalent steady temperature, deg. F.; increment based on Bailey's equation $a = 0.031, n = 6$	10.5	13.1	5.7	13.6	2.2	22.8	23.7
Difference from value based on experiment, deg. F.	+4.5	+2.3	-5.1	-9.8	-0.5	-0.6	-6.9
Value of equivalent steady temperature, deg. F.; increment based on Bailey's equation $a = 0.027, n = 5.6$	11.2	13.7	5.8	13.5	2.2	22.3	22.4
Difference from value based on experiment, deg. F.	+5.2	+2.9	-5	-9.9	-0.5	-1.1	-8.2

While, owing to lack of suitable data, it was not possible to explore a combined stress and temperature cycle, nevertheless the cycles considered include a particularly high-stress and a particularly high-temperature cycle. In Table III, the equivalent steady temperature increments calculated by the analytical methods of Dr. Bailey are also given, and likewise the deviations of these analytical values, and of the values computed by the three methods indicated above from the experimental values.

In line with the procedure of Part I, the results are discussed in terms of the equivalent steady-temperature increments. In the first place, Table III will recall the fact that, for this material, the

Bailey analysis, while giving values lying within ± 5 deg. F. of experiment for most cycles, differed by some 10 deg. F. at the highest stress peak and by 8 deg. F. at the highest temperature peak. Moreover, and this was also the case for other materials, at this high peak the Bailey relation under-estimated the equivalent design temperature increment necessary.

Considering the first method suggested by the authors, it will be noted that, for the lower stress peaks, agreement with experiment is within $3\frac{1}{2}$ deg. F., and, in particular, the agreement with experiment in the case of the highest temperature peak is considerably closer than in the case of the Bailey analysis. However, for the 30/5 and 50/5 stress peaks, the method gives considerably lower values, reaching the order 15 deg. F. lower for the 50/5 cycle.

Turning to Method 2, it is evident that here the agreement is better at the higher stress and temperature peaks than at the lower. At the 10/50 and 20/25 peaks, the difference is some ± 15 deg. F., but diminishes with increasing peak values, giving values within $4\frac{1}{2}$ deg. F. for the highest stress and temperature peaks. However, it is to be noted that in all cases the method over-estimated rather than under-estimated the equivalent design temperature increment required. The Guarnieri-Yerkovitch method, it will be noted, gives results quite similar to those of the authors' Method 1, except that the discrepancies at the 10/50 and 20/25 peaks are larger.

On the basis of the above results it would appear, therefore, that, until any more fundamental basis

for dealing with the problem can be derived, the most helpful advice that can be given to designers is that, for stress peaks less than 30 per cent., or temperature peaks less than 36 deg. F., the methods of Guarnieri and Yerkovitch, of Bailey, and Method 1 suggested by the authors, will give reasonably good results; but for higher stress and temperature peaks, it is advisable to use Method 2.

THE INSTITUTION OF MECHANICAL ENGINEERS: ERRATUM.—We regret that an error occurred in the note, on page 179 of our issue of February 6, dealing with Mr. H. Hillier's paper on "Scale Formation in Sea-Water Distilling Plants and Its Prevention." In the fourth line from the end, ferric hydroxide is described as very soluble, whereas it is, of course, insoluble.

THE PHYSICAL SOCIETY'S EXHIBITION.

THE 37th annual exhibition of the Physical Society will be held at the Imperial College of Science and Technology, Imperial Institute-road, London, S.W.7, from Monday, April 13, to Friday, April 17. A return is to be made to the practice of former years of arranging the whole of the exhibition in the main buildings of the College and this should be of great convenience to visitors. On the first day, the exhibition will be open from 10.30 a.m. to 8 p.m., but admittance will be restricted to Fellows of the Society and the Press until 2 p.m. On Tuesday, Wednesday and Thursday, April 14 to 16, the hours of opening are from 10 a.m. to 8 p.m., and on the last day, Friday, April 17, from 10 a.m. to 5 p.m. Among the many modern aspects of science dealt with in the exhibition will be problems arising from high-speed flight, the industrial use of radio-isotopes, the applications of telecommunications and radar in modern travel, and the use of electronic techniques in general laboratory and industrial instruments. Three discourses, each of approximately 45 minutes duration, will be delivered at 6.45 p.m., on the evenings of April 14, 15 and 16. On the first evening Dr. E. C. Bullard, of the National Physical Laboratory, will speak on the "Seismic Study of Ocean Basins." On the second evening Dr. L. A. Jordan, of the Paint Research Station, will give a discourse on "Particles, Pellicles, Pigments, Paints and Physics." On the third evening, April 16, Professor W. V. Mayneord, of the Department of Physics in the Royal Cancer Hospital, will speak on "Scintillation Counting and its Medical Applications." As in previous years, a comprehensive *Handbook* of the exhibition will be available early in March and copies, price 6s., or by post 7s. 3d., may be obtained on application to the secretary-editor of the Society, 1, Lowther-gardens, Prince Consort-road, London, S.W.7. All other correspondence, such as that relating to tickets of admission, should be sent to the honorary exhibition secretary at the Lowther-gardens address.

SECOND INTERNATIONAL CONGRESS ON RHEOLOGY.—The British Rheological Society, 140, Battersea Park-road, London, S.W.11, with the support of the Joint Commission on Rheology of the International Council of Scientific Unions, is organising a second International Congress on Rheology, to be held at St. Hilda's College, Oxford, from the evening of Sunday, July 26, until the afternoon of Friday, July 31, 1953. In addition to a presidential address, the programme will include a number of invited lectures and a discussion on the international organisation of rheology. The Congress will cover all aspects of the deformation and flow of matter, with the exception of certain specialised subjects which have come to be regarded as branches of applied mechanics, such as aerodynamics and the classical theory of elasticity. There will be a number of excursions, and visits to Oxford colleges. Accommodation will be available at the colleges and at rooms in Oxford. Applications to attend and offers of papers, which will be welcomed, should be made to the honorary organising secretary, Dr. G. W. Scott Blair, The University, Reading.

FIFTH INTERNATIONAL MECHANICAL ENGINEERING CONGRESS.—This year's International Mechanical Engineering Congress will be organised by the Associazione Industriali Metallurgici Meccanici Affini, Via Massena 20, Turin, and will be held at Turin from Friday, October 9, to Thursday, October 15, during the course of the Salone Internazionale della Tecnica, in order that participants in the Congress may have the opportunity of visiting this exhibition. The theme of the Congress will be "Production and Assembly Methods for Components in Mechanical Engineering" and will be covered in 15 working sessions. In view of the wide scope of the Congress, it is not proposed to deal with raw materials, measurements, inspection, tests or erection, but to concentrate on the technology of manufacture, methods of assembly and comparative studies of different techniques. The proceedings will be conducted in English and French and participants will be sent advance copies of papers. After the Congress, from Friday, October 16, to Thursday, October 22, there will be a series of visits to large industrial undertakings in central Italy. Engineers willing to submit papers, and persons desiring further information, should communicate with the director, the British Engineers' Association, 32, Victoria-street, London, S.W.1.

TITANIUM—A SURVEY.*

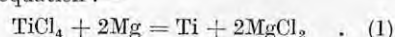
By P. L. TEED, A.R.S.M., F.R.Ae.S.

TITANIUM, unlike the metals first known to man, is not found in the elemental state, but, in combination with other elements, it is widely distributed in the earth's crust. The titanium minerals which are of commercial importance are ilmenite, a combination of iron oxide and titanium oxide, and rutile, consisting of titanium oxide. Both are widely distributed. Ilmenite is found in beach sand deposits, such as those of Travancore (India), Florida and Senegal. Travancore is currently by far the most important producer of this type, its total output since 1924 having been more than 4 million tons. At the present time the principal sources of the mineral are the great ore-bodies at Sogndal in Southern Norway, in the Adirondacks in New York State, and at Allard Lake in Quebec. This last and most recent discovery is so large that it is probable that it will ultimately make North America independent of Indian supply. A third and smaller source of the mineral arises as a by-product from the magnetic concentration of certain tin ores, such as those of Malaya and, to a lesser extent, of Portugal. Rutile, in smaller demand, is derived, often with other products, from beach sands in Australia (Queensland and New South Wales). It is also available in pebble form in the French Cameroons.

PRODUCTION OF METALLIC TITANIUM.

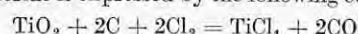
The Kroll process has virtually produced the whole of the titanium so far used for engineering purposes. Simple in conception, it involves chemical engineering problems of the utmost difficulty and complexity. It consists of reducing titanium tetrachloride by a chemically more active metal, magnesium.

The chemistry of Kroll's process is shown in the following equation:—



Put in another way, to produce a pound of titanium, theoretically, requires a pound of magnesium. In practice, about one and a quarter pounds are employed. This indicates to the engineer that titanium, made by this process, cannot be cheap.

The chemistry involved in production of titanium tetrachloride is expressed by the following equation:



Titanium tetrachloride, at normal temperature and pressure, is a liquid having the following physical characteristics: density at 15 deg. C., 1.76; melting point, -25 deg. C.; boiling point (at normal pressure), 136 deg. C. It is decomposed by water and by aqueous vapour, which accounts for its use as a material for the production of smoke screens. Magnesium has a density at 15 deg. C. of 1.74; a melting point of 651 deg. C.; and a boiling point (at normal pressure), of 1,120 deg. C. Titanium has the following characteristics: a density at 15 deg. C. of 4.5; melting point of 1,725 deg. C.; its boiling point has not been determined.

Anhydrous magnesium chloride is extremely hygroscopic. It forms, with water, hydrated salts which decompose, on heating, into magnesia and hydrochloric acid. In its anhydrous form it has the following features: density at 15 deg. C., 2.32; melting point, 708 deg. C.; boiling point, 1,412 deg. C. These differences in physical characteristics indicate some of the difficulties in bringing about the reaction indicated in equation (1). It is, however, the respective chemical properties of the different substances, and the extreme sensitivity of titanium to traces of oxygen and nitrogen, which make this problem of formidable dimensions. Both titanium tetrachloride and anhydrous magnesium chloride react with aqueous vapour. Metallic magnesium, if molten, must be out of all contact with oxygen or water vapour. Similarly, since metallic titanium under the conditions of temperature required by the Kroll reaction will combine with all gases except those of the inert series, the

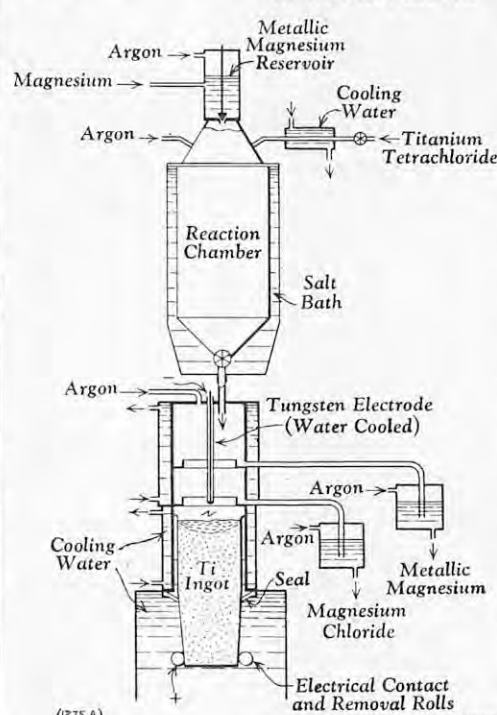
decomposition of titanium tetrachloride must be done either under greatly reduced pressure or in an atmosphere of such completely chemically inert gases as helium or argon.

DEVELOPMENT OF THE KROLL PROCESS.

The Kroll process of 1946 involved a number of difficult and different operations, each of which had to be done on a batch basis. A reaction chamber had to be prepared for each charge. This involved two operations: the chamber had to be closed by means of welding and, after waiting long enough for the contents to cool to atmospheric temperature, the chamber had to be opened by cutting. This led to the loss of the residual heat of both charge and chamber.

The standard way of removing the products of the reaction (roughly one part by volume of titanium sponge intermingled with eight parts of anhydrous magnesium chloride) was by boring out with a machine tool. The chips from this last operation had to be chemically treated in a batch in order to separate the magnesium chloride and leave the titanium as a number of detached particles. These had then to be magnetically treated to remove

Fig. 1. PLANT FOR CONTINUOUS PRODUCTION OF TITANIUM INGOTS.



iron. Finally, the batch application of a powder-metallurgy technique involved heating this sponge for long hours, at a high temperature, in a high vacuum. This gave rise to metal which had to be forged in order to turn it into an engineering material.

The first simplification which has taken place concerns the treatment of the products of the reduction process. Their mechanical boring out and subsequent chemical treatment to remove the anhydrous magnesium chloride has largely been abandoned. When the reaction is complete and the chamber is at about 800 deg. C., time is given for the sponge, anhydrous magnesium chloride and unreacted metallic magnesium to separate under the influence of gravity. While still fluid, they are tapped off. This done, the contents of the hot chamber, now mainly titanium sponge, are subjected to a high vacuum and the remaining magnesium chloride and unreacted magnesium are distilled off. Then, as argon is admitted, the chamber is allowed to cool to atmospheric temperature and pressure, when it is opened, the sponge removed and arc- or induction-melted to form ingots.

Probably the bulk of the titanium now available has been produced by such means, but there is no reason to doubt that the Kroll process will cease to be a batch one. Its reaction chamber will be fed, in stoichiometric quantities and without interruption, with molten magnesium and liquid titanium tetrachloride. It will discharge continuously the products of their reaction into an electric arc furnace in which the freshly created particles of

titanium will be melted into a coherent whole. The resulting anhydrous magnesium chloride and any unacted magnesium will be distilled off and condensed. The former will be used for electrolytic re-reduction to the metallic state, while the unacted magnesium will be merely returned to the molten magnesium tank from whence, ultimately, it will go back to the reaction chamber.

Such a scheme as this has been considered and tried out by Maddex and Eastwood. Their apparatus is illustrated in the diagram reproduced in Fig. 1. Above the reaction chamber is a vessel containing metallic magnesium at a temperature of 760 deg. C., about 110 deg. C. above its melting point. The pressure head in this part of the unit has to be kept constant by the controlled pumping of molten magnesium from a holding furnace, kept at the appropriate temperature. From the cistern of liquid magnesium, the metal runs into the reaction chamber. Here it meets the titanium tetrachloride. This is fed in at the rate appropriate for carrying out the reaction set out in equation (1). The technical requirements of this chamber are such that reaction is complete when the products of it, solid particles of metallic titanium and liquid ones of anhydrous magnesium chloride, reach its conical bottom, from where they flow through a valve to the next part of the unit.

The dimensions of this reaction chamber must be closely related to the speed of chemical reaction, which is influenced by both pressure and temperature. It therefore follows that both these factors must be kept constant during the operation of the plant. Pressure presents no difficulty; the chamber has merely to be in direct communication with a vessel containing an inert gas, such as argon, which is at an appropriate pressure, 2 to 3 lb. per square inch above that of the atmosphere. The maintenance of a suitable temperature is more difficult, since the reaction between metallic magnesium and titanium tetrachloride is exothermic, so that the heat liberated within the chamber, and thus the temperature of the chamber itself, depends on the rate of flow of the reagents into it. This must be strictly controlled and, in order to secure as uniform a thermal condition as possible throughout the whole, Maddex and Eastwood advocate its immersion in a salt bath kept at a steady temperature somewhere between 732 deg. and 871 deg. C.

The next portion of the unit is an arc furnace, the design of which presents great difficulties. Not only has it to melt the particles of titanium so that they run together and may be subsequently continuously cast into an ingot; it has to distil, from the mixture which runs into it from the reaction chamber, the anhydrous magnesium chloride and any unreacted metallic magnesium. These two have to be subsequently and separately condensed and, in liquid form, returned to the appropriate parts of the unit.

It is possible that a continuous process may be evolved in which the input will be almost limited to titanium dioxide, coke and electrical energy.

PROPERTIES AND APPLICATIONS OF PURE AND COMMERCIAL-PURE TITANIUM.

Table I, on page 252, shows that titanium is virtually a non-magnetic metal of high melting point, having a coefficient of expansion comparable with that of steel, an electrical conductivity of about 3.2 per cent. that of conductivity-grade copper, and a thermal conductivity of about the same order. Its density is about 57 per cent. of that of steel and 1.7 times that of aluminium, while its Young's modulus is about half that of iron, and one and a half times that of aluminium. At atmospheric temperature titanium is entirely free from corrosion by air or natural waters, including sea water. In the molten state, titanium is intensely chemically active. It combines violently with all gases, other than those of the monatomic series, such as helium and argon. This demands that the metal must be melted and cast in an atmosphere of the kind indicated, or else *in vacuo*. There is no material, metallic or non-metallic, out of which moulds can be made with which liquid titanium will not react disastrously.

In the form of annealed sheet, strip, bars, forgings, and so on, the commercially pure titanium can be expected to have at least the following mechanical

* Paper presented to the Royal Aeronautical Society in London on Thursday, January 29. Abridged.

properties: 0.2 per cent. proof stress, 33.5 tons per square inch; ultimate tensile stress, 39.0 tons per square inch; elongation, 23 per cent. This metal would cost approximately the following prices: sheet and strip, 11,900l. per ton; bars and forgings, etc., 7,900l. per ton. The combination of the mechanical properties and the price which has to be paid for them prompts examination of their relative significance in practical engineering terms.

Consider a tension member made in sheet or strip of commercial-grade titanium (annealed), aluminium alloy 75S, and magnesium alloy FSI, and assume that in each case the working stress would be the same proportion of the 0.2 per cent. proof stress. The relative costs, deduced from Table II, are as follows: commercial-grade titanium, 43.5; aluminium alloy 75S, 1.0; magnesium alloy FSI, 2.5.

These figures take no account of the respective costs of fabrication. They relate to the simplest type of structural member at atmospheric temperature. By cold work and by alloying, a substantial improvement in the mechanical properties of titanium can be made, but this will not make the

TABLE I.—Physical Characteristics of Pure Titanium, i.e., Better than 99.9 Per Cent. Ti.

Atomic number ..	22
Atomic weight ..	47.9
Crystalline structure:	
Up to 885 deg. C. ..	Close-packed-hexagonal
Above 885 deg. C. ..	Body-centred cubic
Atomic spacing:	
Up to 885 deg. C. ..	$a = 2.950 \text{ \AA}$
	$c = 4.683 \text{ \AA}$
Above 885 deg. C. ..	$a = 3.31 \text{ \AA}$
	$c = 3.31 \text{ \AA}$
Coefficient of linear expansion ..	15–730 deg. C., 8.8–9.2 $\times 10^{-6}$ per deg. C.
Thermal conductivity ..	0.036 calories per sq. cm. per cm. per sec. per deg. C.
Specific heat ..	0.13
Electrical resistance, microhm per cm. per sq. cm. ..	60
Density, gm. per cc. ..	4.507
Melting point ..	1,725 deg. C.
Young's modulus, lb. per sq. in.	15×10^6

TABLE II.—Relative Weight and Cost of Tension Member.

Material.	0.2 Per Cent. Proof Stress, tons per sq. in.	Density, lb. per cub. in.	Relative Weight of Tension Member.	Cost of Material, Shillings per lb.	Relative Cost of Tension Member.
Commercial-grade titanium ..	33.5	0.16	1.39	106.4	43.5
Aluminium-alloy 75S ..	29.5	0.101	1.0	3.4	1.0
Magnesium alloy FSI ..	16.5	0.064	1.13	7.4	2.5

TABLE III.—Relative Cost of the Material in Forgings of Equal Strength Made in Three Aircraft Alloys.

Material.	0.1 per cent. Proof Stress, Tons per sq. in.	Density, lb. per sq. in.	Cost per lb., Shillings.	Relative Cost.
Commercial-grade titanium	32	0.16	70.5	57.7
Aluminium alloy D.T.D. 683	27	0.101	3.3	2.0
Nickel chromium steel, B.S. S.99	70	0.283	1.5	1.0

cost of a tension member approximate to that of one made in the light-alloy aircraft structural alloys.

Since so many physical considerations are involved in the design of struts and beams, no comparison comparable with the one for a tension member can be made. However, on the rigidity/weight basis, titanium and titanium alloys at atmospheric temperature have a somewhat lower specific rigidity than the older structural alloys.

Although the elastic moduli of titanium can be appreciably raised by alloying (at the sacrifice of some desirable qualities), it appears improbable that the metal will be extensively used for the main structure of aircraft.

FORGINGS.

The figures in Table III give the relative price of the material in forgings of titanium, aluminium alloy, and alloy steel. All considerations as to the preparation of the materials for forging, their forging, subsequent machining and heat treatment have been neglected. Such omissions may eliminate the apparent two-to-one advantage shown in favour of nickel-chromium steel. They cannot, however, unfavourably influence the nearly 58 to 1 superiority

of the ferrous alloy over commercial-grade titanium, since the cost of the processes applied to titanium greatly transcends that of their application to the older materials.

One fact emerges clearly—at the present stage of its development commercial titanium is not attractive as a material for airframe forgings. What is not so clear is whether it would be technically suitable. The metal belongs to the hexagonal system and therefore it would be expected to have mechanical properties varying with the direction in which they are measured; more evidence is required on this point before one can be sure that, even were titanium cheap, it would also be useful for the purpose under consideration.

There are, however, at least four ways in which commercially pure titanium might well be employed with technical, if not with certain economic, advantage. The author believes that it could be employed in the form of rivets, closeable by cold heading and with, partly as a result of cold work, a pin shear ultimate as high as 35 tons per square inch. Although not yet an article of commerce, titanium tubing with a 0.2-per cent. proof stress of about 33 tons per square inch and an elongation of over 20 per cent. has been made. If it can be manufactured with the uniformity of quality required for aircraft hydraulic and pneumatic services, there would certainly appear to be a field of application in this sphere, for its specific proof and ultimate stresses are markedly better than those of such alloys as D.T.D. 310, 328, 503 and T.26. As a fireproof bulkhead, commercial titanium can replace stainless steel with a saving in weight for equal thicknesses of 37 per cent. If the oxygen content does not exceed 0.15 per cent., that of the nitrogen 0.05 per cent. and that of the carbon 0.15 per cent., the metal is readily welded by an argon-arc technique, which may simplify the making of the bulkhead. Finally, in military aircraft, titanium may be effective as armour, on a

weight basis, for it can be surface-hardened by a number of methods which have yet to be tested realistically.

(To be continued.)

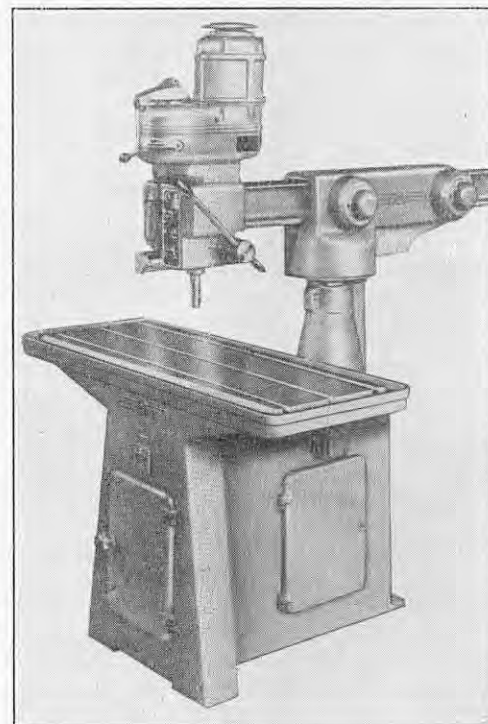
DUST TECHNOLOGY.—The 25th anniversary conference of the sub-committee on dust technology of the Verein Deutscher Ingenieure will be held in Essen on Thursday and Friday, March 26 and 27, 1953. Additional particulars may be obtained from Mr. Paul Grodzinski, A.M.I.Mech.E., Industrial Diamond Information Bureau, 32-34, Holborn Viaduct, London, E.C.1.

OXFORD UNIVERSITY MATHEMATICAL INSTITUTE.—The Congregation of Oxford University issued a statute on February 10 authorising the establishment of a Mathematical Institute of the University at Parks-road, Oxford. The new Institute will form part of the sub-faculty of mathematics and will replace the apartments at the Radcliffe Science Library which have been in use by University mathematicians since the construction of the Library in 1928, and which are now required for the purposes of the Library. The Institute will provide much-needed facilities for lecturing and research work, and, at a later date, it is hoped to set up a computing laboratory there.

WELDING IN STEEL BUILDING STRUCTURES.—The British Constructional Steelwork Association, Artillery House, Artillery-row, London, S.W.1, have issued their Technical Brochure No. 6, entitled *The Use of Welding in Steel Building Structures*. The brochure gives guidance on the design of metal arc-welded structural details required for structures to be loaded under nominally static conditions and to be designed as simple frames. Consideration is also given to the problems involved in the use of either mild or high-tensile steels. Like earlier publications in this series, the brochure contains many worked examples which are well illustrated by engineering sketches. Copies of the brochure may be obtained from the secretary at the above address.

HIGH-SPEED RADIAL DRILL.

THE Otto Muller SR23 high-speed radial drilling machine illustrated on this page is marketed by Kerry's (Great Britain), Limited, Warton-road, London, E.15, who are the sole distributors in this country. Its capacity is 1-in. diameter for drilling, boring, reaming, and tapping, and, unlike most radial drills, it has a table which is arranged transversely to the arm. This layout makes possible the drilling on the table of work up to 4 ft. 3 in. long at a radius of 3 ft., and 6 ft. 6 in. long at a 4-ft. radius, and, since the arm can be rotated through 360 deg., a baseplate can be fitted at the rear of the machine for very deep work. The spindle speeds are infinitely variable between 115 r.p.m. and 1,580 r.p.m. with the standard motor, but the speeds can be increased by a factor of 1.5 throughout if it is replaced by a pole-changing motor. The spindle feed stroke or drilling depth is 5 in. The steel column is mounted in a cast-iron frame with a precision honed bore and rotates on ball bearings. The shaft for adjusting the column height is housed within the column and is driven by a $\frac{1}{2}$ -h.p. motor, which raises the column at a speed of 1 in. per

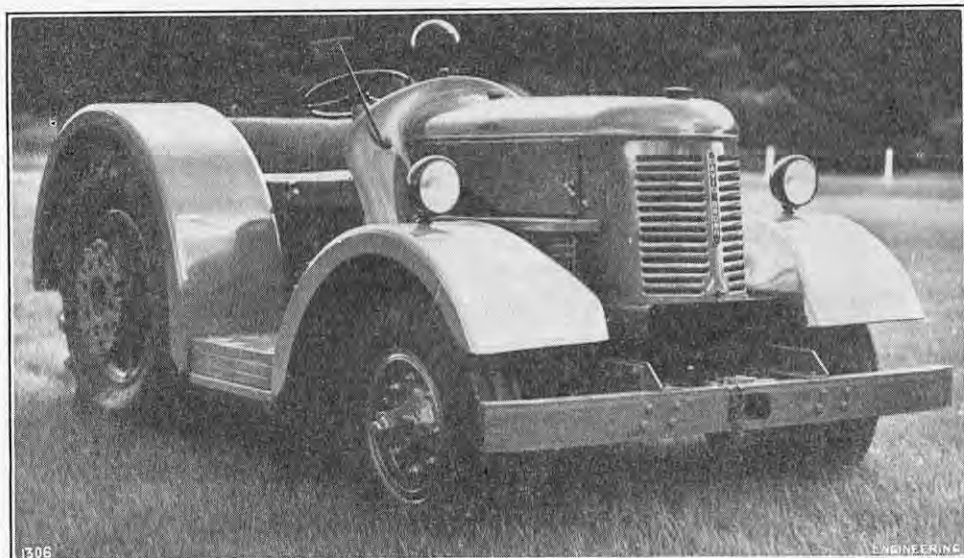


second to a height of 15 in. above its normal position, giving a maximum distance of 21 in. (535 mm.) between the spindle and the table, and of 45 in. (1,380 mm.) between the spindle and the baseplate.

A steel arm, of I-section, is mounted on the Witzig system in four adjustable roller bearings incorporating eight ball bearings to give free movement, and the arm and column can both be locked in position by the remote control pre-selector switches placed on the front of the base frame. An advantage claimed for the unusual layout of this machine is that the column can be moved close up to the roller-bearing housing, so that it is only exposed to bending stresses over one-third of its length, enabling it to be much lighter than in a radial drilling machine in which the column is fixed in the baseplate; also the arm is only subject to simple bending stresses because the drilling head is mounted squarely at its nose. The drilling head is a complete unit comprising the motor, gearbox with speed-selection lever, and a centrally-placed control panel. The spindle is driven from the motor shaft through a system of adjustable V-belt pulleys, which transmit the drive to an intermediate spindle, and then through precision-cut gears, completely immersed in oil, to the drilling spindle. The drilling spindle is relieved of thrust from the gears by being mounted in U.K.F. precision ball bearings together with a thrust bearing. The spindle is bored No. 2 Morse taper. The motor permits frequent changes of direction to be made, and is switched on and off

INDUSTRIAL TRACTOR.

DAVID BROWN TRACTORS, LIMITED, MELTHAM, YORKSHIRE.



and reversed by means of a control which operates two air-gap contacts. It has a manual feed, and follow-up of the spindle feed is obtained by using the automatic height adjustment to the column, operated by a push button. The control panel at the front of the drilling head has an illuminated scale for the overload coupling, an arbor feed scale, a push button for raising the column and one for lowering it, a light switch and a push button which is coupled with the pre-selection switches on the main frame for locking the position of the arm and column, a lighting and power circuit fuse box, a switch for change-over from drilling to tapping, and a switch which sets the tapping feed for automatic or manual control. To the left of this panel a rotary control in the form of a twist grip is fitted, which starts and stops the motor, controls the direction of rotation, gives a selection of three speeds for clockwise rotation of the spindle and can be used for swinging the arm into the drilling position. When the drive is set for tapping, the anti-clockwise speed is three times that of the speed in the clockwise direction. An overload release clutch is built into the spindle to prevent the breaking of drills and taps and this clutch can be adjusted to the required clutch pressure for each diameter of the tap, with the aid of the overload scale on the control panel, and a handwheel on the far side of the head; adjustment can be made to this release clutch while the spindle is running. In a position adjacent to this handwheel is a square nut for adjusting the tension of the return spring for the drilling arbor. The worktable of the machine is 20 in. (500 mm.) by 51 in. (1,275 mm.), has three T-slots $\frac{3}{4}$ in. (18 mm.) wide on 6 in. (152 mm.) centres, is 34 in. (850 mm.) above ground level, and the nose of the spindle is $6\frac{3}{8}$ in. (160 mm.) above it, when the column is in its lowest position. The base-plate, which is 60 in. (1,500 mm.) long by 40 in. (1,000 mm.) wide, has four T-slots $\frac{3}{4}$ in. (18 mm.) wide, placed on 10 in. (250 mm.) centres, and is normally set into the ground with its top face at ground level. The radial arm can be mounted in the roller-bearing housing in the reverse position to that shown in the illustration, giving 52 in. (1,300 mm.) maximum radius of rotation; the minimum radius of rotation obtainable is 10 in. (250 mm.) when in the normal position. The weight of the machine is 17 cwt., and its overall height with column extended is 88 in.

DIPLOMAS in AGRICULTURAL ENGINEERING.—The 1953 examinations of the Institution of British Agricultural Engineers, for the National Diploma in Agricultural Engineering (N.D.Agr.E.), will take place at the Essex Institute of Agriculture, Writtle, near Chelmsford, commencing on Tuesday, July 21 next. Application forms and particulars of the syllabus may be obtained from the secretary of the Institution, 24, Portland-place, London, W.1.

CONTRACTS.

VENNER LTD. have been informed by the Ministry of Transport that their plug-in synchronous flashing unit for "Zebra" crossings, fitted with differential synchronisers, open tungsten contacts and radio suppressors for both the incoming supply and the contacts, has been approved.

THE ENGLISH ELECTRIC CO. LTD. have received an order from the National Coal Board for five 700-kW dual-fuel engine alternator sets, complete with all station equipment and engine accessories, for the Point of Ayr Colliery. The engines will operate on methane gas supplied from boreholes on the site. They are naturally-aspirated eight-cylinder type engines, each having a rating of 1,100 b.h.p. at 428 r.p.m. The 700-kW alternators, also of English Electric manufacture, will be direct-coupled to the engines and are of the salient-pole, rotating-field type, generating at 3.3 kV, three-phase, 50-cycles supply. Waste heat from the engine-jacket water and exhaust gases will be utilised for space heating and pit-head baths.

I.T.D. LTD. (Industrial Truck Development), 95-99, Ladbroke-grove, London, W.11, are to supply to the China National Import and Export Corporation, fork-lift trucks, platform trucks, service parts and other ancillary equipment to the value of 500,000l., and capable of being used for the mechanical handling of a wide variety of goods.

The acceptance of offers by **KINNEAR, MOODIE & CO. LTD.**, for the construction, under the River Clyde, of a tunnel with associated shafts through which a new water main is to be laid, and for a sewer at Peel Glen, Drumchapel, in connection with housing developments, has been recommended by Glasgow Corporation.

GUY MOTORS LTD., Fallings Park, Wolverhampton, have obtained an order for 24 Otter Diesel passenger vehicles for the State Transport Authority, Travancore, India.

FIELD AIRCRAFT SERVICES LTD., Croydon Airport, Surrey, have obtained from the United States Air Force, the contract for the overhaul of a substantial number of C-47 Dakota transport aircraft and Pratt and Whitney engines. Air frames will be overhauled at Tollerton Airport, Nottingham; engines and propellers at Croydon, and instruments at Bovingdon Workshops.

VICKERS-ARMSTRONGS LTD., and British European Airways have signed a contract for the purchase of 12 new air liners to be designated the Viscount 800. It is emphasised that the new Viscount is not intended as a replacement for the Viscount 700. The essential differences between the "700" and the "800" are a fuselage longer by 160 in., permitting the installation of four more rows of passenger seats and an increase in take-off weight to 65,000 lb., made possible by a version of the **ROLLS-ROYCE** Dart engine (to be known as the R.Da.5) giving 1,540 s.h.p., and 1,690 e.h.p. The 12 aircraft will have been delivered by October, 1955.

HEAD, WRIGHTSON & CO. LTD., Thornaby-on-Tees, have secured the contract for iron-ore handling and blast-furnace equipment for the new steelworks at Aviles, Asturias, Spain. The contract is valued at 3,500,000l., and is being shared with the Fraser and Chalmers Engineering Works of the **GENERAL ELECTRIC CO., LTD.**, Erith.

INDUSTRIAL TRACTOR.

THE medium industrial tractor illustrated on this page is designed for haulage work and gives a maximum drawbar pull of 7,000 lb. Its three-speed and reverse gearbox provides maximum forward speeds ranging from 1.45 m.p.h. in first gear to 12.22 m.p.h. in top gear, and a reverse speed from 1.94 m.p.h. to 4.47 m.p.h. The engine revolutions corresponding to these speeds are 1,000 and 2,300 per minute, respectively. A six-position towing hitch at the rear gives a choice of drawbar height of from 13 $\frac{1}{2}$ in. to 26 $\frac{1}{2}$ in., and at the front a towing hitch is mounted centrally on the bumper bar. The tractor is also provided with a winch with sprag, which gives a pull of 15,000 lb. Girling 16-in. internal-expanding brakes are fitted to the rear wheels, and Clayton-Dewandre vacuum-servo trailer braking is also provided.

The VIG/1C industrial tractor, as it is called, has hitherto been supplied by David Brown Tractors, Limited, Meltham, Yorkshire, to Air Ministry specifications for towing the heaviest aircraft in service, but it is now available for general use. The VIG/1C is an improved and more powerful version of the tractor which was produced in large numbers during the last war for the Royal Air Force. A number of these tractors were released as surplus at the end of the war, and most were reconditioned either at the factory or by dealers before going into industrial use. The tractor weighs nearly 5 tons, and is driven by a David Brown four-cylinder overhead-valve petrol engine, with wet cylinder liners and shell-type main and big-end bearings. The engine, of 3 $\frac{3}{8}$ -in bore and 4-in. stroke, develops 41 brake horse-power at 2,300 r.p.m. (maximum). A Borg and Beck single dry-plate clutch is fitted, in conjunction with a self-priming Brockhouse turbo-transmission unit with a torque multiplication ratio of 3:1. The oil level is automatically maintained from a reservoir. The final drive is through spiral bevel gears at the differential to spur reduction units at the wheels. The tractor has 12-volt lighting and starting systems and coil ignition. The VIG/1C tractor now available for general use varies only in minor details from those which have been supplied to the Royal Air Force and the Royal Canadian Air Force, and many parts are interchangeable with other machines in the David Brown industrial and agricultural ranges.

AUSTRALIAN AND NEW ZEALAND ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—This Association has accepted an invitation from the Australian Commonwealth Government to hold its next general meeting in Canberra from Wednesday, January 13, to Wednesday, January 20, 1954, and a detailed programme is expected to be available in the near future. The Association has similar aims and organisation to those of the British Association and its meetings are held biennially in Australia or New Zealand. The honorary secretary of Section H (Engineering and Architectural Science) is Professor A. H. Corbett, A.M.I.Mech.E., Royal Military College, Duntroon, A.C.T., Australia, from whom further particulars may be obtained.

FILMS ON MECHANISED COAL-HANDLING AT COLLIERIES.—Automatic methods for the mechanised handling of coal tubs at the pit top of the Kingshill Colliery, Scotland, and at the reconstructed pit bottom of the Shilbottle Colliery, Northumberland, are the subjects of two short instructional films produced by the National Coal Board, and primarily intended for use within the industry. The films ably demonstrate what can be done to speed up the handling of coal tubs and to reduce the demand for man-power in the coal-mining industry, and will be of considerable interest to mine managers and others. The film of Kingsmill Colliery shows how tubs are mechanically withdrawn from the cages and transferred to an endless rope, to which they are automatically clipped to be towed to the tipping and cleaning plant before being returned empty. The second film, of the pit bottom at Shilbottle, shows how trains of tubs are divided and delivered to the cages, one tub at a time, after weighing, and also how trains of empties are made up from tubs automatically withdrawn from the down-coming cages. By making use of hydraulically-operated cage doors, rams and stops, remotely controlled by the weighman, the whole of this operation, involving 1,500 tons of coal a day, is performed by two men, exclusive of the electric locomotive driver.

MULTIPLE NUT-TIGHTENING AND TAPPING WITH PNEUMATIC MOTORS.

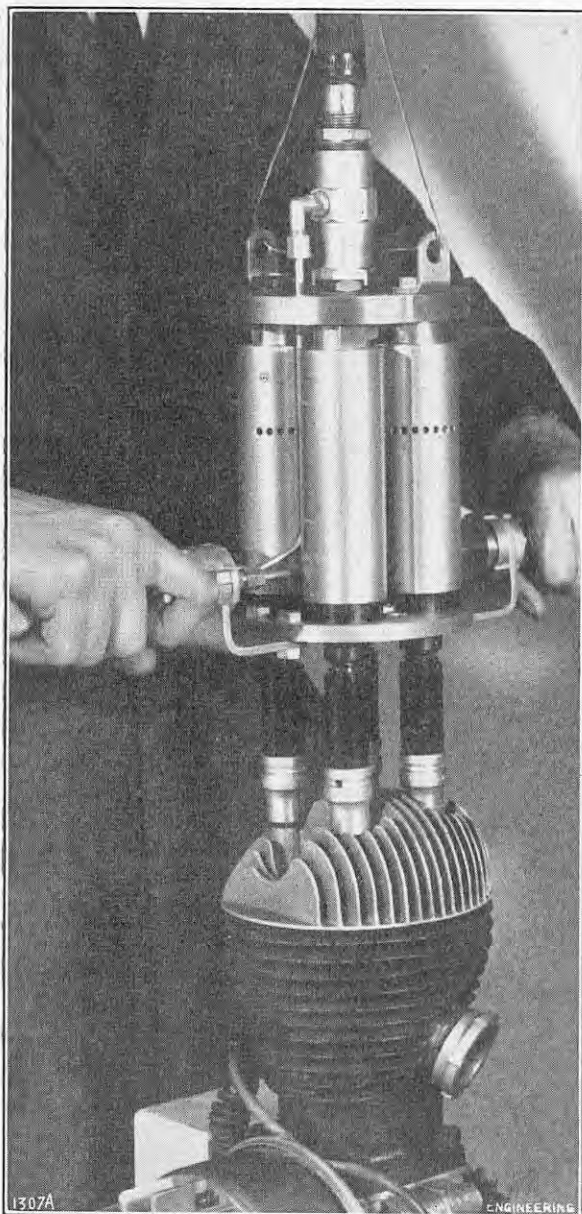


FIG. 1. QUADRUPLE NUT-TIGHTENING UNIT.

MULTIPLE NUT-TIGHTENING AND TAPPING WITH PNEUMATIC MOTORS.

WHEN controlled torque is to be applied simultaneously at a number of points, a group of pneumatic motors can frequently be used with advantage. The tightening of a group of nuts by pneumatic motors, and the tapping of holes in a component by means of three pneumatic motors arranged on a special rig, are illustrated above. These are typical of the special applications for which two types of Desoutter pneumatic tools can be usefully employed. The multiple torque unit shown in Fig. 1 can be made up to incorporate any number of SR50 motors, according to the number and pattern required. The small diameter of the motors allows them to be arranged with their axes only 2 in. apart, and as the weight of each is only 2 lb. 9 oz. the complete unit can be readily handled. The SR50 motor develops nearly $\frac{3}{4}$ h.p. at a torque of 500 lb.-in., but by adjusting the pressure-regulating valve a precise tightening torque can be applied uniformly to all nuts without risk of overtightening, thus eliminating the need for checking. Using such a multiple torque unit there is little torque reaction, and unskilled operators can be employed on the work without special training.

In the other application, illustrated in Figs. 2 and 3, three standard Desoutter R 16/40 pneumatic tappers, mounted radially on slides on a circular aluminium base, are used for tapping Bakelite lampshade holders by Ranton and Company,

Limited, Brentford. The operation starts when the component is placed on the centre fixture, which carries a vertical air valve. The operator opens this valve by pressure through the central hole in the component, which allows air to pass through an Enots air-control valve to a pneumatic cylinder. The plunger of the cylinder, moving outwards, rotates a central cam, one face of which opens the air-control valve, supplying compressed air to the three tappers. On removing the component from the fixture and releasing pressure from the valves, the air is shut off, allowing the cylinder to return to neutral and the cam to the starting position. A manually-operated lever has been added to this machine for use in the event of a breakdown of the pneumatic system, but so far it has never been used. The drilling operation, prior to the tapping, is carried out on a similar assembly. In this case three Desoutter P2 pneumatic drills are operated by a hand lever connected to a central cam, one face of which opens and closes an Enots air-control valve. These tools have been in use for two years and have drilled and tapped over a million components. Though the tools were designed to operate in a horizontal plane, Ranton and Company have found it more convenient to use them mounted on the vertical walls of their assembly benches.

The machines incorporating the Desoutter tools were designed and made by the Gildersleve Design and Tools, Reigate, Surrey, and the Desoutter tools themselves are made by Desoutter Brothers, Limited, The Hyde, Hendon, London, N.W.9.

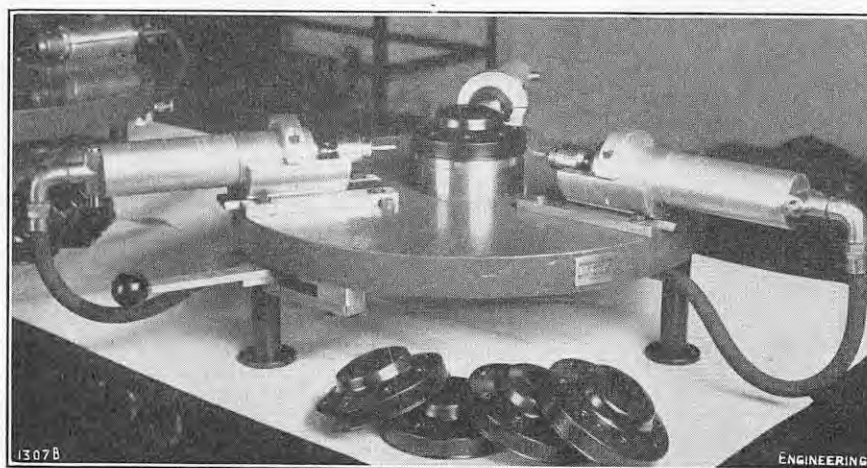


FIG. 2. TRIPLE RADIAL TAPPING MACHINE.

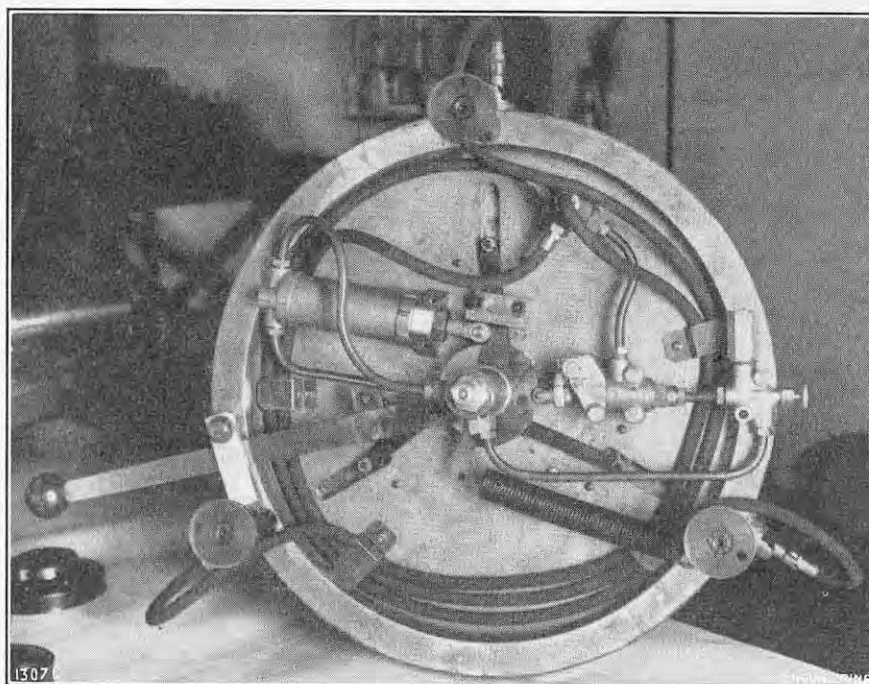


FIG. 3. UNDERSIDE OF TRIPLE TAPPING MACHINE.

LAUNCHES AND TRIAL TRIPS.

M.S. "SONGKHLA."—Single-screw cargo vessel, built and engined by Burmeister and Wain, Ltd., Copenhagen, for the East Asiatic Co., Ltd., Copenhagen, Denmark. Main dimensions: 456 ft. by 62 ft. 4 in. by 29 ft. 6 in. to second deck; deadweight capacity, 9,944 tons on a draught of 26 ft. 4 in. B. and W. seven-cylinder single-acting two-stroke Diesel engine, arranged to run on boiler or Diesel oil and developing 9,870 i.h.p. at 115 r.p.m. in service. Speed, about 16.8 knots. Launch, December 18.

M.S. "HELIX."—Single-screw oil tanker, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for the Anglo-Saxon Petroleum Co., Ltd., London, E.C.3. Main dimensions: 530 ft. between perpendiculars by 69 ft. 3 in. by 39 ft.; deadweight capacity, about 18,000 tons on a draught of 29 ft. 7 in.; gross tonnage, 12,000; oil-carrying capacity, 17,600 tons. Two impulse turbines, each coupled direct to a two-pole alternator supplying three-phase current for an electric motor directly connected to the propeller shaft, and developing 7,500 s.h.p. at 100 r.p.m. in service. Main machinery constructed by the British Thomson-Houston Co., Ltd., Rugby. Two Babcock and Wilcox steam-generating sets, constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Service speed, 14½ knots. Launch, January 16.

S.S. "HARPA."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Belfast, for the Anglo-Saxon Petroleum Co., Ltd., London, E.C.3. Main dimensions: 530 ft. between perpendiculars by 69 ft. 3 in. by 39 ft. to upper deck; deadweight capacity, 18,000 tons. Double-reduction geared steam turbines, developing 7,500 s.h.p. in service; and two Babcock and Wilcox oil-burning boilers, constructed by the shipbuilders. Launch, January 29.

ANNUALS AND REFERENCE BOOKS.

The Association of Supervising Electrical Engineers' Year Book, 1952-53.

Fraser Pearce, Limited, Brighton, Sussex. [Free to members.]

THE latest edition of the year book of the Association of Supervising Electrical Engineers, 54, Station-road, New Barnet, Hertfordshire, contains a great deal of information which is likely to be of interest to members. The "directory material," such as requirements of membership, has been revised to bring it into accordance with the new rules, and additions have been made to the sections on competitions, on the I.E.E. wiring regulations and the Association's own publications. A useful feature is a glossary of electrical terms and definitions. The presidential address delivered by Mr. C. T. Melling last autumn has been reproduced in full.

Sell's National Directory and British Exporters' Register, 1952.

Business Dictionaries Ltd., St. Dunstan's House, 133-137, Fetter-lane, London, E.C.4. [Price 2l. 10s.]

PUBLISHED by the proprietors of *Sell's Directory of Registered Telegraphic Addresses*, the *National Directory and Exporters' Register*, now in its 35th year of publication, is intended as a selective home and export guide to British firms of importance, and, therefore should be of special interest and value to exporters and importers at home and abroad. The main sections of the work are an alphabetical list of British exporting and importing firms, containing the names, postal and cable addresses and trade particulars of the leading firms in Great Britain and Ireland engaged in these trades; an alphabetical list of cable addresses; an alphabetical index to trade headings; and a classified British export section. This last section contains particulars of the leading exporters in Great Britain and Ireland, alphabetically arranged under their respective trades. Shorter sections in the directory include a list of brands and trade marks, an aviation supplement, a leather-goods section and an international-trade section. This contains announcements of overseas firms desiring to trade with Great Britain. A useful feature of the volume is the series of French, Spanish, Portuguese and Italian indexes to trades, which have been inserted to facilitate inquiries by overseas buyers.

The Exporter's Year Book, 1953.

Edited by A. J. DAY. Syren and Shipping, Ltd., 26-28, Billiter-street, London, E.C.3. [Price 2l., post free.]

AS has been the case with previous editions, this year-book contains a great deal of information on such matters as the weights and measures, postal service, currency, principal banks, chief ports and cities, airports, main shipping lines, and overseas commerce of countries in the British Commonwealth of Nations and foreign sovereign States. Great Britain and Northern Ireland and the British Empire appear first, then come foreign countries in alphabetical order, followed in each case by their colonies and dependencies, where such exist. The section covering Great Britain contains data on export invoice requirements, Imperial preference regulations, export credits guarantees, prescribed methods of payments for exports, and many other matters of interest to exporting firms. Conversion tables and factors, lists of weights and measures, commercial glossaries and other useful data are given in appendices. Blank paper for memoranda and a diary are included. The price of the work includes a monthly copy of the journal, *The Merchant Shipper*, which contains addenda to the *Year Book*.

The Wire Reference Year Book and Directory, 1952-53.

Compiled by Mr. D. J. BLASHILL and Mr. N. LINDSAY. Alfred Hinde, Ltd., Clarence Street Printing Works, Wolverhampton. [Price 1l. 5s.]

IN order to accommodate additions to the directory portion of this *Year Book* without increasing the number of pages, the compilers have adopted an ingenious, yet simple, geographical code to indicate each firm. An alphabetical index to firms producing wire and wire goods, and machinery, apparatus and products used in wire manufacture and ancillary trades, is first given, and, to each firm listed, is given a code number. In the classified-trades section, only the code numbers are given, thus enabling many entries to be compressed into a small space. The reference portions of the year book contain illustrated data on heat-treatment furnaces for wire, the manufacture of wire cloth, cold-heading techniques and wire used for cold heading, aluminium and aluminium-alloy wire, wire ropes and their handling, and other matters. A galvanisers' glossary, bibliographies on wire, lists of British Standard specifications and various tabular data are also included.

RADIO BUOY FOR "MARKING" WHALES.

THE extent to which science has changed the ancient industry of whaling was indicated in an article on page 90, *ante*, which described the "Electrosonic Equipment for Locating Whales" now being made by Messrs. Kelvin and Hughes (Marine), Limited, and particulars were also published recently by the General Electric Company of an "electric harpoon," which electrocutes the whale when it has been located and caught; but the modern process of whaling, in which a fleet of small whalecatchers may be hunting at considerable distances from the parent factory-ship, introduces another problem, namely, that of ensuring that the catch is not lost while the whalecatcher is pursuing others of the school, for it is not economically practicable for the catcher, having killed one whale, to tow it to the factory ship before going in search of another.

This problem has now been met by Messrs. Venner, Limited, New Malden, Surrey, whose marine department have developed the radio marker buoy which is illustrated herewith. It is a usual practice, of course, for a catcher to report its position by wireless after killing a whale, before proceeding elsewhere,



but winds and currents may carry a dead whale for a considerable distance before a vessel can reach the spot from which it was reported; it is stated, in fact, that some 10 per cent. of the whales killed are lost for this reason. The suggestion of a radio transmitting marker buoy came from Messrs. Chr. Salvesen and Company, of Leith, who own a large fleet of whaling vessels, and the prototype buoy is now in transit to South Georgia, where it will be tested in this season's whaling programme. It is generally similar to Messrs. Venner's standard radio-transmitting dan buoy, though smaller, but is made of an aluminium alloy, supplied by the British Aluminium Company. The weight is 65 lb., compared with the 275 lb. of the standard buoy, but it is expected that the weight of a production buoy can be further reduced, possibly to 55 lb. Part of the reduction in weight is due to the smaller size and the substitution of light alloy for steel, but a considerable saving has been made also by providing radio equipment with a transmitting period of only 22 hours instead of the 72 hours of the standard buoy. The range, 30 miles, is the same as that of the standard buoy, and the delay of operation by means of a time switch is also retained.

TRADE PUBLICATIONS.

Pneumatic Tools.—The Atlas Diesel Co., Ltd., Beresford-avenue, Stonebridge Park, Wembley, Middlesex, have sent us three illustrated catalogues relating to air compressors, pneumatic tools for workshops, shipyards and foundries, and to spray guns and paint spraying outfits. The company are the sole distributors in the United Kingdom for the parent company, Aktiebolaget Atlas Diesel, Stockholm, 1, Sweden.

Crucible Furnaces.—The Morgan Crucible Co., Ltd., Battersea Church-road, London, S.W.11, have issued three pamphlets describing their furnaces. The tilting furnace, fired by oil or gas, with manual or power-driven tilting gear, is produced in sizes from a capacity of 150 lb. to 1,680 lb. of brass; the bale-out furnace, oil, gas or coke fired, intended for use in die-casting work, in sizes from a capacity of 100 lb. to 1,100 lb. aluminium; and the lift-out, oil or gas fired, in sizes from a capacity of 30 lb. to 350 lb. brass. These furnaces are also suitable for metals other than those shown.

Hydraulic Variable-Speed Gear.—A leaflet describing the addition to their range of a variable-speed gear for transmitting 1½ h.p. at 1,430 r.p.m. has been published by Carter Gears, Ltd., Thornbury-road, Bradford, Yorkshire.

The Design of Electric Coils.—The Varley Coil Designers' Handbook, a copy of which has been received from Oliver Pell Control, Ltd., Cambridge-row, Burrage-road, Woolwich, London, S.E.18, contains useful information on the design and manufacture of electric coils. Construction, insulation treatment and connections are all dealt with and a range of finishes is also set out.

Electric Water Heaters.—A pamphlet received from the Hotpoint Electric Appliance Co., Ltd., Peterborough, gives details of their electric water heaters and circulators.

Terrazzo Flooring.—An illustrated leaflet has been sent to us by the Metals Division of Imperial Chemical Industries, Ltd., Kynoch Works, Witton, Birmingham, 6, describing "Terrabond" strip for Terrazzo or similar flooring. Terrabond strip is an extrusion of brass or aluminium alloy and it serves to divide large floor areas to prevent cracking of the floor surface. Copies may be obtained from the above address or from other offices of I.C.I., Ltd.

Diesel Loader and Dumper.—Two brochures received from E. Boydell & Co., Ltd., Elsinore-road, Old Trafford, Manchester, 16, deal, respectively, with the Muir-Hill Diesel-driven dumper truck, of 3 cub. yd. capacity, and the Muir-Hill loader and the alternative scoops, dozer blades and crane attachment, for use with it.

Chain Wheels.—Details of their range of plate wheels and adaptors for 8-mm. chain is given in a pamphlet received from the Renold & Coventry Chain Co., Ltd., Manchester.

Compressed-Air Equipment.—B.E.N. Patents, Ltd., High Wycombe, Buckinghamshire, have issued an illustrated leaflet giving brief particulars of their range of air compressors for industrial and garage use; spray-painting plant, guns and accessories; garage equipment, and miscellaneous compressed-air equipment.

Cutting Fluids.—The Regent Oil Co., Ltd., 117, Park-street, London, W.1, have issued a 50-page illustrated booklet on the subject of lubricants and coolants for cutting and grinding; in particular, the booklet gives the physical and chemical properties of the company's range of Caltex cutting and grinding oils.

Pneumo-Hydraulic Circuit-Breaker Mechanism.—The pneumo-hydraulic mechanism, which has been designed by the Brush Electrical Engineering Co., Ltd., Loughborough, for operating oil circuit-breakers, is described in a pamphlet recently sent to us.

Medium-Voltage Underground Joint and Service Boxes.—British Insulated Callender's Cables, Limited, Norfolk-street, London, W.C.2, have published a booklet dealing with the various types of underground joint and service boxes which they manufacture for use on medium-voltage systems.

Wiring Specification for Inter-Communication Telephones.—Communication Systems, Ltd., Arundel-street, London, W.C.2, have sent us a copy of a specification which is issued to wiring contractors in order to secure uniformity in the cabling for their intercommunication telephones and as an aid to tendering.

Coal Sampler.—A broadsheet has been published by International Combustion, Ltd., 19, Woburn-place, London, W.C.1, describing a coal sampler produced by them for attachment to conveyor belts in power stations.

Flexible Couplings for Shafts.—In a leaflet from Howard Clayton-Wright, Ltd., Wellesbourne, Warwickshire, sizes and tabulated performance figures are given of the Harrisflex (Torflex) type "K" couplings.

Arc Welding Cables.—The Edison Swan Electric Co., Ltd., 155, Charing Cross-road, London, W.C.2, have published a pamphlet dealing with cables for arc-welding machines. The cables conform to British Standards.

NOTES ON NEW BOOKS.

Rewinding and Repair of Electric Motors.

By KARL WILKINSON, M.A.E.T. E. and F. N. Spon, Limited, 15, Bedford-street, Strand, London, W.C.2. [Price 20s. net.]

THIS is a workshop handbook and should be of much value to the type of user for whom it is intended. Small electrical shops are frequently called upon to repair or rewind small electric motors of which there are hundreds of thousands in industrial and domestic use. The bulk of the operations involved in the winding and assembly of an electric motor can be performed by semi-skilled labour in a manufacturer's works owing to the repetition nature of the jobs and the special jigs and other appliances provided. Conditions are very different in a small repair shop; the facilities available are much more restricted and the range of types which have to be dealt with may be much greater. As Mr. Wilkinson points out, under such conditions "the final result depends almost entirely upon the skill of the operator," and he expresses regret that "craftsmanship and good bench work are declining." In this book he has certainly made a valuable attempt to ensure that the small workshop employee shall not fail to achieve satisfactory results owing to lack of guidance. The mechanical features of motor repair, such as brush replacement and adjustment or attention to bearings, are not neglected, but the bulk of the book is, rightly, concerned with rewinding. This is the aspect of the subject on which the workman is most likely to need instruction. The book furnishes the necessary background to the work in a chapter describing the various types of winding likely to be met with. Winding procedure is then dealt with, particular stress being laid on the need to record all particulars of the old winding before commencing a new one. Throughout, the instructions are accompanied by clear and informative sketches.

Practical Mathematics.

By PROFESSOR C. I. PALMER and S. F. BIBB. Fourth edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 6.00 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 48s.]

Practical Mathematics is an elementary text-book covering the fundamentals of arithmetic, algebra, geometry and trigonometry, taken to the standards required in the first year of the National Certificate course in engineering. Within its 720 pages, the authors have been able to discuss fully the various processes of elementary arithmetic, geometry (avoiding Euclidian theorems), algebra up to the solution of simple equations and logarithms, and trigonometry up to the solution of oblique triangles.

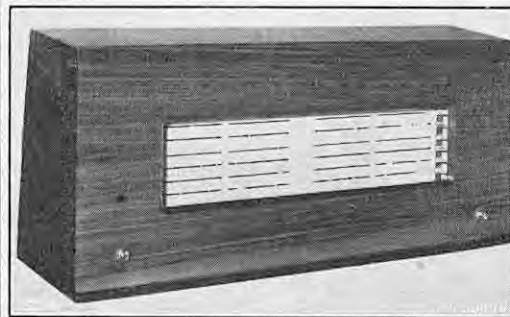
The Stratford-upon-Avon & Midland Junction Railway.

By J. M. DUNN, The Oakwood Press, Tanglewood, South Godstone, Surrey. [Price 5s. net.]

THIS little monograph—No. 10 in the "Oakwood Library of Railway History"—is concerned with one of the most curious examples, in that history, of combined operation. With its associated lines, the "S.M.J." linked Olney and Blisworth, in the east, with Towcester and so to Banbury, to the south-west, and beyond Stratford, to Broom Junction, Redditch and Evesham, on the Midland Railway. The mineral traffic, for which its promoters hoped, never developed; its finances were repeatedly in a state for which, in the author's phrase, "embarrassment would be too mild a word"; its rolling stock was miscellaneous to the point of being bizarre, and its organisation seems, in the description, to have been more complicated than was usual with joint lines in the pre-grouping era. In matters of detail, however, the history of the line seems to have been, if anything, over-simplified, for there are more occasions than is usual in this series of booklets when the author has to confess himself defeated by a lack of documentary or other evidence. He has done his best with the available material, and the result should appeal to the amateur historian of railways, for whom it was written.

PRODUCTION-OPERATION TIME RECORDER.

THE instrument illustrated on this page has been designed to provide a time record of the periods of operation of a number of different machines and processes, and is made by F. C. Robinson and Partners, Limited, 287, Deansgate, Manchester, 3. It can record simultaneously the running times of ten machines, and is mounted in a metal or walnut cabinet with a 16½-in. wide window through which the white strip chart made from heat-sensitive paper and calibrated on a time basis is visible. The chart is driven at a speed of 2 in. per hour, by a synchronous electric clock motor, and moves from right to left. At the right-hand end of the window are ten markers containing a small heating unit



capable of maintaining them at a constant temperature not exceeding 120 deg. C. The markers are attached to the armature of an electromagnetic relay which brings them independently into contact with the chart at a predetermined pressure, sufficient to effect a transfer of heat to the sensitised surface of the paper, thereby producing a clear black line on its surface. The instrument uses a current of 0.1 ampere at 16 volts for operating the pen. A light twin wire is suitable for connecting the recorder to the machine, and a simple relay connected across the terminals of the motor driving the machine is required to energise the armature. It is claimed that a period as short as 30 seconds shown on the chart can be seen from a distance of several feet.

RUTHERFORD LECTURER FOR 1953.—The Council of the Royal Society announce that they have appointed Sir James Chadwick, D.Sc., Ph.D., F.R.S., Master of Gonville and Caius College, Cambridge, as Rutherford Lecturer for 1953, and that Sir James will deliver the lecture at McGill University, Montreal, in the autumn. This will be the second lecture under the terms of the Society's Rutherford memorial fund. The first was delivered by Sir John Cockcroft, C.B.E., Sc.D., F.R.S., M.I.E.E., in New Zealand last year.

SUMMER SCHOOL OF WELDING.—The third Summer School of Welding, organised by the British Welding Research Association, will be held at Ashorne Hill, near Leamington Spa, Warwickshire, from Monday, April 27, to Saturday, May 2, 1953. The school will study "Welding Fabrication and Production" and, in addition to lectures on the broad aspects of the subject, there will be lectures on special problems applicable to the aircraft industry, the shipbuilding industry, structural engineering, the automobile and sheet-metal industries, and general engineering. Applications should be made as soon as possible to the secretary of the Association, 29, Park-crescent, London, W.1.

THE "GRIPTAL" CHAIN WRENCH.—The "Griptal" chain wrench, which is now being manufactured by Messrs. Melvin, Limited, 2A, Middle-lane, London, N.8, is distinguished from other tools of its class in having no teeth or serrations. It consists essentially of a chain, one end of which is attached to a lever, the other being wrapped round the object to be tightened and then passed through a slot in the lever. The grip is tightened by turning the lever in the appropriate direction. The wrench will take round parts of a minimum diameter of 2 in., the maximum diameter depending on the length of the chain. For instance, one model with a 14-in. lever and a 15½-in. chain will take a round up to 4½ in., while another model with a 20-in. lever and 31-in. chain will take up to 8½ in. Hexagons, squares and irregular shapes can also be dealt with.

BOOKS RECEIVED.

- Historical Metrology.* By A. E. BERRIMAN. J. M. Dent and Sons, Limited, Aldine House, 10-13, Bedford-street, London, W.C.2. [Price 16s. net.]
- Ministry of Transport. Railway Accidents. Report on the Collision which Occurred on 18th August, 1952, between Dalmarnock and Bridgeton Cross in the Scottish Region, British Railways.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 6d. net.]
- Fuel Efficiency Bulletin No. 53. The Wetting of Slack to Assist Combustion.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 6d. net.]
- Overseas Economic Surveys. Hayti.* Prepared under the supervision of D. J. MILL IRVING. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1s. 6d. net.]
- Photo-Electric Multipliers.* By S. RODDA. Macdonald and Company (Publishers), Limited, 16, Maddox-street, London, W.1. [Price 22s. 6d. net.]
- Electrical Measurements and the Calculation of the Errors Involved. Part II.* By DR. D. KARO. Macdonald and Company (Publishers), Limited, 16, Maddox-street, London, W.1. [Price 30s. net.]
- National Building Studies. Special Report No. 19. The Assessment of Vibration Intensity and its Application to the Study of Building Vibrations.* By R. J. STEFFENS. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1s. net.]
- Physical Constants of Some Commercial Steels at Elevated Temperatures.* (Based on measurements made at the National Physical Laboratory, Teddington.) Edited by the British Iron and Steel Research Association, Metallurgy (General) Division Thermal Treatment Subcommittee. Butterworths Scientific Publications, Limited, Bell Yard, Temple Bar, London, W.C.2, in conjunction with the British Iron and Steel Research Association, 11, Park-lane, London, W.1. [Price 21s.]
- Electrical Trades Directory 1953.* The Electrical Journal Blue Book. Benn Brothers, Limited, Bouverie House, 154, Fleet-street, London, E.C.4. [Price 50s., carriage free.]
- A Guide to Birmingham.* The City of Birmingham Information Department, The Council House, Birmingham. [Price 1s.]
- La Mécanique Ondulatoire.* By THÉO. KAHAN and BERNARD KWAL. Librairie Armand Colin, 103, Boulevard Saint-Michel, Paris (5e), France. [Price 260 francs.]
- The Structure and Capacity of Australian Manufacturing Industries.* Division of Industrial Development, Department of National Development, 203, Collins-street, Melbourne, Victoria, Australia; and Angus and Robertson, Limited, 48, Bloomsbury-street, London, W.C.1. [Price 60s. net.]
- Physical Metallurgy for Engineers.* By PROFESSORS DONALD S. CLARK and WILBUR R. VARNEY. D. Van Nostrand Company, Incorporated, 250, Fourth-avenue, New York 3, U.S.A. [Price 6.50 dols.]; and Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 48s. net.]
- The Institution of Mechanical Engineers. War Emergency Proceedings, Nos. 63-69, 1951.* Vol. 165. Offices of the Institution, Storey's Gate, St. James's Park, London, S.W.1.
- Famous British Engineers.* By LESLIE HALWARD. Phoenix House Limited, 38, William IV-street, London, W.C.2. [Price 12s. 6d. net.]
- Précis de Physique Générale. IV. La Structure de la Matière.* By PROFESSOR ERNEST STAHEL. Editions du Griffon, Neuchâtel, Switzerland. [Price 15 Swiss francs.]
- The Melco Metallizing Handbook.* By H. S. INGHAM and A. P. SHEPARD. Metallizing Engineering Company, Incorporated, Long Island City 1, New York, U.S.A. [Price 3 dols.]; and Metallizing Equipment Company, Limited, Chobham, Woking. [Price 21s. 6d.]
- Liverpool Observatory and Tidal Institute. Annual Report, 1952.* The Director, Liverpool Observatory and Tidal Institute, The Observatory, Bidston, Birkenhead.
- British Commonwealth Scientific Conference. Australia. February-March, 1952. Report of Proceedings.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3s. net.]
- United States National Bureau of Standards. Building Materials and Structures Report No. 133. Live Loads on Floors in Buildings.* By JOHN W. DUNHAM, GUTTORM N. BREKKE and GEORGE N. THOMPSON. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 20 cents.]
- United States Bureau of Mines. Bulletin No. 514. American Standard Safety Code for Installing and Using Electrical Equipment in and about Coal Mines (M2.1).* [Price 20 cents.] No. 515. *Coal Deposits in the Deep River Field, Chatham, Lee, and Moore Counties, N.C.* [Price 75 cents.] The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A.
- Greenly's Model Steam Locomotive Designs and Specifications.* Revised by ERNEST A. STEEL. Cassell and Company, Limited, 37-38, St. Andrew's Hill, Queen Victoria-street, London, E.C.4. [Price 4s. 6d.]