

STRESS-PROBING: A RAPID METHOD FOR STRESS-SURVEYING.*

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THE measurement of stresses in pressure vessels generally involves the use of a large number of strain gauges of one sort or another. The attachment of a large number of mechanical or electric gauges necessitates a considerable outlay on expen-

structural member subjected to slow cycles of loading. The deflections of the measuring pointer are, of course, a measure of the strain induced by the application of load. The method as applied by the present authors uses a different measuring device, and application by hand has been avoided.

The method, as applied by Robertson, is very useful in the detection of stress peaks, but its accuracy has limitations. Among these is the fact that the magnification in the mechanical strain gauge used is influenced by the angle included by

surface of the test specimen also has an influence on the accuracy of measurements. It has been found, however, that strain measurements can be taken even on the roughest surface.

For carrying out stress probing there are two requirements: firstly, an apparatus for the application of cyclic loads to structural specimens or pulsating pressures in vessels and tubular components, and, secondly, a device for measuring the changes of strain induced by these pressure pulsations or cyclic loads.

A full description of the method of operation of

Fig. 1. DIAGRAMMATIC LAYOUT OF PULSATING PRESSURE PLANT

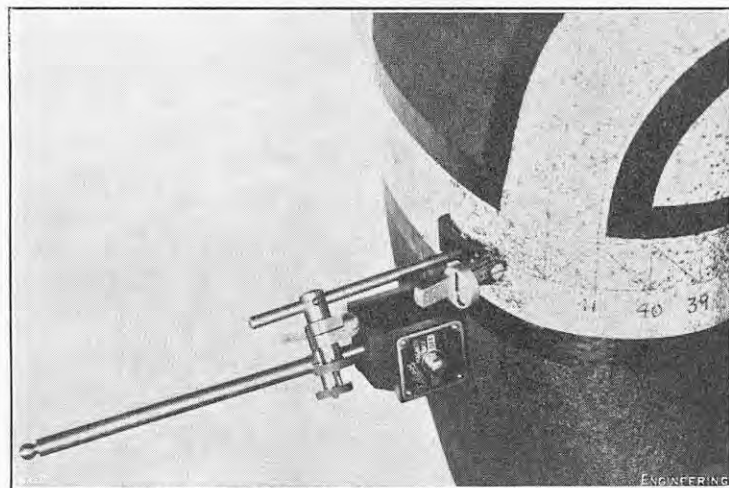
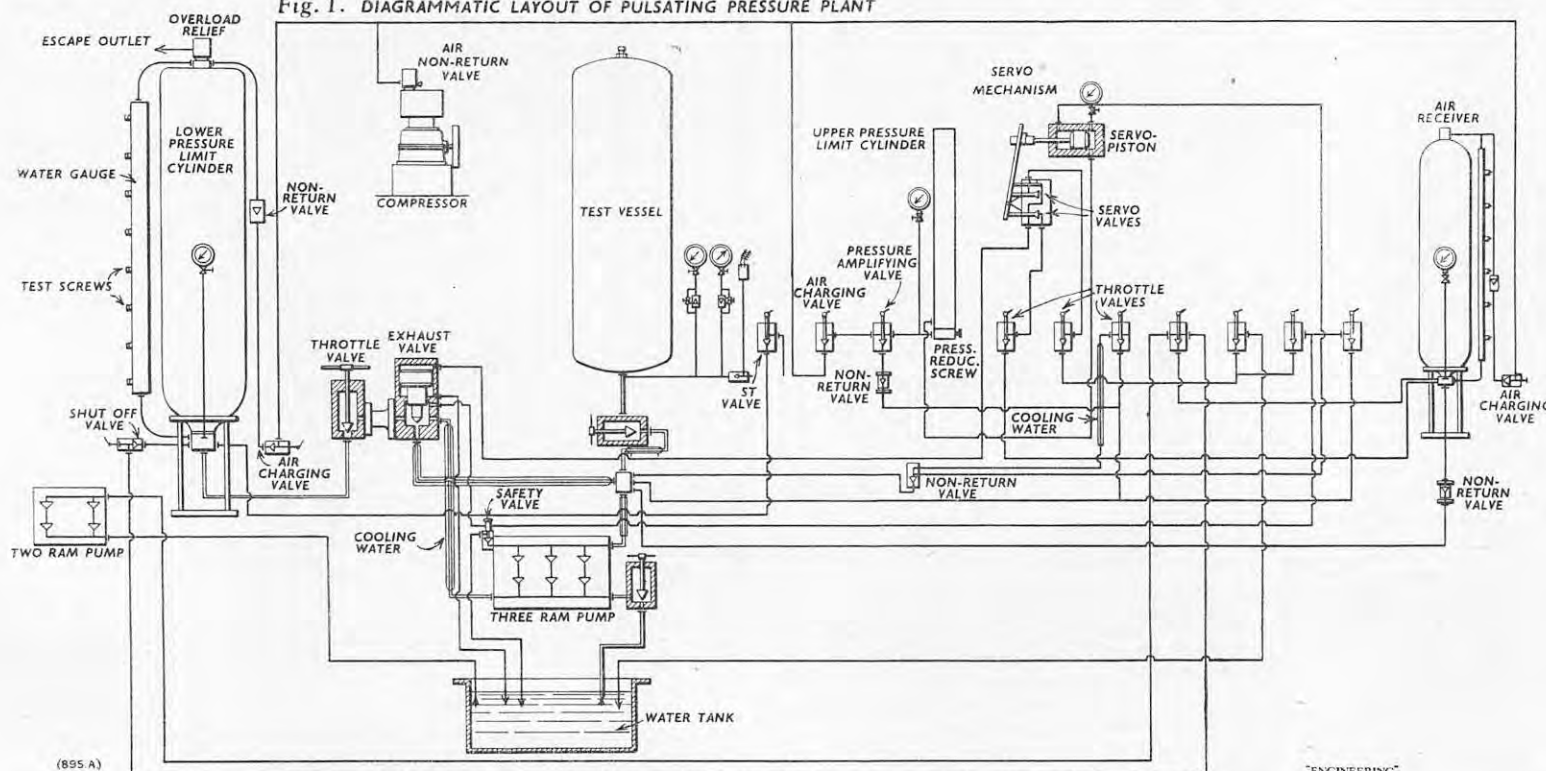


FIG. 2. GAUGE IN POSITION ON DRUM HEAD.

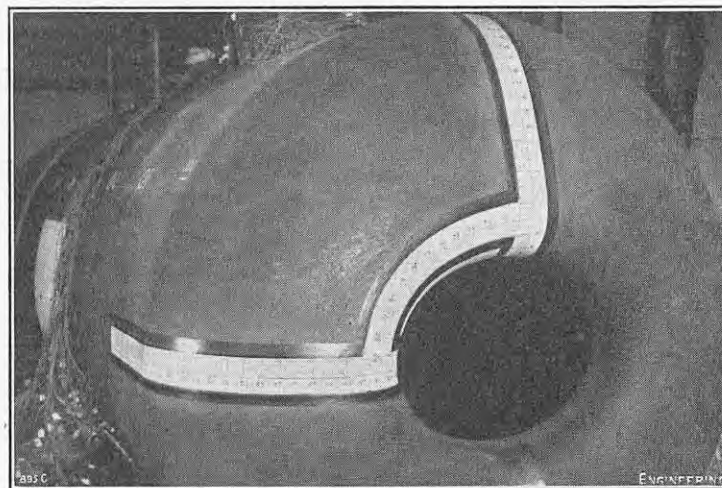
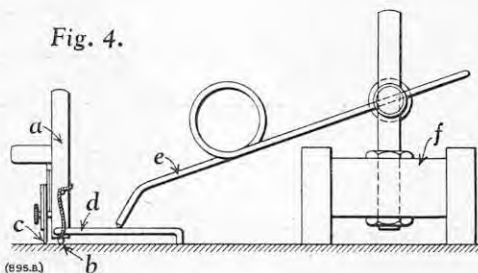


FIG. 3. MEASURING STATIONS ON DRUM HEAD.

sive instruments and on time for applying the gauges and taking the necessary readings. Sometimes the number of these instruments is such that automatic recording of the results is necessary and this causes additional complications.

A method has been devised for simplifying this procedure considerably. This was suggested by T. S. Robertson, and its first application to simple structural members was described by G. B. B. Owen.† The original method consisted in applying by hand a mechanical gauge (Huggenberger) to a

Fig. 4.



the axis of the instrument with the vertical. It is also influenced by variations in the force applying it to the test specimen.* The condition of the

pulsating pressure plant was published in *ENGINEERING* of November 17, 1950 (vol. 170, page 384). In essence, this consists of an arrangement whereby the test vessel is alternately connected to a high-pressure pump and to either the atmosphere or a vessel in which the lower test limit has been pre-set. Obviously, the method of control of the valve connecting the pump to the test vessel is the most important item, and, in the case of the test plant used for these experiments, this valve was operated and controlled by a pneumatic hydraulic arrangement, as shown in Fig. 1, herewith.

It was found that a commercially-produced measuring gauge, based on the change of helix angle of a perforated twisted strip, would be a suitable instrument for the measurement of strain. This gauge has been described by S. A. Eskilson

* Based on Report FE 12/22 of the Committee on Stresses in Welded Pressure Vessels to the British Welding Research Association.

† *Engineering Structures: Colston Papers*, page 255. Butterworth and Company (Publishers), Limited, London (1949).

* *Dehnungsmessungen und ihre Auswertung*, by F. Röttscher and R. Jaschke, page 97. Julius Springer, Berlin (1939).

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Fig. 5. PRESSURE PULSATIONS BETWEEN 70 AND 400 LB. PER SQ. IN.

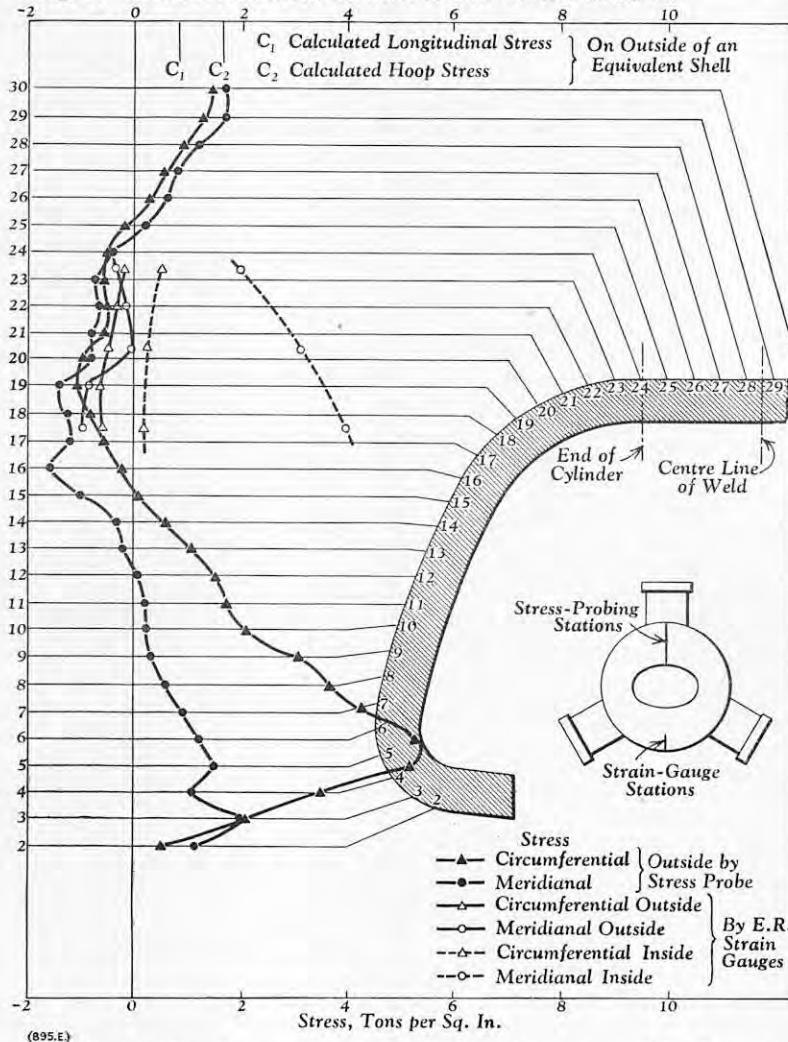


Fig. 6. PRESSURE PULSATIONS BETWEEN 70 AND 400 LB. PER SQ. IN.

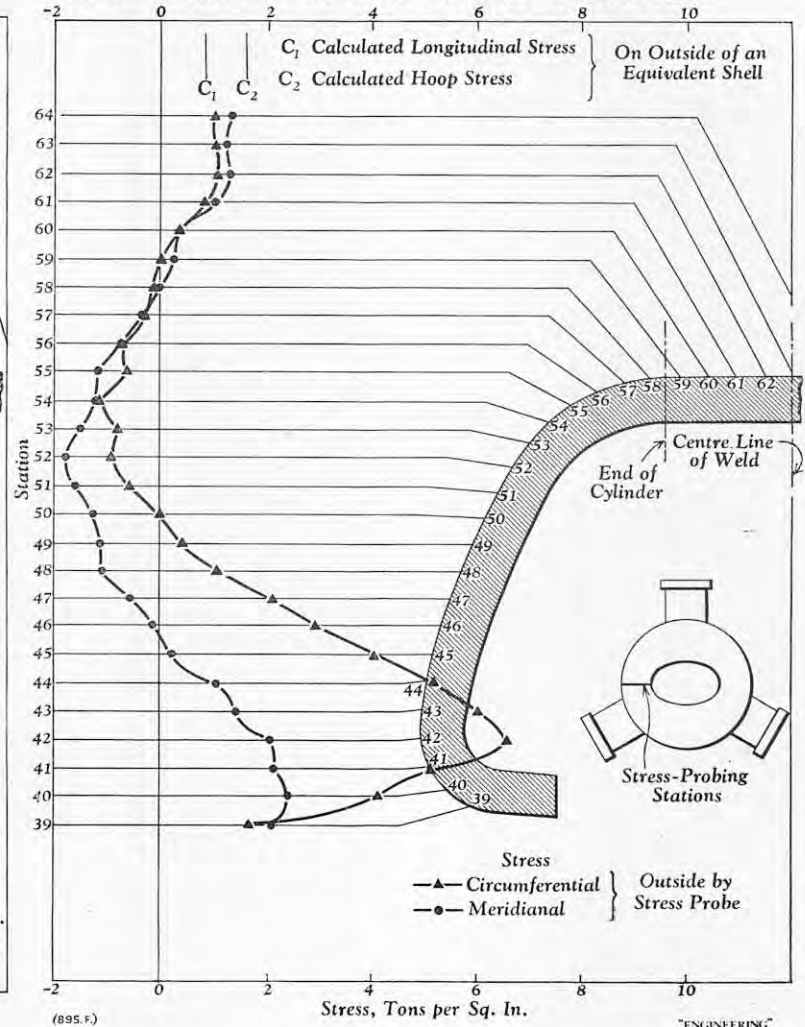
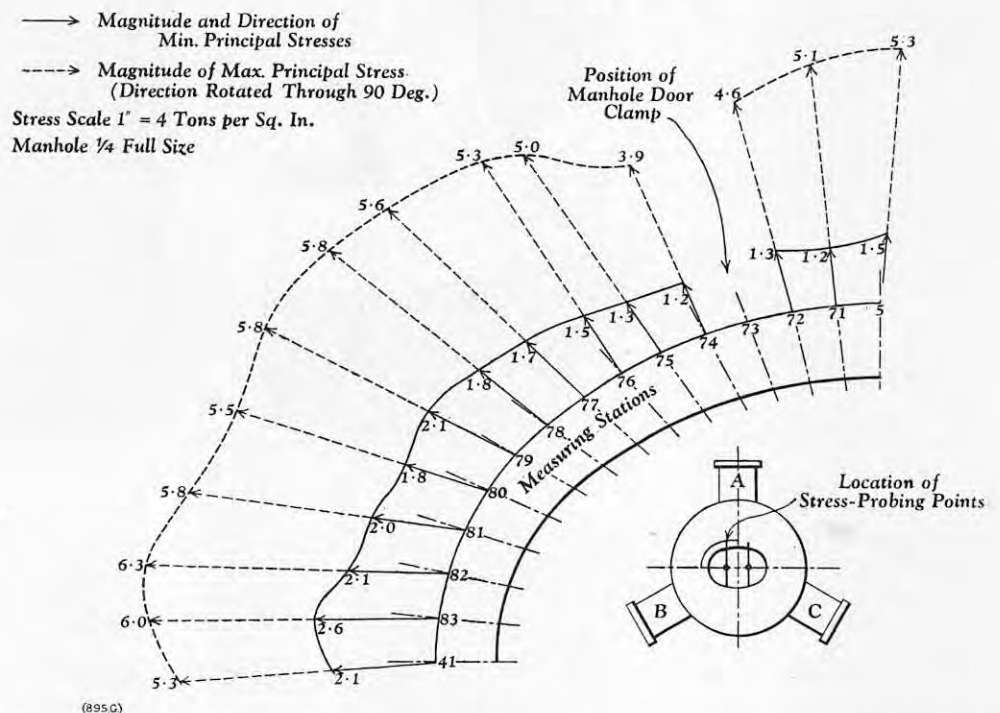


Fig. 7. PRESSURE PULSATIONS BETWEEN 70 AND 400 LB. PER SQ. IN.



and R. Gunnert* and more recently by Gunnert.† One of its advantages is that one model is made with a small base length, which can be varied between $\frac{1}{8}$ in. and $\frac{1}{16}$ in. It has been established, by tests on a calibrating bar which can be rotated in all directions, that this gauge is not influenced by the position of its axis relative to the vertical. To avoid small irregularities due to variations of pressure when the gauge is applied by hand, it is held in place by a spring-loaded arm attached by a magnetic clamp to the test specimen (Fig. 2, on page 97, in which *a* is the extensometer; *b*, the fixed knife edge; *c*, the movable knife edge; *d*, a supporting stirrup; *e*, a spring-loaded arm; and *f*, a magnet block.) The spring-loaded arm is so designed that readings at many stations can be taken with the magnet in the same position.

One essential factor for accurate stress-probing is that the pressure range to which the test vessel is subjected should be constant. Since it is obviously complicated to measure pulsating pressures, a special unit for doing this accurately has been devised, which is described fully in Report FE.12/23 of the British Welding Research Association. This is based on an electrical resistance strain gauge, the signals from which are measured by a sensitive mirror galvanometer with a suitably small periodic time.

Fig. 3, on page 97, shows the drum head of an experimental pressure vessel, on which the measuring stations have been marked. At each station, three measuring directions have been used. Where the directions of principal stresses were known, the measurement in the third direction served as a

check on the accuracy of the other two measurements while, at the other positions, from the three measurements, the directions and magnitudes of the principal stresses could be established. This illustrates one of the advantages of the stress-probing method. While a similar check on the accuracy of measurements with electrical resistance strain gauges would mean an increase by 50 per cent. in the number of gauges used, and in the time of installa-

tion, etc., with stress-probing such a check for each point can be obtained in a matter of a few seconds.

The gauge in position during measurement is shown in Fig. 4, on page 97. Results of these measurements can be seen in Figs. 5, 6 and 7, on this page. Results of measuring Series I and II are shown in Figs. 5 and 6, and those from Series III are shown in Fig. 7. It is important to note that, in this figure, the direction of the maximum principal

* "Undersökning av Svetsars Krympspänningar." *AGA Journal*, June, 1937.

† "Méthode des Mesures des Deformations Élastiques et Plastiques et des Tensions de Soudure." *Arcos*, April, 1951, page 3027.

STRESS PROBING.

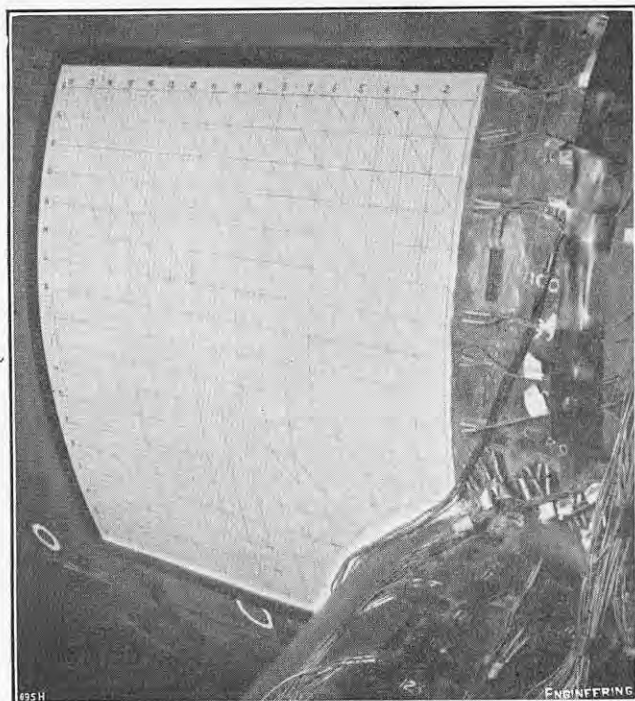


FIG. 8. MEASURING STATIONS FOR STRESS PROBING.

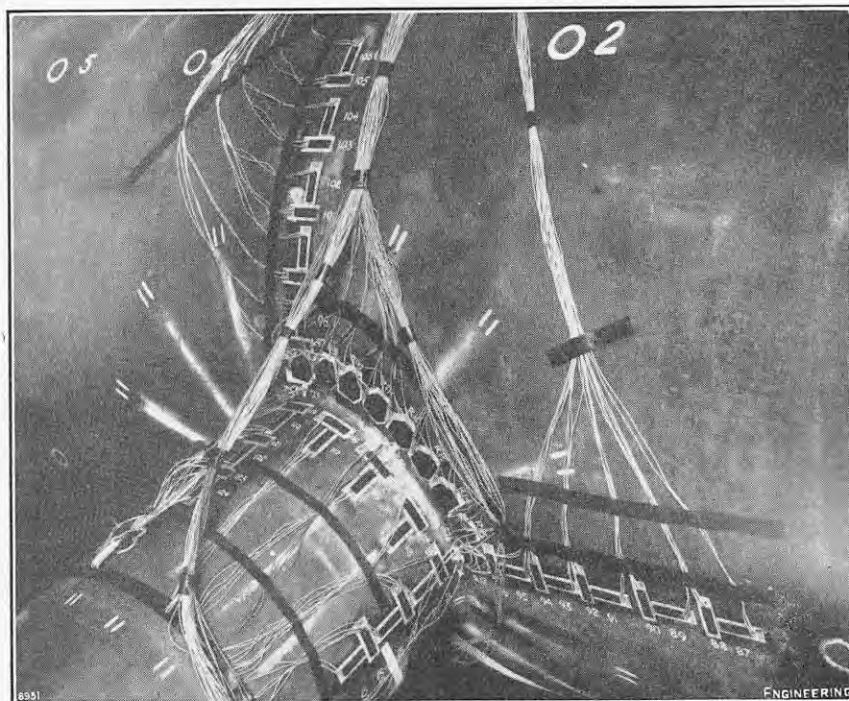


FIG. 9. DISTRIBUTION OF STRAIN GAUGES ROUND BRANCH.

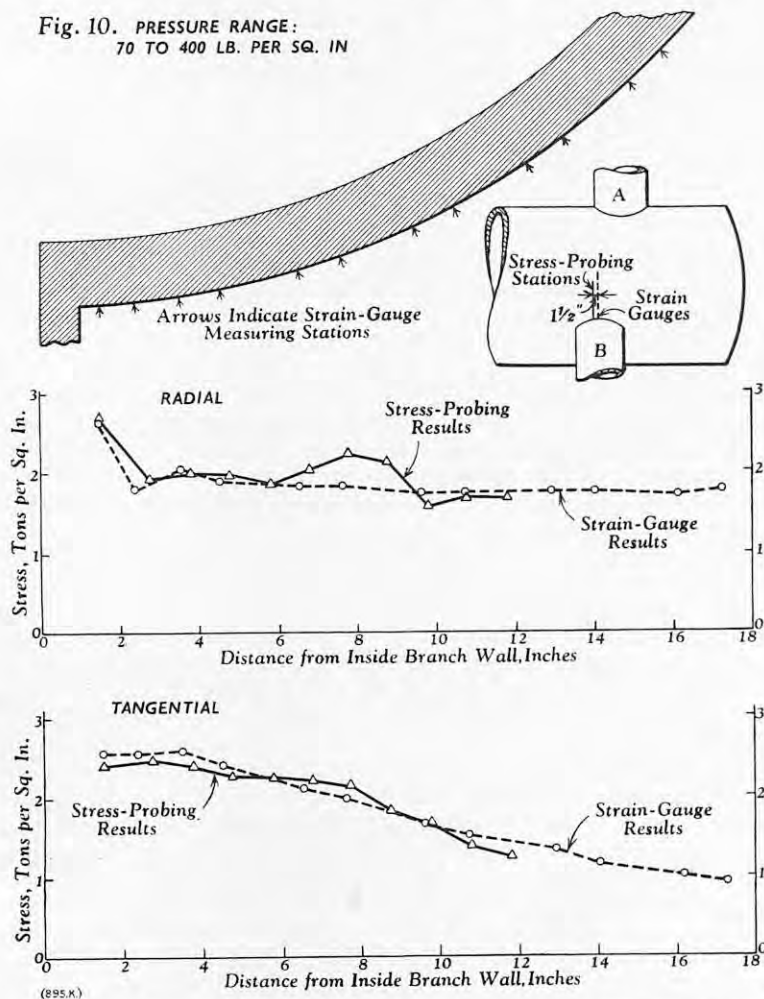
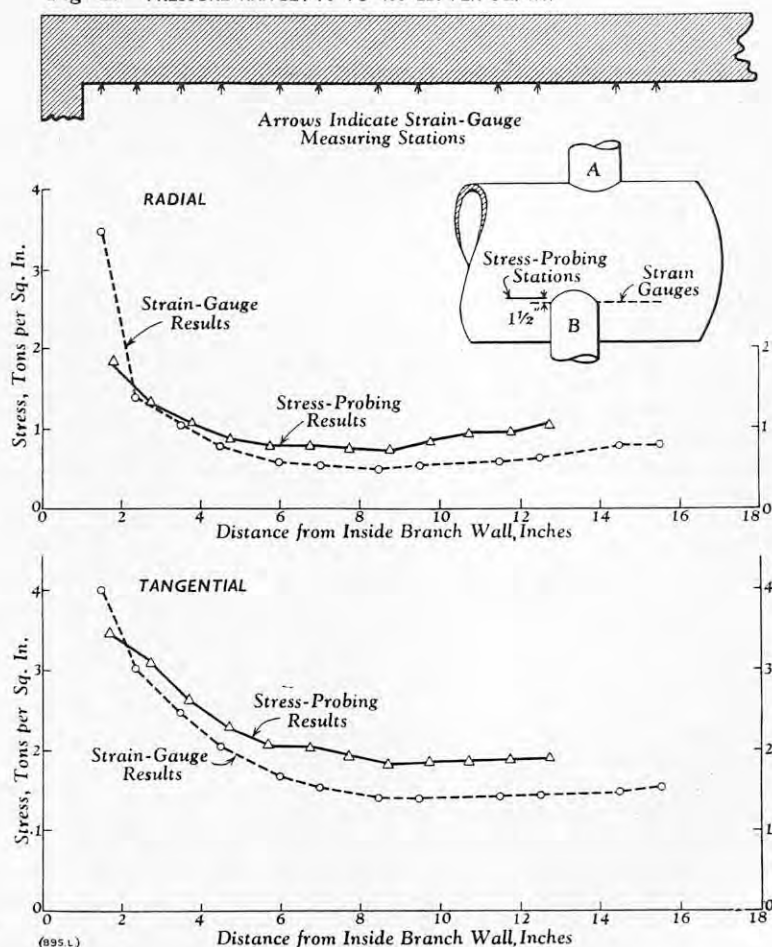
Fig. 10. PRESSURE RANGE:
70 TO 400 LB. PER SQ. IN

Fig. 11. PRESSURE RANGE: 70 TO 400 LB. PER SQ. IN.



stresses have been rotated through 90 deg. for convenience, while the directions of the minimum principal stresses are as shown.

A comprehensive stress survey of the type described above can be obtained by stress probing in about 10 to 12 hours. It is not easy to estimate the time which would be required if three electrical resistance strain gauges were applied at each measuring station, but it can safely be assumed that it would be at least 20 times as much. This does not mean, of course, that electrical resistance

strain gauges can be dispensed with in such investigations. It is essential in problems concerning shells of revolution to measure on both faces when it is desired to establish the stress distribution due to application of pressure or external loads. On the inside surface, electrical resistance strain gauges are still the only reliable means available.

In Fig. 5 are shown the results of stress-probing on the outside surface of a drum head, and measurements by electrical resistance strain gauge on the inside and outside surfaces. It should be noted

that, while the strain gauges had been applied on the lower half of the drum, stress-probing was carried out on the upper half so as to avoid having to remove the strain gauges; and that the two halves were not absolutely identical in thickness and shape. The method employed for measuring strains inside vessels under water pressure in this investigation has been described elsewhere.*

* Nicol Gross: "Experiments on Short-Radius Pipe Bends" (FE. 16/9, B.W.R.A.); "Experimental Stress Analysis," *Trans. Soc. of Engineers*, 1951.

A further comparison between measurements taken with electrical resistance strain gauges and those obtained by stress-probing was carried out on the shell of the same vessel in the vicinity of a welded-in nozzle. Fig. 8, on page 99, shows the location of the measuring stations for stress probing, which were at the intersections of the numbered and lettered lines; and Fig. 9 shows the distribution of the strain gauges. The lettered lines are in the direction of the longitudinal axis of the vessel and the numbered lines are in the direction of its girth. As can be seen, the first hoop line (1) is not identical with the axis of the strain gauges, the distance between the two being $1\frac{3}{8}$ in. The measurements taken along line A (the lowermost line in Fig. 8) are not only displaced by $1\frac{3}{8}$ in. with respect to the axis of the strain gauges, but are also on the opposite side of the branch, as shown in the small diagrams in Figs. 10 and 11, on page 99, where the results of the comparison are presented.

The comparisons between results obtained from strain-gauge measurements and stress-probing show very good agreement. The small differences which do exist can reasonably be attributed to the fact that the measuring stations used for stress-probing were not absolutely identical with those used for the electrical resistance strain gauges, as mentioned above. Differences in the geometry of the vessel in adjoining or corresponding sections can well explain such small discrepancies. The results outlined above show that the stress-probing technique can be used to replace most of the strain gauges which would be used to obtain a stress survey of the outside of a vessel. Strain gauges can be used afterwards at points of stress concentration, as detected by the stress probing. Stress-probing obviously cannot replace strain gauges for measuring stress inside vessels under internal pressure.

LITERATURE.

Advanced Engineering Mathematics.

By PROFESSOR C. R. WYLIE, JR. McGraw-Hill Book Company, Incorporated, 330, West 42nd-Street, New York 18, U.S.A. [Price 7-50 dols.]; and McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 64s.]

IN these days, the serious student of engineering should acquire a working knowledge of those parts of pure mathematics which are most frequently utilised in the mechanical sciences. In the course of the work, it is essential to realise that careful analysis of the principles taken as fundamental is more important in the present regard than in pure mathematics, since it matters little to the pure mathematician what is taken as fundamental. Experience also shows that a rigorous proof often provides the easiest way to render a statement reasonably plausible. Indeed, some of the most important results, of which Cauchy's theorem is an example, are so surprising at first sight that nothing less than a proof can make them credible. In his book, Professor Wylie places the right emphasis on these requirements by presenting his readers with reasonably adequate statements of conditions for the truth of the theorems that they are likely to use.

Following a systematic exposition of differential equations, including those of the simultaneous linear type, the author proceeds, in Chapter 4, to applications in the case of mechanical systems and electrical circuits. The method of presentation here brings the general problem of disturbances of a simple periodic character into close relation with the consideration of Fourier series and integrals by steps that lead easily to a chapter on the Laplace transformation, in the development of which the student is introduced to a novel procedure in obtaining the inverse forms of Laplace transforms of a periodic type. In the subsequent discussion of partial differential equations, due attention is

paid to questions involving the use of boundary values, and to the reason why Fourier series are inadequate for the purpose of expressing the transverse vibration of a beam with ends subjected to constraints.

The 16 chapters of the book cover the subject in an admirable manner, and they afford guidance on sections of the work which are of increasing importance in technology, as, for instance, Bessel functions, analytical functions of a complex variable, integration and infinite series in the complex plane, the theory of residues, conformal mapping, and the use of analytical functions in the study of fluid motion. The contents of some of these chapters may appeal more to those interested in applied mathematics than to the student of engineering, but the final chapters, on vector analysis and on numerical analysis, are of real value in most branches of engineering. Professor Wylie evidently realises that many students whose interests are mainly in applications have difficulty in following formal analysis, not on account of incapacity, but because they need to recognise the aim of the argument before their interest can be aroused. The evidence for this is further indicated by the inclusion of illustrative examples at appropriate places in the text, by the hints given to the solution of the exercises, which amount to more than 950 in all, and by the review, in the final 50 pages of the book, of the elementary principles of determinants and matrices, tests for convergence, the expansion of functions in Taylor's series of one or more variables, and other topics drawn from algebra and the calculus.

Finite Deformation of an Elastic Solid.

By PROFESSOR F. D. MURNAGHAN. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 4 dols.]; and Chapman and Hall, Limited, 37 Essex-street, London, W.C.2. [Price 32s. net.]

SINCE the classical theory of elasticity provides a complete and exact solution of certain practical problems of stress distribution, engineers have long used it as the foundation of calculations of strength and load-bearing capacity. Its applicability depends on a linear relationship between stress and strain, and, so far as the mathematical treatment is concerned, no other postulate is required save Hooke's Law and the simple fact of continuity; but this Law only holds within very small limits, so that the student not infrequently requires guidance in the analytical treatment of problems to which the linear theory cannot properly be applied. In his book, Professor Murnaghan meets this requirement by investigating the deformation of an elastic solid in the case where the deformation is not so small that squares and higher powers of the components of strain can be neglected.

Of the seven chapters in this informative book, the first is devoted to vectors and matrices because the theory of finite deformation of an elastic solid is most easily presented and understood by the use of matrices. These topics lead to the consideration of the strain matrix, in the next chapter, where the reader is introduced to the important matter of invariance, and to the compatibility relations between the elements of the strain matrix and their derivatives. Some of the mathematical operations in this part of the work are quite formidable for those who are not well trained in tensor calculus, but the author has wisely indicated those sections of the text which may be omitted in a first reading. Further exposition of the matrix analysis occurs in Chapter 3, where the connection between stress and strain brings under review the essential conditions of equilibrium, and the virtual work in any virtual deformation. Here, as in other parts of the study, due attention is paid to important details, such as the gradient of a function of a matrix, in the discussion of elastic energy,

which is followed by a section on the general problem of boundary conditions.

The statement that a deformable medium is isotropic if it is elastically insensitive to every rotation of the initial rectangular Cartesian frame of reference may be regarded as a noteworthy point of departure, in Chapter 4, in the process of formulating the elastic constants of an isotropic medium. Two points merit special notice at this stage of the work: the remarkably close agreement indicated by the subsequent comparison of theory with experiment in the case of extremely high hydrostatic pressures, and the demonstration of the fact that applied stress can render non-isotropic a medium which is isotropic when free from stress. As may be expected, the derivation of the relation between stress and strain for non-isotropic media is much more complicated than for isotropic media; even in the classical theory, many more elastic constants are required than the two that suffice for elastic media. But, for the second-order approximation, in which the number of elastic constants usually becomes so large that the theory is too complicated for practical purposes, it is possible to construct an integrated linear theory that is useful in practice, as is shown in Chapter 5. The way in which theoretical considerations are directed to practical ends is further indicated by the utilisation of a modified stress matrix, first, in the discussion of simple shear and tension, and, second, in the final chapter, in the solution to the problem of a spherical shell or a circular tube under compression, and a circular cylinder in torsion. The book as a whole sets an attractive pattern for the development of the non-linear theory of elasticity.

Coast Erosion and Protection: Studies in Causes and Remedies.

By R. R. MINIKIN, Chevalier de la Legion d'Honneur. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 30s. net.]

READERS of this book who are also long-standing readers of ENGINEERING will be reminded inevitably of the contributions made to our columns between the wars, by the late Mr. Ernest Latham, M.I.C.E., whose work as a consulting engineer was concerned so largely with the problems of coast erosion and its prevention; for, although Mr. Minikin's survey extends over a wider field, many of the examples which he describes and illustrates relate to the south coast of England, where a great deal of Mr. Latham's best work was done as several textual references indicate. This area, indeed, provides a wide variety of such examples, and presents also some peculiar conditions, such as the 11 miles of naturally-graded shingle along Chesil Bank, Dorset, and the shingle banks which close or almost close the estuaries of several of the small rivers flowing into the English Channel; these are treated in some detail.

That some other peculiarities of coastal erosion and accretion, such as those to be observed to the north and south of the Mersey estuary, are not discussed at greater length is to be explained, perhaps, by the author's observation, in the concluding paragraph of his preface, that the proper appreciation of the behaviour of shores requires "the development of a sea-sense, a quality only acquired from intimate contact and patient study of all that happens on a beach"; the inference is that Mr. Minikin has had greater opportunity to study those on the south coast. It would have been interesting, however, to have had his comments on, for instance, the periodic piling up and washing away, at intervals of some ten or eleven years, of the sand along the seaward line of the Wirral peninsula, in Cheshire. Nevertheless, the book as it stands is a useful contribution to the literature of the subject, which should be welcomed by those who share Mr. Minikin's long interest in it, and also by those who seek dependable information without having the direct responsibility of advising upon coastal protection.

DETERMINATION OF THE DRY WEIGHT OF FILTER PAPERS.

By H. H. WATSON.

DURING some recent investigations at the Pneumoconiosis Research Unit of the Medical Research Council at Llandough Hospital, Penarth, Glam., it was required to obtain the weight of fine coal dust caught on a standard Whatman No. 41 filter paper 5.5 cm. in diameter. The paper was supported in a suitable holder, the dust from a measured volume of air being deposited uniformly over a central area 3.9 cm. in diameter. As only some 3 to 10 mg. of dust were collected, weighing had to be done as accurately as possible. A micro-balance was available, but, to speed up operations, it was decided to use an Oertling air-damped balance. Weights were thus estimated to 0.1 mg., which is one half of the smallest division of the projected scale.

Paper and finely divided coal are both very hygroscopic and it was realised that some care would have to be taken to dry the filter papers and to keep them dry until they were weighed. Some considerable preliminary investigation was done to ascertain the accuracy with which Whatman No. 41 filter papers could be weighed. Each paper was dried and weighed both before and after fine coal-dust had been deposited on it.

METHODS USED TO DRY AND WEIGH.

A circle of paper was folded along a diameter, but without creasing, and then rolled into a loose cylinder such that it could be easily inserted into a neckless glass weighing bottle, 1.75 in. high and 0.75 in. in diameter. The paper was numbered with an ordinary B grade graphite pencil on the side opposite to that on which the dust was to be deposited. The number was then on the outside of the loose cylinder and could be read while the paper was in the weighing bottle. The weighing bottle, with its stopper at its side, was placed in an air-oven and left overnight at a temperature thermostatically controlled at 105 deg. C. Usually, some six to eight bottles were treated at the same time.

In the morning, the oven was opened, the stoppers replaced with forceps and the bottles transferred to cool in a desiccator containing anhydrous. After a cooling period of an hour or more, weighing was started. Each bottle was first weighed with the paper and then without the paper. Transfer of the paper to and from the bottle was done with forceps. It was found convenient to transfer the hot bottles by hand from the oven to the desiccator, the fingers being protected from heat by a piece of clean linen lawn. The cold bottles were transferred with clean uncovered fingers, as handling and wiping a bottle with a linen lawn often affected the immediate weight, which then took several minutes to attain apparent constancy. With the method adopted, steady deflection on the balance scale was obtained; the mean of three readings was taken, the balance arm being lowered between each. No difficulty was experienced in uncurling a paper, folded in the manner described above, in order to place it flat in the dust-sampling instrument, where it was held between two fibre washers.

A single paper weighed about 0.2 g. After the first weighings, the papers were replaced in their respective weighing bottles and the process of drying, cooling and weighing was repeated. The results of such duplicate weighings of 60 clean filter papers, and of 32 on which dust had been deposited, are as shown in Tables I and II, herewith. The standard error of a single weighing with clean papers was estimated as 0.080 mg., and so it can be said that, on 95 per cent. of occasions, the error in the determined weight of the filter paper will not

TABLE I.—Clean Papers.

Difference Between Successive Weighings, mg.	No. of Papers.
+0.2	8
+0.1	15
0	20
-0.1	13
-0.2	4

TABLE II.—Papers with Dust.

Difference Between Successive Readings, mg.	No. of Papers.
+0.2	1
+0.1	6
0	10
-0.1	13
-0.2	2

exceed ± 0.16 mg. The standard error with papers and dust comes to 0.070 mg., so that, on 95 per cent. of occasions, the error in weighing will not exceed ± 0.14 mg.

DISCUSSION OF RESULTS.

The above results indicate that highly reproducible drying was obtained, and that differences between successive weighings were possibly no larger than those to be expected with the balance that was used. In other words, the limitations of weighing accuracy were possibly set by the balance. It was realised that it was not necessary to dry in the oven for more than an hour or so, but it was convenient at first to adopt a procedure whereby the papers were left in the oven overnight. This point is referred to below. Each paper was weighed before and after receiving its dust load, and so the standard error of the determined weight of dust on a single paper was 0.11 mg. The weight of dust found was the "dry" weight.

Belcher and Mott* have shown that fine coal is a very hygroscopic substance, and a better desiccant than most materials commonly used for drying; thus it is essential for the stoppers of the weighing bottles to be inserted as they are removed from the oven. Weighing bottles as received from manufacturers will often not be moisture-tight. This was shown by leaving stoppered bottles with dried papers on the open bench over a week-end, when gains of 1 to 2 mg. were recorded. Smaller gains were obtained after re-grinding the stoppers in their respective necks. No trouble was experienced, however, with any bottle when it was left for a long period in a desiccator containing anhydrous, the stopper being inserted on removal from the oven.

The results given above do not necessarily give more than a measure of the constancy of weighing; there may be consistent errors that are not revealed, both in the determined weight of paper and of coal-dust. The possibilities are (a) the paper may be damaged slightly by manipulation and insertion in the apparatus, so that, on re-weighing with the coal dust, the measured change (increase) in weight is not truly that of the dust. To test this point, a number of papers of determined clean weights were placed in turn in the dust-sampling apparatus. No dust was drawn through the apparatus, but it was carried round as it would be in practice, and on several occasions actually into a coalmine. The actual results are given in full in Table III, herewith. It is concluded that no error occurred due to manipulation of the papers.

(b) Heating at 105 deg. C. may cause some decomposition of the cellulose. Davidson and Shorter† report that such changes are negligible for bleached cotton, up to 130 deg. C., but become significant at higher temperatures. No errors would be expected in the above results, therefore, on this account.

* R. Belcher and R. A. Mott, *J. App. Chem.*, vol. 1, page 204 (1951).

† G. F. Davidson and S. A. Shorter, *Shirley Institute Memoirs*, vol. 8, page 197 (1929).

(c) Room air when heated to 105 deg. C. is not absolutely dry; therefore, the true dry weights were not obtained. The determined "dry" weight depends on the actual relative humidity in the oven, which is a function of oven temperature

TABLE III.—Effect of Manipulating Papers.

Paper No.	First Weights, gm.	Weights After Manipulation, gm.
22	0.2068 0.2068	0.2067 0.2068
50	0.2089 0.2087	0.2087 0.2087
51	0.1925 0.1927	0.1926 0.1926
54	0.2065 0.2065	0.2064 0.2064
57	0.2010 0.2010	0.2010 0.2010

and the absolute humidity of the room air. Thus, room air at 70 deg. F. (21.1 deg. C.) and 50 per cent. relative humidity will, when heated to 105 deg. C., have a relative humidity of 1.0 per cent. Table IV, herewith, gives further information on this point.

TABLE IV.—Effect of Relative Humidity.

Room Air.		Rel. Hum., per cent., in Oven.	
Deg. F. (Deg. C.)	Rel. Hum., per cent.	80 Deg. C.	105 Deg. C.
70 (21.1)	90	4.8	1.9
	70	3.7	1.5
	50	2.6	1.0
	30	1.6	0.6
80 (26.7)	90	6.7	2.6
	70	5.2	2.0
	50	3.7	1.5
	30	2.2	0.9

It is clear, therefore, that, for highly accurate and consistent results to be obtained, papers must be dried under controlled specified conditions. No measurements were made of the hygrometric state of the air in the room containing the oven, but some indications of possible errors can be obtained. The true dry weight of cellulose is defined by Davidson and Shorter* as the constant weight obtained by prolonged exposure at room temperature to the dry atmosphere produced by phosphorus pentoxide. This is a reproducible magnitude, and is the same as that obtained when air which has been artificially dried and heated (up to 130 deg. C.) is used to dry cotton (and, by inference, paper). On the other hand, if the cotton is heated in undried air, the weight is greater than the true dry weight. The difference is termed the moisture regain, and, for pure cotton at 100 deg. C., is about 0.2 per cent. of the true dry weight (0.25 per cent. in summer and about half in winter). The same approximate values are assumed for Whatman No. 41 filter paper. For a paper of mass 0.2 gm., the regain at 105 deg. will be approximately 0.4 mg. when the room air is at 70 deg. F. (21.1 deg. C.) and 60 per cent. relative humidity. Under these conditions the relative humidity in the oven will be 1.2 per cent. Should the room condition change, the regain at 105 deg. C. will change, too. Table V,

TABLE V.—Approximate Moisture Regain of No. 41 Papers in Oven at 105 deg. C. with Room Air at 70 deg. F. (21.1 deg. C.), at Various Relative Humidities.

Relative Humidity, per cent.	Regain, mg.
40	0.26
60	0.40
80	0.51
90	0.60

herewith, gives calculated values under different conditions; they are not quite absolute, but little error is likely in the differences between values.

* Loc. cit.

The error introduced by a change in relative humidity of from 60 per cent. to 40 per cent. is 0.14 mg., and from 60 per cent. to 90 per cent. is 0.20 mg.

(d) There may be changes in the weight of the fine coal-dust due to heating for long periods at 105 deg. C. Schmidt* has reviewed the published information on the rate of oxygen take-up by coal at different temperatures. In general, the amount X of oxygen taken up in time t is given by:

$$X = Ct^b,$$

where C and b are terms that depend on the temperature, the particle size and the type of coal. For instance, calculation shows that the 200-mesh coal from the Barnsley seam in Yorkshire takes up oxygen, when heated in air at 100 deg. C., as shown in Table VI, herewith.

TABLE VI.—Absorption of Oxygen by Coal.

Values of t .	O ₂ Taken Up, Per Cent. of Coal-Substance.
1 hour	1.2
2 "	1.6
1 day	3.9
2 "	5.1
3 "	5.9

Some of the oxygen taken up probably remains "attached" to the coal, while some combines with carbon and escapes as CO₂ or CO, or as water by combination with the hydrogen. Thus, it would not be expected that the coal would increase in weight by as much as the oxygen take-up; in fact, there may be a small net loss. The dusts collected on the filter papers in the present series were very fine, with a maximum particle size of about 15 μ . The specific surface was about 15,000 sq. cm. per gramme, compared with one of about 3,000 sq. cm. per gramme for 200-mesh graded coal. Schmidt† gives evidence to suggest that the rate of oxygen take-up varies as the one-third power of the specific surface. Thus, it would be expected that—15 μ Barnsley coal dust would take up oxygen at a rate 1.71 times faster than indicated in Table VI. It is reasonable to expect that South Wales coal dusts, which were used in the present investigation, would take up oxygen more slowly than coal from the Barnsley seam.

Any change in weight of the coal (gain or loss) occurring during the first overnight heating (say, for 16 hours) would not be determined by the technique used. The change during a further similar heating must have been very small; it was certainly less than 0.1 mg., corresponding to less than 2 per cent. on 5 mg. A change of 1 per cent. during the second 16-hour period would correspond with one of 3.4 per cent. during the first 16-hour heating period. It is not possible to be sure, therefore, to within some 3 to 5 per cent., of the correct dry weight of coal dust when using the above technique, when the actual weight of dust is about 5 mg. Drying would have to be done in a stream of inert gas, such as nitrogen, for higher accuracy to be obtained. A suitable apparatus is described in British Standard Specification No. 1016-1942 (Fig. 2a).

FURTHER INVESTIGATIONS ON WEIGHING FILTER PAPERS.

The points discussed above led to a number of further investigations, which were carried out by Mr. S. R. Morgan, on clean Whatman No. 41 papers.

Moisture Regain at 105 Deg. C.—It would have taken too long to determine absolute dry weights by drying over phosphorus pentoxide, and so the papers were placed in an oven, held thermo-

statically at 83 deg. C., through which dry air was passed. The air-drying train consisted of a sulphuric-acid bubbler, followed by a droplet trap and a bed of anhydrous. The oven capacity was 32.5 litres, the dry air being passed at a rate of 6 litres per minute. Before emerging into the oven space, the dry air was preheated by being passed through a flat coil of thin-walled copper tubing placed on the floor of the oven. A series of seven papers was weighed after drying at 105 deg. C. in the normal way and then in dry air at 83 deg. C. The mean moisture regain at 105 deg. C. was found to be 0.51 mg. This is consistent with the regain calculated above for room air at 70 deg. F. (21.1 deg. C.) and a relative humidity of 80 per cent. All papers were weighed six times after each method of drying. Repeat weights were consistent with the standard error reported above for the first series of weighings. The range of weights of individual papers was 0.1996 to 0.2088 gm.

Time to Reach Constant Weight.—This short series was done in the dry-air oven at 83 deg. C. After an initial heating for two hours, a constant weight was obtained (11 papers). A similar result was found after drying for one hour (three papers only).

Effect of Passing Clean Moist Air Through Paper.—When dust samples are taken on a filter paper, air is drawn through it for long periods. In coal mines, for instance, this air may have a high humidity. To determine whether any permanent changes occurred in the paper under these conditions, filtered humid air was drawn at 350 c.c. per minute for seven hours through three different papers, of which the original true dry weights (83 deg. C.) had been determined. The results shown in Table VII, which were obtained with three different papers, suggest that no change in the paper occurred during the treatment that was given.

TABLE VII.—Absorption of Moisture by Papers.

—	No. 1.	No. 2.	No. 3.
Original weight of paper (gm.)	0.1865 0.1864	0.1869 —	0.1786 0.1785
Treatment (7 hours)—			
Air at: Deg. C.	21.0	25.0	25.2
Per cent. R.H.	80.0	100.0	99.0
Moisture content of air mg.	14.5	22.8	23.0
Moisture absorbed by paper, mg.	12.4	28.3	27.5
Final weight of paper, gm., after re-drying	0.1864 0.1864	0.1866 —	0.1785 —

INSTITUTE OF MATERIALS HANDLING.—Since the formation of the Institute of Materials Handling, 20-21, Took's-court, Cursitor-street, London, E.C.4, which was recorded on page 751 of our 173rd volume (1952), the secretary reports that 360 applications for membership have been received. Three main committees have been set up, to deal respectively with executive matters and membership, programmes and publicity, and finance. It is hoped to hold discussion meetings in London, Birmingham and Manchester at the end of September, and to hold an inaugural general meeting and dinner in October. Further details of the programme for the autumn and winter sessions will be announced shortly.

IRON AND STEEL DISTRIBUTION.—A number of changes in the Iron and Steel Distribution Scheme are detailed in the Iron and Steel Distribution (Amendment No. 2) Order, 1952, on sale at H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2d. net.] A revised edition of *Notes for Consumers* will also be available shortly at H.M.S.O. Manufacturers of products incorporating springs will in future have to give the spring manufacturers a sub-authorisation from their main allocation; the amount of electrical conduit which can be obtained without permit has been reduced to 3 cwt. a month; and some relaxations have been made in the restrictions on the use of alloy steel containing nickel and molybdenum.

TRAINING FOR ENGINEERING DEVELOPMENT.

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

In these days of specialisation, it is not easy for a young man to obtain direct experience in carrying out a piece of engineering development work entirely on his own. In a large organisation he is inevitably a small component; he is expected to do a particular job with material and information supplied to him. Neither he nor perhaps any other member of the organisation is familiar with every facet of the work involved in transforming an idea into physical reality. A member of a small firm has a much better opportunity of perceiving the general picture, but in that case it may be a rather narrow one, on a small scale. The level of technical training expected nowadays leaves little room for anything but intensive study in the time available, and it is only at post-graduate level that there is any possibility of undertaking original work.

It is also true that not all students have the ability to profit by advanced instruction or by opportunity to do research work. There is at present some waste of time and effort in giving higher education to students who lack the ability or the perseverance necessary to gain anything useful from it. Evidence that a man has the qualities required to produce a successful engineer may not appear until he has spent some years in industry, because engineering is more than book-learning; and so there is justification for postponing any special instruction in engineering development until the individual has proved himself in theoretical study, practical work and personal qualities. A post-graduate course for students already known to have the desirable attributes can be expected to succeed, whereas indiscriminate extra education is often uneconomic.

In the last few years a number of post-graduate schools have been established in Great Britain, and of these the one at Sheffield University deals with the subject of applied mechanics. This title may be interpreted in various ways, but in view of the needs that suggested the recent development of post-graduate schools, the emphasis has been on the application of the principles of mechanics to problems in mechanical engineering. In the session just completed the students have taken lectures on the application of modern techniques in stress analysis, lubrication, vibration and metrology. The subject of gear design, a specialised branch of kinematics, but one of wide importance in engineering, has been studied in a utilitarian way. It was examined as a good example of a subject in which practical success is attainable despite theoretical uncertainties, and in which long-standing pedantry can be short-circuited by free thinking. Each student also undertook research work of a nature that offered reasonable expectation of useful results in a few months. Each one was left to examine existing knowledge on his subject, to propose a procedure, and after approval to design apparatus, to obtain material, to build or otherwise to acquire what he needed, to do the work and to report on it.

Current revision of British Standards on gears suggested the subject-matter of one of these research items. Full use of the flexibility of the involute system will lead to a wider variety of standard gear-tooth forms than was envisaged in the existing Standards, and so more information is required about values of the strength factor, which is the ratio of load per unit width of tooth of unit diametral pitch to the maximum tensile stress in the tooth. The values of the strength factor in the existing specifications were obtained by calculation on the simple Lewis basis; the effect of stress

* L. D. Schmidt, *Chemistry of Coal Utilisation*, vol. 1, ch. 18 (edited by H. H. Lowry), John Wiley and Sons, New York (1945).

† *Loc. cit.*

HEAT TRANSFER IN WASTE-HEAT BOILERS.

Fig. 1.

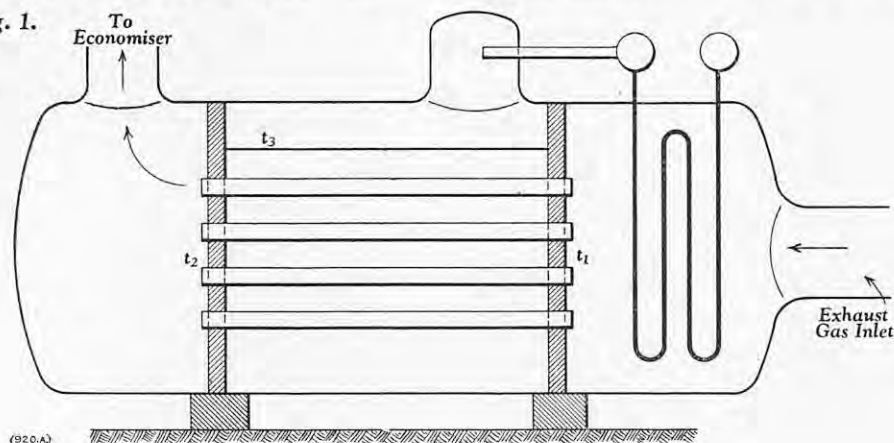


Fig. 2.

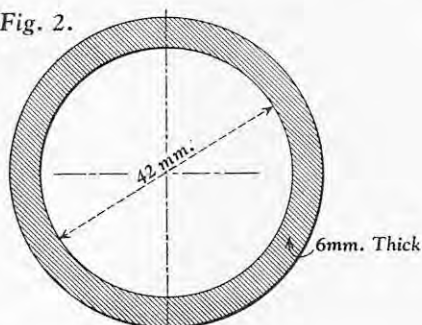


Fig. 3.

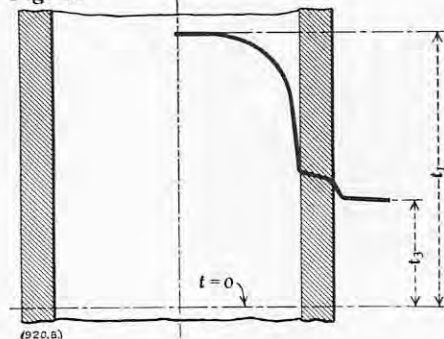


Fig. 4.

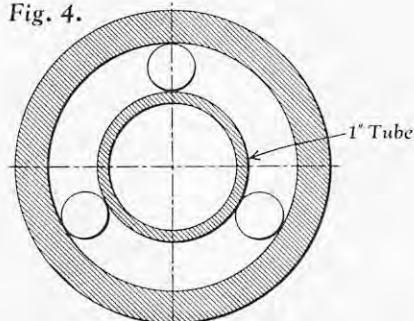
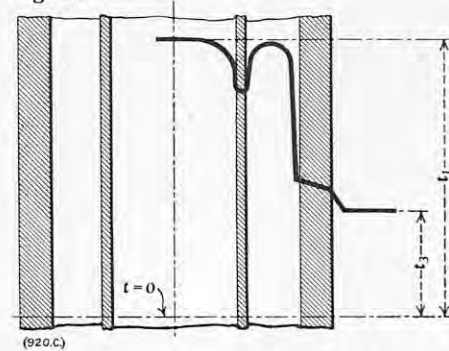


Fig. 5.



concentration was vaguely taken into account in fixing basic allowable stresses for the various materials. In this new investigation it was decided to use photo-elastic analysis to ascertain the relation between load and maximum stress without requiring the concept of the "stress-concentration factor," which is in general the ratio of the actual maximum stress to the maximum stress calculated in some easy but optimistically inaccurate manner.

Partly to save expense and partly because of the technical interest of the scheme, the optical system was designed so that no lenses are needed. Three 250-watt mercury-vapour lamps provide adequate illumination for visual examination or photography of the photo-elastic fringe patterns in Columbia Resin No. 39 models of 1 diametral-pitch teeth, which, finished by careful filing, are permanently free from appreciable edge-stresses. To cover the full scope of the investigation, several hundred stress patterns must be formed, recorded and analysed. This work has not yet been completed, but the clarity of the fringes and the consistency of the results so far achieved guarantee a successful conclusion. Contact stresses can in fact be determined without difficulty and certain features of the figures promise to make this an unexpectedly interesting by-product of the work.

This research has proceeded with a rapidity possible only for a worker who combines keen interest with a complete disregard for the 40-hour week, and these qualities are shared by the other students who participated in the course. There

were ten of them, drawn from widely different branches of engineering industry, and the mingling of diverse types of person with a great variety of experience has in itself been educational to all. Research was undertaken by other students on photo-elastic analysis of stresses in press frames, on short-life fatigue of notched specimens, on strength of steels at very low temperatures, on a special problem in lubrication, on friction between materials of special composition, and on measurement of surface finish by optical interference. A most gratifying proof of the exceptional interest taken by the students in the course was a suggestion made by them that, after the final examination, there should be a meeting of staff and students to discuss the extent to which the original aims and intentions had been achieved. This meeting was appreciated by the staff, who had had their own ideas on the subject, and from it have been derived hints for improving, during the 1952-53 session, on the more than satisfactory progress made in the first year of the school.

The one-session course, which extends from October to June, is open to graduates in engineering or physics and to non-graduates with comparable technical training. Graduates may use original work done during the course to form a thesis for a Master's degree. Graduates and non-graduates are eligible for a Diploma on successful completion of the one-session course. Longer courses are arranged for students who wish to work on special projects, and graduates who do this may thereby qualify

for the Ph.D. degree. While the possibility of obtaining a higher degree is an obvious attraction, the main aim of the school is to give the student experience in the application of theoretical principles to practical problems and to fit him for the responsibility of original investigation and development work in the engineering industry. Many young men who are capable of such work have not had a chance to practise in it. The Sheffield Post-Graduate School of Applied Mechanics is a means whereby employers may give their promising engineers a good start in this direction.

IMPROVED HEAT TRANSFER IN WASTE-HEAT BOILERS.

By ING. DR. RICHARD DOLEŽAL.

In this article, a method of improving heat transfer in waste-heat boilers is described, the example cited being a boiler designed to utilise the heat of the exhaust gases of internal-combustion engines working with blast-furnace gas. These gases were relatively clean, containing only the small dust particles which managed to pass through the mechanical and fluid blast-furnace gas cleaners.

A diagrammatic cross-section of the reconstructed boiler is shown in Fig. 1, herewith. The boiler has a heating surface of 200 square metres and was designed to supply superheated steam at a pressure of 12.5 kg. per square centimetre and a temperature of 320 deg. C. After the boiler was put into service, it was found that the economiser was too large, so that the temperature of the feed water leaving the economiser was nearly as high as that of the saturated steam in the boiler. As a result of this, the water sometimes boiled in the economiser, when the feed was irregular. The rate of heat transfer of the boiler heating surfaces was lower than the value assumed by the designers and consequently the output of steam was lower and the steam pressure obtained was also below the designed figure.

Reconstruction work was necessary to reduce the feed water temperature in order to eliminate the risk of boiling in the economiser. It was not advisable to reduce the surface of the economiser, because that would have led to further reduction of the steam output and boiler efficiency. To improve the operating conditions of the installation, it was decided to increase the coefficient of heat transfer of the boiler heating surface by the method described below.

A cross-section of a tube of the boiler is shown in Fig. 2. The heat transfer through these tubes is mainly by convection, as the mean temperature of the exhaust gases is too low, and the cross-section of the gas stream is too small, to produce an appreciable heat transfer by radiation from the gas stream. The temperature characteristic across the stream of the exhaust gases, the tube wall and the water is shown in Fig. 3, which represents the conditions at the inlet end of the tube.

To increase the rate of heat transfer through the tube, a thin-walled tube of a smaller diameter was inserted into the boiler tube, as shown in Fig. 4. The inserted tube is open at both ends and was centred by means of three small spacers cut from steel rod and welded on to the inserted tube. As these spacers are not joined to the outer tube, the whole insert can be removed if necessary.

After the tube was inserted, the gas flowed through the inside of the inserted tube and also through the annular space between the inner and outer tubes. As a result, the temperature of the inserted tube increased to a value which was lower than the temperature of the gases, but higher than that of the outer tube. The temperature characteristic of the whole assembly is shown in Fig. 5. The temperature of the inserted tube being less than the mean temperature of the gas stream, the gas gave up part of its heat to the inside and outside surfaces of the inserted tube which, however, was considerably hotter than the outside tube, which was cooled by the surrounding water. The inner tube therefore transferred part of its heat to

the outer tube by radiation. The transfer of heat through the inserted tube being by conduction, it was necessary to keep the wall thickness of this tube to a minimum and to use a material having a good heat conductivity, i.e., mild steel.

Inserting the thin-walled inner tube caused only a negligible increase of the gas speed, but the hydraulic radius of the gas stream in the tube was considerably reduced, which brought about an increased heat transfer by convection from the gases to both tubes. The inside tube was inserted for the sole purpose of increasing the heat transfer and it was therefore not necessary to use high-quality tubes for the purpose; in fact, cheap reject tubes were used.

The pressure loss of the exhaust gases increased only very slightly after inserting the inner tubes as a result of turbulence at the entry and exit, because these losses are mainly dependent on the velocity of the exhaust gases in the tube, which remained practically unchanged. Pressure losses due to friction of the gases along the tube surfaces increased because of the reduced hydraulic radius of the gas stream, but these losses are small compared to those due to turbulence at the inlet and outlet ends of the tubes; and therefore the total pressure loss increased only slightly as a result of the presence of the inserted tubes.

Before fitting the inner tubes, various values were measured; these are given in the first column of Table I, herewith. After fitting the insert tubes, measurements were again made, the values being as shown in the second column of the Table. It is necessary to bear in mind that hard untreated feed water was used. When the boiler was taken out of service, it was found that the heating surfaces of the economiser were covered by a very thick layer of scale, which certainly affected adversely the heat-transfer values obtained during the tests. Those carried out before the inner tubes were fitted were made after cleaning the economiser.

Before the inner tubes were fitted, the feed water was heated from a temperature of 165 deg. C. at the exit from the economiser to the boiling temperature of 185 deg. C., the evaporation being at a rate of 2.38 tons per hour. The necessary heat quantity $Q = 1.185 \times 10^6$ kcal. per hour.

TABLE I.—Test Results.

	Before Fitting Tube Inserts.	After Fitting Tube Inserts.
Steam output N, tons per hour	2.38	2.50
Steam pressure p, kg. per sq. cm.	10.1	12.5
Feed-water temperature at T_1 inlet to economiser, deg. C.	62.0	66.0
Feed-water temperature T_2 at exit from economiser, deg. C.	165.0	144.0
Exhaust-gas temperature t_1 at entry into boiler tubes, deg. C.	516.0	515.0
Temperature of the exhaust gases t_2 at exit from boiler tubes, deg. C.	287.0	264.0
Water boiling temperature in the boiler, deg. C. t_3	185.0	192.0
Quantity of exhaust gases (calculated values), M cub. m. per hour	17,300.0	16,900.0

The average value of the heat drop between the exhaust gases and the water boiling temperature in the boiler was, according to the values of the first column of Table I,

$$\Delta t = \frac{1}{2}(t_1 + t_2) - t_3 = \frac{1}{2}(516 + 287) - 185 = 216 \text{ deg. C.}$$

As the heating surface of the boiler was 200 sq. m., the heat absorption rate was:

$$q = \frac{Q}{F} = \left(\frac{1.185 \times 10^6}{200} \right) = 5,900 \text{ kcal. per sq. m. per hour,}$$

and the heat-transfer coefficient through the tube wall was:

$$k = \frac{q}{\Delta t} = \frac{5,900}{216} = 27.3 \text{ kcal. per sq. m. per hour per deg. C.}$$

After fitting the tube inserts, the measured steam output was higher and the feed water temperature was lower (see second column of Table I) and the heat quantity absorbed in water heating and steam generation was: $Q = 1,300,000$ kcal. per hour and the mean value of the heat drop is (2nd column of Table I)

$$\Delta t = \frac{1}{2}(t_1 + t_2) - t_3 = \frac{1}{2}(515 + 264) - 192 = 197 \text{ deg. C.}$$

The heat absorption rate of the heating surfaces was, therefore,

$$q = \frac{Q}{F} = \frac{1,300,000}{200} = 6,500 \text{ kcal. per sq. m. per hour;}$$

and the coefficient of heat transfer through the tube surfaces was

$$k = \frac{q}{\Delta t} = \frac{6,500}{197} = 33.0 \text{ kcal. per sq. m. per hour per deg. C.}$$

Comparing the values obtained for the heat-transfer coefficient before and after fitting the tube inserts, it was found that there was an increase of $100 \left(\frac{33.0}{27.3} - 1 \right) = 21$ per cent. This value is in good agreement with that obtained by calculation. Calculations also show that the increase is due partly to heat radiation of the inserted tube and partly to increased heat transfer by convection, resulting from the reduced hydraulic radius of the stream of exhaust gases. These factors contribute approximately equal shares to the increase of the heat transfer.

Fitting of the insert tubes proved fully successful, the temperature of the water at the exit of the economiser falling from 165 deg. to 144 deg. C., i.e., by 21 deg. C. The steam output also increased slightly, as shown, from 2.38 tons to 2.50 tons per hour—about 5 per cent.; and the steam pressure increased to the desired value of 12.5 kg. per square centimetre, in spite of the fact that the water coming from the economiser was cooler.

The gas input during the second series of tests was 2 per cent. less than during the earlier measurements, made before fitting the insert tubes, and the inflow remained practically unchanged. As the boiler output was 5 per cent. higher than in the earlier tests, the efficiency of the boiler increased by $100 \left(\frac{1.05}{0.98} - 1 \right)$, i.e., by about 7 per cent.

The increase would have been larger if softened feed water had been used. After the inserts had been in continuous service for over a year, the surfaces of the flue-gas tubes and the insert tubes were found to be perfectly clean.

The boiler installation is in operation 6,500 hours per annum. As a result of fitting the insert tubes, the steam generation increased from 2.38 to 2.5 tons per hour, i.e., by $(2.5 - 2.38) \times 6,500 = 780$ tons per annum. On the basis of costs of material, labour and steam production in Czechoslovakia, and taking into consideration an interest rate of 3.25 per cent., depreciation of 5 per cent. per annum and an additional 5 per cent. as possible maintenance costs, the net saving per boiler was approximately equivalent to the value of 720 tons of steam per annum. Thus, by fitting the insert tubes the feed-water temperature was reduced by 21 deg. C., the steam output increased by 5 per cent., the overall efficiency by about 7 per cent. and a considerable financial saving was obtained.

COURSES IN HIGHER TECHNOLOGY.—A list of advanced courses in various branches of technology commencing in the autumn, in the London district has been issued by the London and Home Counties Regional Advisory Council for Higher Technological Education, in Part I of their *Bulletin of Special Courses in Higher Technology*, 1952-1953. Part II of the *Bulletin*, covering the spring and summer of 1953, will be issued in December. The bulletin may be obtained from the Secretary of the Regional Advisory Council, Tavistock House South, Tavistock-square, London, W.C.1, at a price of 2s. 6d. for both parts.

SIR JOHN CASS COLLEGE.—The prospectus for the 1952-53 session of Sir John Cass College, Jewry-street, Aldgate, London, E.C.3, has been published. The College prepares students for the Intermediate Science, B.Sc. (General and Special), and B.Sc. (Engineering) Metallurgy examinations of the University of London, and for higher degrees in science and metallurgy. Full-time and part-time day and evening courses are available. Students are also prepared for the examinations of the Institute of Physics, the Royal Institute of Chemistry, the Institution of Metallurgists, the City and Guilds of London Institute and other examining bodies. Particulars of the School of Art and Crafts and of the Department of Navigation of the College are also contained in the prospectus. The 1952-53 session opens on Monday, September 22, 1952, but students should enrol during the previous week. Copies of the prospectus may be obtained on application to the Principal of the College.

CONCRETE SHELL ROOF CONSTRUCTION.

(Continued from page 75.)

In an introductory paragraph to the theoretical analysis of the methods, it was shown that within the shell the extensional forces or thrusts were proportional to t , the thickness of the shell, and that the moments were proportional to t^3 ; that is, the thrusts were proportional to the area of the cross-section per unit area, and moments were proportional to the moment of inertia per unit length. The analysis of the shell was dependent on the first and third powers alone of t , and the merits of the five equations examined were dependent upon the relative importance of the terms in each of these two powers. As a basis for comparison, Dr. McNamee and his colleagues at the Building Research Station had deduced the equation which is also given below.

The five equations to be examined were then presented, re-written as necessary for the purpose of comparison, in terms of the normal displacement, w . The equations had been simplified by taking Poisson's ratio to be zero and are given below. The operators $\nabla^2, \nabla^4, \nabla^6$ are defined by

$$\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}$$

$$\nabla^4 = \left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} \right)^2$$

$$\nabla^6 = \left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} \right)^3$$

Dischinger:

$$\frac{t^3}{12} \left[\nabla^6 + \frac{2}{R^2} \left\{ \nabla^6 + \nabla^2 \left(\frac{\partial^2}{\partial y^2} - \frac{\partial^2}{\partial x^2} \right) \frac{\partial^2}{\partial x^2} \right\} \right. \\ \left. + \frac{1}{R^4} \left(\nabla^2 + \frac{\partial^2}{\partial x^2} \right)^2 \right] w + \frac{t}{R^2} \frac{\partial^4 w}{\partial x^4} = 0$$

Aas-Jakobsen:

$$\frac{t^3}{12} \left[\nabla^6 + \frac{2}{R^2} \left(\nabla^6 - \nabla^2 \frac{\partial^4}{\partial x^4} \right) + \frac{1}{R^4} \left(\nabla^2 + \frac{\partial^2}{\partial x^2} \right) \frac{\partial^2}{\partial y^2} \right] w \\ + \frac{t}{R^2} \frac{\partial^4 w}{\partial x^4} = 0$$

B.R.S. (unpublished):

$$\frac{t^3}{12} \left[\nabla^6 + \frac{2}{R^2} \left(\nabla^6 + \nabla^2 \frac{\partial^4}{\partial x^2 \partial y^2} \right) + \frac{1}{R^4} \left(\nabla^2 + \frac{\partial^2}{\partial x^2} \right)^2 \right] w \\ + \frac{t}{R^2} \frac{\partial^4 w}{\partial x^4} = 0$$

Donnell-Kármán-Jenkins:

$$\frac{t^3}{12} \nabla^6 w + \frac{t}{R^2} \frac{\partial^4 w}{\partial x^4} = 0$$

Finsterwalder:

$$\frac{t^3}{12} \left[\nabla^4 \left(\frac{\partial^2}{\partial y^2} + \frac{1}{R^2} \right)^2 - \frac{1}{R^2} \left(\frac{\partial^2}{\partial y^2} + \frac{1}{R^2} \right) \frac{\partial^4}{\partial x^4} \right] w \\ + \frac{t}{R^2} \frac{\partial^4 w}{\partial x^4} = 0$$

Schorer:

$$\frac{t^3}{12} \frac{\partial^6 w}{\partial y^6} + \frac{t}{R^2} \frac{\partial^4 w}{\partial x^4} = 0$$

All the equations contain the identical term in the first power of t , this term being the contribution of the direct stresses to equilibrium. In respect of the terms in t^3 , the moment terms, the first four equations are markedly similar in that they each contain the differential operator ∇^6 ; the other two equations are, however, substantially different. Dr. McNamee then examined the derivation and relative magnitude of the terms in the coefficient of t^3 .

In the second part of the paper, Dr. McNamee compared the stresses determined according to the equations of Schorer, Finsterwalder and that attributed jointly to Donnell, von Kármán and Jenkins in two hypothetical examples. No means existed of saying which of the equations most accurately assessed the stresses in a prototype structure, although the stresses evaluated by the various equations did not differ significantly. Schorer's

equation had, however, the advantage of being most easily computed.

Mr. A. Goldstein pointed out in the discussion that, so far as the design office was concerned, the time of calculation for solving the compatibility equation was insignificant when compared with total time spent on the whole design. What was most important was to have in the design office a method that could be followed and applied by a practising engineer, as opposed to a mathematician. Just such a method was presented in his (Mr. Goldstein's) paper, which followed Dr. McNamee's. Mr. Goldstein agreed with the opinion expressed in the paper that degree of accuracy in computation was more than was possible with a slide rule and that a desk calculating machine was essential. He added that he thought the experience of the behaviour of shell roofs showed the design theory to be well founded.

Dr. K. Hajnal-Konyi congratulated the author on the presentation of a paper that examined the differences between the accepted analyses. Nevertheless, he wished to emphasise the limitations of the analyses: they were based upon an idealised elastic material and took no account of such factors as creep, shrinkage and cracking.

FLEXIBILITY COEFFICIENT METHODS.

Mr. Goldstein's paper, "Flexibility Coefficient Methods and their Application to Shell Design," was a restatement in general terms of the design method described in the excellent paper by Col. G. W. Kirkland and himself.* The present paper set out to explain a method of calculating the integration constants from the boundary conditions, as opposed to the development and solution of the appropriate elastic equations.

In explanation of the method, the first part of the paper approached the method by illustrating its application to familiar statically-indeterminate structures. Basically, the method was an application of the reciprocal theorem of Clerk Maxwell and the Müller-Breslau theorem. To quote the first example given in the paper, of a beam of uniform dimensions continuous over a central prop and loaded uniformly ω per foot, as in Fig. 4; let the central prop be removed, then the vertical deflection at point 2 will be

$$+ \frac{5}{384} \frac{\omega L^4}{EI} = + v_{2l}.$$

Now apply a vertical unit point load at point 2; the vertical deflection is then $+\frac{1}{48} \frac{L^3}{EI} = + v_{22}$.

But, since there is no settlement of the support, or, in the terms of the text, the "gap" with the simultaneous application of both load and support prop has to be closed, then, if the central reaction is V_2 ,

$$V_2 v_{22} + v_{2l} = 0.$$

Hence,

$$V_2 = \frac{-v_{2l}}{v_{22}} = -\frac{5}{8} \omega L$$

and,

$$V_1 = V_3 = -\frac{3}{16} \omega L.$$

Mr. Goldstein continued his paper with the application of flexibility coefficients to the design shells of the form shown in Fig. 1, on page 75, *ante*. From basic considerations it could be shown that any force or deflection in a shell at the centre could be expressed in the form

$$Y_A a + Y_B b + Y_A' a' + Y_B' b'$$

where Y_A, Y_B, Y_A', Y_B' are integration constants, and a, b, a', b' are the roots of the compatibility equation.

The problem considered was the calculation of Y_A, Y_B, Y_A' and Y_B' from the edge conditions. In practice, various types of edge condition occurred, each of which lent itself to its own particular treatment; the most frequently occurring conditions were shown in Fig. 5. In Fig. 5 (a) and (b), where there were no edge beams, the integration constants were statically determinate and could be calculated directly, since the edge conditions of

thrust, moment, shear and deflections were all known. In Fig. 5 (c) and (d) the edge conditions were indeterminate and had therefore to be calculated from a consideration of the relative stiffnesses of the beam and the shell.

The edge forces acting between the beam and the shell, equal and opposite on the beam and shell respectively, were considered as a vertical force V_0 ,

horizontal force H_0 , longitudinal force $\int \frac{\delta N_{x\phi_0}}{\delta x} dx$

and moment M_{ϕ_0} . These forces varied along the length of the shell according to a Fourier Series, the unit value at the centre of the shell being $\frac{4}{\pi}$

(for the first load term) with the exception of N_{ϕ_0} , the unit value of which was 0 at the centre and $\frac{4}{\pi}$ at the ends. For this reason it was more convenient

to work through the calculation in terms of $\frac{\delta N_{\phi_0}}{\delta x}$

which had a unit value of $\frac{4}{\pi}$ at the centre. Only the

centre of the shell need then be considered in calculating the integration constants.

The movement of the indeterminate forces in their own line of action was conveniently expressed as the differences between shell and beam for vertical

Fig. 4. TWO-SPAN CONTINUOUS BEAM UNDER UNIFORM LOAD.

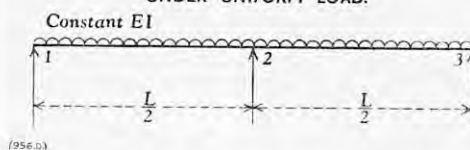
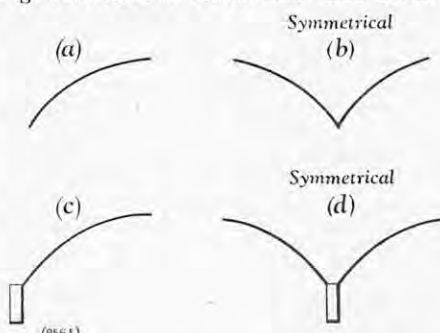


Fig. 5. FREQUENTLY OCCURRING EDGE CONDITIONS.



deflection, horizontal deflection, longitudinal stress and tangent rotation. The differences could be termed "gaps" between the shell and beam and the flexibility criteria enabling the solution to be found was that these gaps should be zero. The membrane forces were considered to be acting on the shell and were assumed to be transmitted to the beam; all the loads on the beam were similarly assumed to be acting. A hypothetical cut assumed to exist between the shell and beam gave rise to differential distortions. All the loads were then removed and the shell considered only (without the beam). A unit vertical load was applied at the shell edge and the resultant vertical and horizontal deflections, longitudinal stress and tangent rotation calculated. To do this, the integration constants for the vertical edge load must be obtained. The beam was then considered as acting without the shell and equal and opposite unit loads were applied successively at the point of shell-beam contact. The evaluation of the flexibility coefficients of the beam, considered as simply supported, presented little difficulty, with the possible exception of the torsional properties (a point Mr. Goldstein emphasised in presenting his paper, when he asked that further information on this point might be forthcoming). For each application of a unit load to beam and shell the "unit gaps" were obtained, making allowances for sign sense. Since the total "gaps" were to be zero, the statically indeterminate edge forces could be evaluated from the simultaneous equations so formed.

Mr. Goldstein pointed out that the method, though it was apparently complicated when written in general terms, could be broken down

into simple steps each amenable to numerical calculation in the design office.

Dr. P. B. Morice, of the Cement and Concrete Association, opened the discussion, and asked the members of the symposium for their comments on the suggestion that the Association, or some other such research organisation, should produce sets of tables and graphs for the solution of the characteristic equations. Dr. Morice pointed out that the considerable number of variables could be reduced to two parameters, the length and radius of the shell, and that the tables could be calculated in sufficiently small increments of the parameters to be of use in the design office.

RESEARCH AND DEVELOPMENT.

In his own paper, Dr. Morice began with a brief history of earlier theoretical and experimental work before proceeding with a description of his tests at the Cement and Concrete Association's laboratory at Wexham Springs.

The first concrete shell roofs were built in Germany in 1924, and since then their use had spread throughout the world, the shortage of steel in the post-war years having particularly accelerated the choice of such construction. Cylindrical shells had been most commonly used for concrete roofs although they had not always been the most convenient form. Little was known of the performance of other shapes and, furthermore, the mathematics of their design was complex, being beyond the range of most practising engineers not prepared to specialise in this particular branch of applied geometry.

Apart from the classical work of A. E. H. Love and later workers in the field of elastic stability, the first published work on the solution of the edge disturbance problem was that of Finsterwalder in 1933. This was followed by Schorer in 1936, when he published his much more thorough-going approximation and, to quote Dr. McNamee, "in retrospect, one can only be amazed at the soundness of his intuition." An "exact" solution, by Dischinger, had been given in 1935, but this involved three simultaneous partial differential equations. In 1939, Jakobsen simplified Dischinger's work by expressing all the influences in terms of a single parameter, the normal displacement. The latest published direct solution of the cylindrical shell problem was due to Jenkins, who had obtained the considerably simplified resultant equation,

$$(m^2 - \nu)^4 + 4 = 0,$$

where m is a parameter which determines the shell stiffness and ν is a shell shape constant. The merit of this equation lay in the simplicity of the relations between the influences and it had an explicit solution, leading to great savings in calculation.

The paper continued with a brief survey of the experimental work that has been done at the City and Guilds College, London, under the guidance of Professor A. L. L. Baker.* Many observations were made within the range of normal working loads before the models were loaded until final rupture occurred, and measurements were made to assist in the formation of a theory for shells in the cracked state, thereby facing up to the problem that reinforced concrete does not obey Hooke's Law except at very low strains. Piling sand bags on the model was the normal procedure for loading in the laboratory.

A model investigation on a particular structure had been described by Torroja, who described some work done in connection with the design of the roof of a sports stadium. The model of this structure, which was a rather unusual form, was to a one-tenth scale in reinforced mortar, and was used to confirm behaviour as predicted by Finsterwalder's theory.

In discussing the research required on shells, Dr. Morice pointed out that continuity stresses in shells, although probably small, were not predictable with any degree of precision. Relative settlement of supports might be of importance, but neither theoretical nor experimental work was available to predict the magnitude thereof; similarly, little work had been done so far on buckling.

For his own tests at Wexham Springs, Dr. Morice

* "The Design and Construction of a Large Prestressed Concrete Shell Roof," by G. W. Kirkland and A. Goldstein, *Jl. Inst. Struct. E.*, April, 1951.

* "Recent Research in Reinforced Concrete and its Application to Design," by A. L. L. Baker, *Jl. Inst. C.E.*, February, 1951.

chose to study the particular problems of continuity and support settlement, and he was using a continuous shell specimen carried on four frames, each supported by eight screw jacks which served to measure the support loads. The leading dimensions of the model were: total length, 24 ft. 0 in.; radius of curvature, 9 ft. 3 in.; chord width, 10 ft. 0 in.; and membrane thickness, $\frac{1}{2}$ in. The membrane of the shell was cast in mortar and reinforced by two meshes of 13 s.w.g. mild steel. The frames supporting the shell were themselves carried in such a way as to offer little resistance to rotation, and conveniently raised the model to enable strain observations to be made on, and inspection of, the soffit of the shell. Deflections were measured off an independent scaffold frame by normal dial-type gauges, while strains were also measured mechanically using a demountable gauge working on an 8-in. gauge length. At the time of presenting the paper, only preliminary settlement tests had been made and the results obtained had taken the form that might have been reasonably anticipated.

When presenting his paper, Dr. Morice made, among others, the following interesting point. Owing to the form of the shell roof, incidental live loading was strictly limited and with present practice dead load accounted for about 60 per cent. of the design load. Since it was impracticable to reduce the thickness of the shell below 2½ in., the possible use of lightweight concrete was very desirable and worthy of further consideration.

In opening the discussion on Dr. Morice's paper, Mr. H. Tottenham briefly reviewed the work done in Russia on the subject of shell roofs; generally the work, theoretical, experimental and constructional, had been in keeping with that done in Europe and America. Continuing his remarks in respect of the experiments being conducted at Wexham Springs, Mr. Tottenham criticised the relative dimensions of the model as bearing no relation to the majority of shells either already built or being considered. He also expressed a personal preference for loading the model by suspending the weights beneath the shell, as opposed to stacking the top of the model with sand bags and so hiding the formation of cracks, particularly those near the end tie-frames. Mr. Tottenham also suggested that the edge beams should be deliberately loaded along their own length, and that, as the effects of shrinkage and creep were far larger than that of varying load, tests should be made with that in view. Dr. Morice later acceded to both these last points and reported that they had already been considered.

Professor A. L. L. Baker followed and briefly introduced his plastic theory for shell roofs, making it clear that it was in fact an elastic theory for cracked sections. Pointing out that the cracked shell was then very sensitive to the position of the neutral axis, Professor Baker stated the need for an accurate knowledge of the stress-strain distribution in reinforced concrete in bending and of the size and distribution of cracks on the tension side.

In contrast to the experimental work just reported, aimed at establishing the hypotheses on which the structural theory of shells could be founded, the next paper, "Theory of New Forms of Shell," by Mr. R. S. Jenkins, attacked the problem of analysing the conditions to be found in new forms of shell. No attempt was made to recast in any way the fundamental assumptions on which structural analysis was normally made, assumptions of elastic behaviour and homogeneity of the material. The paper was concerned with determining a more convenient algebraical description of shells, either of the conventional dome or barrel vault type together with possible future variations of anti-clastic and conoidal forms, so that more powerful mathematical tools could be applied to the reduction of the problems. It had been recognised, he said, that general problems in the theory of elasticity were well suited to the tensor calculus and he put forward the idea of using the allied calculus of matrices. The reasons for this suggestion were as follow. First they were a labour-saving notation, providing a mathematical language of exceptional clarity because the argument could be conducted without becoming immersed in detail, and it was better to extend this tool rather than acquire a new one. Secondly, matrices provided an advantageous

scheme for computation and it was suggested that engineers would take more readily to a matrix analysis which worked in terms of physical components.

After mentioning first principles, the theory of shells was developed in matrix notation, which lead up to domes for which extensional solutions were applicable, and the paper ended with a brief reference to end disturbances.

In introducing his paper, Mr. Jenkins remarked that a third partner, the mathematician, had been introduced into the architect-engineer combination that had already been forged for the design and construction of shell roofs. Continuing, he asked that models should be constructed to enable problems of buckling to be studied; this was a most urgent problem as the introduction of anti-clastic shells, liable to easy buckling because of their double-curvature, was being prohibited. Mr. Jenkins pointed out the power of relaxation methods in the reduction of "shell" mathematics and introduced Mr. D. G. de G. Allen, of the City and Guilds College, who gave a demonstration of the value of this process in solving arithmetically the values of the dependent stress function across the surface of a shell. Contributions along similar lines by Dr. J. W. Harding and Mr. J. C. de C. Henderson had to be curtailed but will be given in full in the proceedings of the symposium when they are finally published.

PRESTRESSING IN SHELL ROOFS.

In the final session of the second day, the meeting turned to consider the introduction of prestressing into shell roof construction reviewed in a paper by Mr. C. V. Blumfield. Of the two distinct methods available for prestressing—pre-tensioning, when the cables are tensioned in position before the concrete is poured, and post-tensioning, when the cables are threaded through sheaths in the already hardened concrete—only post-tensioning had so far proved of wide application. Pre-tensioning, however, did appear to have some possibilities where whole units of the shell roof or the edge beams were pre-cast independently prior to erection. Some attempts at pre-casting sections of shell roofs had been attempted in Germany during the last war, but it was doubtful if any real economies were achieved by its use. The purpose of prestressing was to introduce into the concrete compressive stresses which would negative the tensile stresses induced by the working position in the structure of the concrete concerned, so that the section could be regarded as homogeneous and uncracked. Prestressing found its greatest use in shell construction when used in very long edge-beams or end gable stiffening beams, where considerable economies could be obtained by reducing the sections of the beams; furthermore, the prestress, in ensuring that cracking would not occur, would tend to prolong the life of the concrete. In a long barrel vault the shell tended to act as a beam and shear stresses would be found near the ends of the span; that gave rise to diagonal tensions, which could be overcome by placing tensioning cables in a suitable curve, generally parabolic. The degree of curvature in the cables was limited only by the loss in tension due to friction when tautening. Alternatively, the shear stresses could be taken up by hogging the shell and edge beam so that the cables remained straight, thereby reducing the friction losses and making the positioning of the cable more easy. A suggestion that hogging of the shell put up the cost of shuttering was disputed during the discussion that followed the paper.

Both the Freyssinet and Magnel-Blaton methods of prestressing had so far been used for shell construction. The two methods differed in that the whole cable, loaded perhaps to 25 or 30 tons, had to be tensioned by a single heavy-duty jack in the Freyssinet method, whereas in the Magnel-Blaton method, the individual wires of the cable could be tensioned either singly or in pairs using a light jack. In either case, when the tensioning was complete, grout was injected through the end anchorages.

Mr. Blumfield suggested that it was preferable to erect the sheathed cables before concreting, rather than attempt to thread the cables through holes left in the concrete by solid rubber formers or inflated rubber tubes. Whichever method was used, however, great care had to be exercised during

concreting so that the cable would operate in the designed position. When the concrete had sufficiently hardened, tensioning could be undertaken; wherever possible it was desirable that the cables should be tensioned symmetrically with respect to the structure and arrangements should therefore be made for shifting the jack from one position to another, unless two sets of jacks were provided.

Finally, Mr. Blumfield considered at some length the economies of prestressing. The most important advantage appeared to be the increase in length-depth ratio that could be obtained by prestressing, with a consequent improvement in architectural appearance. With normal reinforced concrete it was undesirable to exceed a ratio of 10:1 between the length of the barrel and the depth reckoned from the crown of the arch to the soffit of the edge beams. Another advantage, particularly at present, was the saving in steel that accrued from prestressing. On the adverse side, there had to be set the extra time and labour incurred by the contractor in placing the cables and anchorages, tensioning and finally grouting the cables. With the high cost of labour compared with materials it was at once apparent that the greater the length of barrel the less in proportion would these factors add to the cost, and the conclusion was drawn that prestressing could only be economical for long barrels. For ordinary symmetrical barrels, prestressing was hardly worth while for spans under 70 ft., and between 70 ft. and 110 ft. there was no significant saving to be found. For spans greater than 110 ft., however, there was a rapidly increasing advantage in prestressing. For north-light roofs the lengths would be proportionally less.

Structurally, prestressing with shell roof construction appeared to bring spans of 200 ft. or 300 ft., or even more, into economical reach. Apart from increasing the maximum clear span, prestressing was able to permit a considerable increase in the distance it was possible to allow a cantilever to project. The future development of new forms of shell, which would permit the greater use of straight cables, would enhance the advantages of prestressing.

In opening the discussion on Mr. Blumfield's paper, Mr. J. W. A. Ager mentioned the difficulties found at site if concrete slurry penetrated through the sheath and caused high friction losses when the cable was being tensioned. Although expensive, a seamless steel tube appeared to be the most satisfactory sheath. Mr. Ager continued by bringing to the attention of members that the emergence of grout at the far end of a sheath or duct did not necessarily guarantee that the cable had been fully grouted throughout its length. Mr. Ager advocated casting beams with deep ductways in their sides into which the cables could afterwards be placed, then tensioned, and finally concreted into position.

Mr. Goldstein briefly considered the effect of prestressing on the calculations and pointed out that, by ensuring that cracking of the concrete did not occur, the material was more nearly akin to that idealised medium on which the theory of design was based. Dr. A. H. Hass, of the Netherlands, mentioned the difficulties involved when prestressing an edge beam or tie frame that was continuous over several supports, a problem discussed at a previous symposium and reported at some length in *ENGINEERING* for November 30 and December 7, 1951.

(To be continued.)

INSTITUTION OF MINING AND METALLURGY.—Arrangements have been made for the third Sir Julius Wernher Memorial Lecture of the Institution of Mining and Metallurgy to be delivered by Professor A. M. Gaudin at the Royal Institution, Albemarle-street, London, W.1, on Monday, September 22, commencing at 5 p.m. The public will be admitted to the lecture without charge. Professor Gaudin, who is Professor of Mineral Engineering at the Massachusetts Institute of Technology, will deal with some aspect of mineral dressing, but the precise subject to be chosen has not yet been decided. The Institution's three-day symposium on mineral dressing will commence at the Huxley Building of the Imperial College of Science and Technology on the morning of the following day, September 23, as stated on page 211 of our issue of February 15, 1952. Communications respecting these events should be sent to the secretary of the Institution, Salisbury House, Finsbury-circus, London, E.C.2.

ROLLS-ROYCE APPRENTICE-TRAINING SCHOOL.

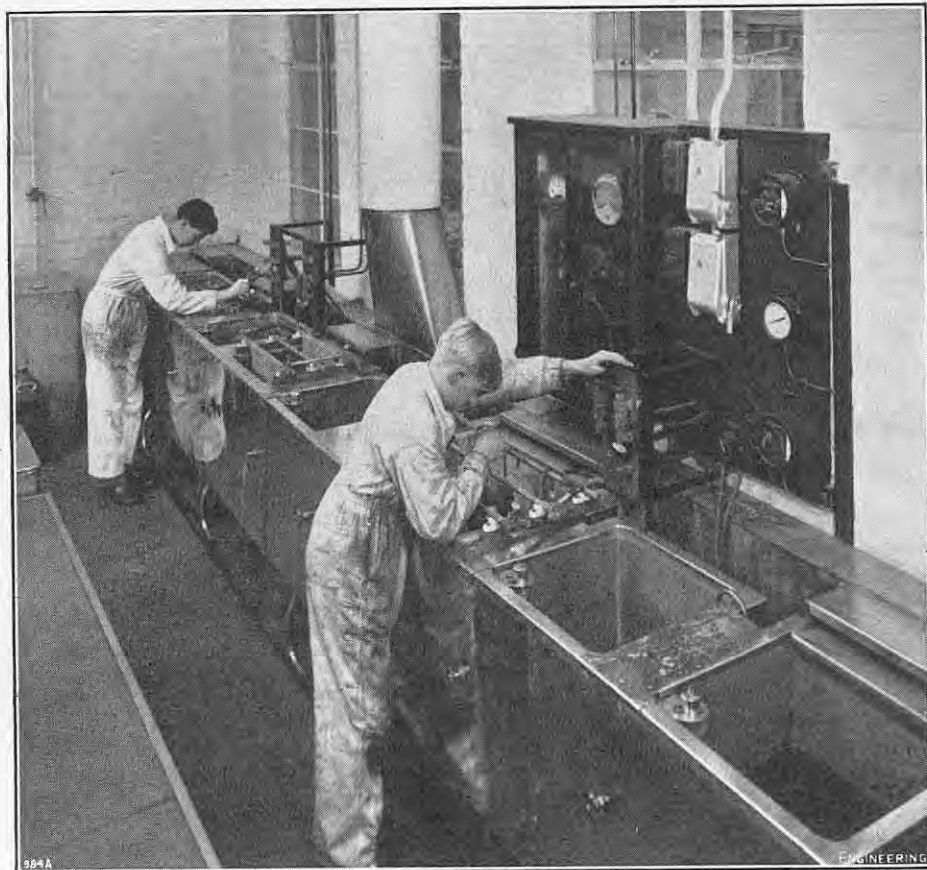


FIG. 1. ELECTROPLATING SECTION.

APPRENTICE-TRAINING SCHOOL FOR ROLLS-ROYCE WORKS, DERBY.

THE three main products of Messrs. Rolls-Royce Limited, are aero engines of the reciprocating and turbo-jet types, motor-cars and oil engines, for the general excellence of which they have acquired the highest possible reputation. The parent factory and head offices are situated on the original site at Nightingale-road, Derby, which is at present occupied by the aero-engine division, although there are important extensions to this division in other parts of Derby, at Glasgow, at Barnoldswick in Yorkshire, at Mountsorrel in Leicestershire, and at Hucknall in Nottinghamshire. It will be obvious that the training of engineers and craftsmen for the Derby group of factories, which include the oil-engine division as well as the aero-engine division, is an important and extensive part of the organisation.

Three training schemes are provided: trade apprenticeship, which is intended primarily for the production of skilled craftsmen, such as turners, millers, grinders, fitters, sheet-metal workers, patternmakers, moulders and core makers; engineering apprenticeship to enable boys to become technicians, draughtsmen, designers, physicists, metallurgists, etc., and provides opportunities for them to obtain academic qualifications leading to a professional career; and graduate training, which enables engineering graduates to obtain practical training and experience to supplement their academic attainments. This class of training is of a similar character to a post-graduate scholarship, and from it men of suitable character can reach the highest positions. Although the three schemes are separately defined as above, complete flexibility is considered by the management to be essential. It is therefore possible for a trade apprentice who shows outstanding ability to transfer to engineering apprenticeship, and an engineering apprentice who obtains a degree, either externally or by proceeding to a university, is afforded the same training facilities as a graduate coming directly from a university.

It would be of considerable interest to deal fully with all three schemes, but space considerations

render it necessary for us to refer only to the trade-apprenticeship scheme to which attention has just been directed by the fact that a new training school has recently been constructed and equipped for this class of apprentice at Ascot-drive, a short distance from the Nightingale-road works. The school was formally opened on Friday last, July 18, by Sir Walter Monckton, Minister of Labour and National Service, in the presence of the Mayor of Derby, the chairman of the company, Lord Hives, and a large number of guests. We refer to the opening ceremony on page 115 of this issue.

Trade apprentices are usually boys who have left school at the age of 15 and enter the training school in groups three times a year. No special examination qualifications are required but the boys are expected to have obtained a standard of education sufficient to enable them to take full advantage of the instruction given. All applicants are interviewed and tested to ensure that this is the case, special attention being given to general intelligence and mechanical aptitude. At first, no decision is made regarding the trade or occupation the boy will ultimately follow, although if he has any particular preference he is encouraged to express it; his early training period in the school enables the staff to assess his abilities and aptitudes and to advise him accordingly. All trade apprentices spend their first year in the school where the course consists of a broad basic training in the general principles and practices of the main engineering crafts, technical education in day and evening classes at the Derby Technical College, leading to City and Guilds or National Certificates, general education in English, workshop mathematics, industrial history, with special reference to the history and traditions of the Rolls-Royce organisation, health and safety and similar subjects.

The school is laid out as a small self-contained factory and, although none of its output is used in aero-engine manufacture, so that the training is not affected by questions of output, the work of the school, generally of a millwright or tool-room nature, is all intended for use by the boy himself, for the school equipment or in the works; exercise jobs are only done as a test of progress.

Some idea of the equipment of the school can be

obtained from the photographs reproduced in Figs. 1 to 5, on this page and on page 112. Fig. 2 is a general view of the machine shop, which includes a full range of modern milling machines, lathes, grinders, etc., while Fig. 3 shows the fitting section, which is equipped with numerous small benches, vices, and hand tools. The electrical section, shown in Fig. 4, is provided with the necessary instruments and accessories for elementary electrical measurements, and a part of it is used for training in electroplating work. The vats for this work can be seen in the background of Fig. 4, but are more clearly shown in Fig. 1, on this page. For instruction in smiths' work a forge and the usual tools are provided, as shown in Fig. 5, on page 112. The necessary tools and equipment are also available for instruction in sheet-metal work, which is used to a considerable extent in the aero-engine division.

After leaving the school, the apprentice's training is continued in the production shops under the guidance of experienced supervisors. A continuous record of his progress through the shops is kept and his foremen are regularly consulted by the supervisors to ensure that he receives an all-round training in the particular craft selected. By these means it is possible to maintain a supply of craftsmen capable of carrying on the high traditions of the firm. No premiums are payable by apprentices who, in fact, receive wages immediately they commence their training. The wages are made up of a basic rate, the national bonus, and a combined merit award and production bonus. These amount to a total of 11. 17s. 8d. for a boy of 15 and to 6l. 1s. 0d. for a young man of 20.

In the aero-engine division at the present time there are just over 1,000 youths and a small proportion of adults receiving craft and technical instruction under the three schemes mentioned above. Of this total, 77 per cent. are craft apprentices serving a five-year apprenticeship, the remainder being engineering apprentices, trainee draughtsmen and three-year trade trainees. In addition, over 1,000 men per annum from customers' establishments, including the Services, take courses of specialised instruction in aero engines at the Rolls-Royce aero-engine school.

COLLAPSE OF A RAILWAY FOOTBRIDGE AT BURY.—H.M. Stationery Office have published a *Report on the Collapse of a Footbridge which occurred on 19th January, 1952, at Knowsley Street Station, Bury, in the London Midland Region, British Railways* [price 3s. net]. About 200 people, who had been queuing on the bridge to catch a special train, fell on to the tracks 15½ ft. below; two persons lost their lives and 173 were injured. In his report, Brigadier C. A. Langley points out that the bridge collapsed because some wrought-iron straps around the bottom timber booms had corroded to such an extent that they were no longer carrying any load. The straps had been almost completely hidden by boarding and examinations in 1944 and 1948 had apparently been carried out in a cursory manner. He concludes, however, that such a lapse in inspection procedure will not occur again as specially trained bridge examiners had been appointed on the London Midland Region before the accident occurred. Unfortunately, the examiner in the Blackburn district—which includes Bury—had only just taken up his new duties.

SULPHUR EXTRACTION FROM PETROLEUM IN CANADA.—The first Canadian plant to produce sulphur from petroleum was put into service on June 10, last, at Jumping Pound, Alberta, where it adjoins the Shell Petroleum Company's natural-gas treatment plant which was started a year ago. The new plant, which has cost about 400,000 Canadian dollars, is designed to recover more than 10,000 tons of sulphur per annum. Contracts have been entered into for the supply of the entire output to the Powell River Company, of British Columbia, who will distribute it among pulp and paper manufacturers on the Pacific Coast for use in the production of sulphite pulp. The sulphur is obtained from the hydrogen sulphide removed from the natural gas in the scrubbing plant and is of a high purity. It is piped into steel vats, where it cools and solidifies. When a vat is filled and the contents are solid, the steel shell is stripped off, exposing the block of solid sulphur, which is broken up with explosive charges and collected for removal. The present capacity of the gas plant is 25 million cub. ft. of natural gas a day, but this is to be increased shortly to provide an additional 10 million cub. ft. a day for domestic and industrial use in Alberta.

4,500-H.P. DIESEL ENGINE FOR M.V. "MIDDLESEX."

THERE would appear to be little doubt that the use of geared Diesel engines for the propulsion of merchant ships of all types continues to gain in popularity. The Federal Steam Navigation Company, for example, already have two vessels, of some 9,000 tons gross each, in service with this type of propelling machinery and two more building, while the New Zealand Shipping Company have two such vessels under construction. Several advantages can be claimed for this form of propulsion, the most outstanding of which is, possibly, the convenient means it affords of transmitting high powers through a single shaft. Other advantages claimed for this arrangement include a lower first cost, a considerable reduction in the space occupied by the engine room, and ease of overhaul, the parts being lighter and, therefore, more convenient to handle. Its use also offers greater reliability as, in an emergency, one engine can be easily disconnected from the gearbox and the necessary repairs or adjustments effected without stopping the propeller, a definite advantage in single-screw vessels. In a large installation, some engines could be shut down when the vessel is running light or in a partly-loaded condition, and the others operated at their most efficient rating.

Several Diesel-engine manufacturers are now producing units suitable for this type of installation. Sulzer Brothers, Winterthur, Switzerland, have been building such engines for some time and were responsible for those of the Rotterdam Lloyd motorship Willem Ruys, a twin-screw passenger liner of 21,300 tons gross, which is propelled by eight of their two-cycle single-acting engines. These are arranged in sets of four, each set driving a single propeller through electro-magnetic couplings and mechanical gearing. Until recently, however, Messrs. Sulzer have only produced engines with cast-iron sumps, bedplates, crankcases, etc., it being their belief that there is no reason why welded designs should be regarded as generally superior to what might be termed the cast engine; the saving in weight by welding with large engines, they state, is only about 15 to 20 per cent. if simplicity of design and reasonable manufacturing costs are to be retained. It should be mentioned that the price of steel plate is considerably higher in Switzerland than, for example, in this country, and, in consequence, welded engine frames cost more to produce than the equivalent castings. This does not necessarily apply in other countries, where, in certain cases, engines built up from welded components can be produced at less cost than those in which the corresponding parts are of cast iron. Moreover, it is not always convenient to use castings, particularly in countries where the foundry capacity is limited.

Several of the Sulzer licensees have, therefore, shown a marked preference for welded engines, and, in response to their requests, the firm have introduced a range of engines which, from the cylinders downwards, are constructed entirely from welded steel plate. This is by no means a new departure for the company, as they have been building double-acting Diesel engines having cylinder outputs of 2,000 h.p. at 250 r.p.m. since 1931 with welded-steel frames and bedplates throughout. Furthermore, they have built their high-speed locomotive engines from welded plate for more than 20 years, as the reduction of weight thus achieved by comparison with cast-iron units being more pronounced because, in this case, the thicknesses of the cast components are fixed not so much by considerations of mechanical strength as by the limitations of foundry technique.

The new range of Sulzer Diesel engines, which has been designated the RS 58 series, has been designed specifically for marine propulsion plant employing reduction gearing. Several engines of the new type are already under construction elsewhere, but Messrs. Sulzer Brothers decided to build the first engine and give themselves a sufficient start so as to ensure that any problems encountered could be overcome in their own shops. This first engine has now been completed and is at present undergoing tests at Winterthur, where we recently

DIESEL ENGINE FOR M.V. "MIDDLESEX."

SULZER BROTHERS, LIMITED, WINTERTHUR, SWITZERLAND.

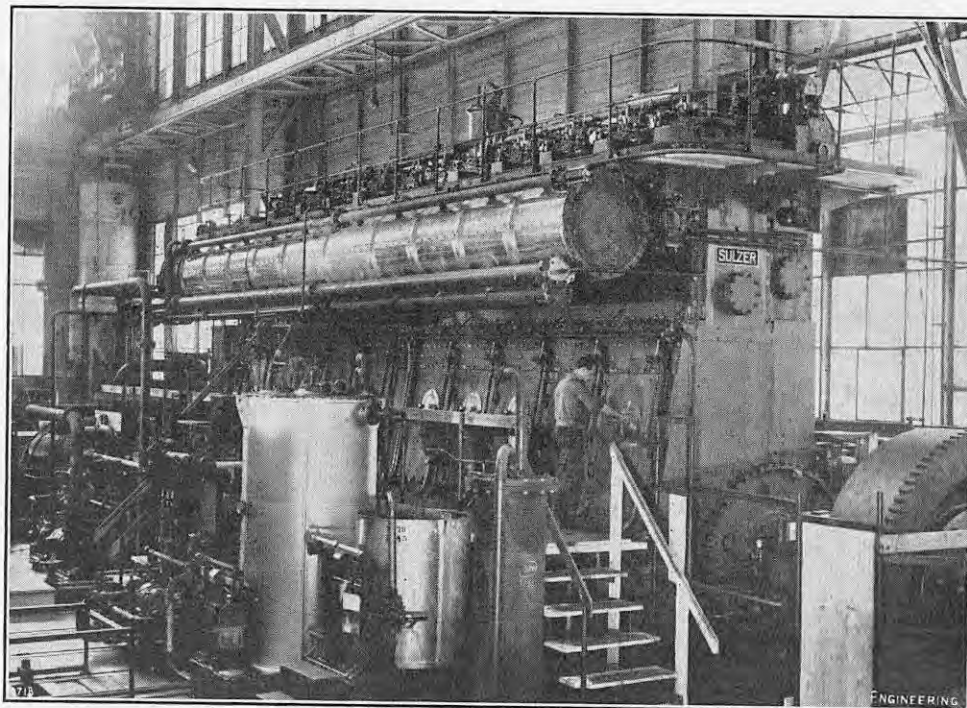
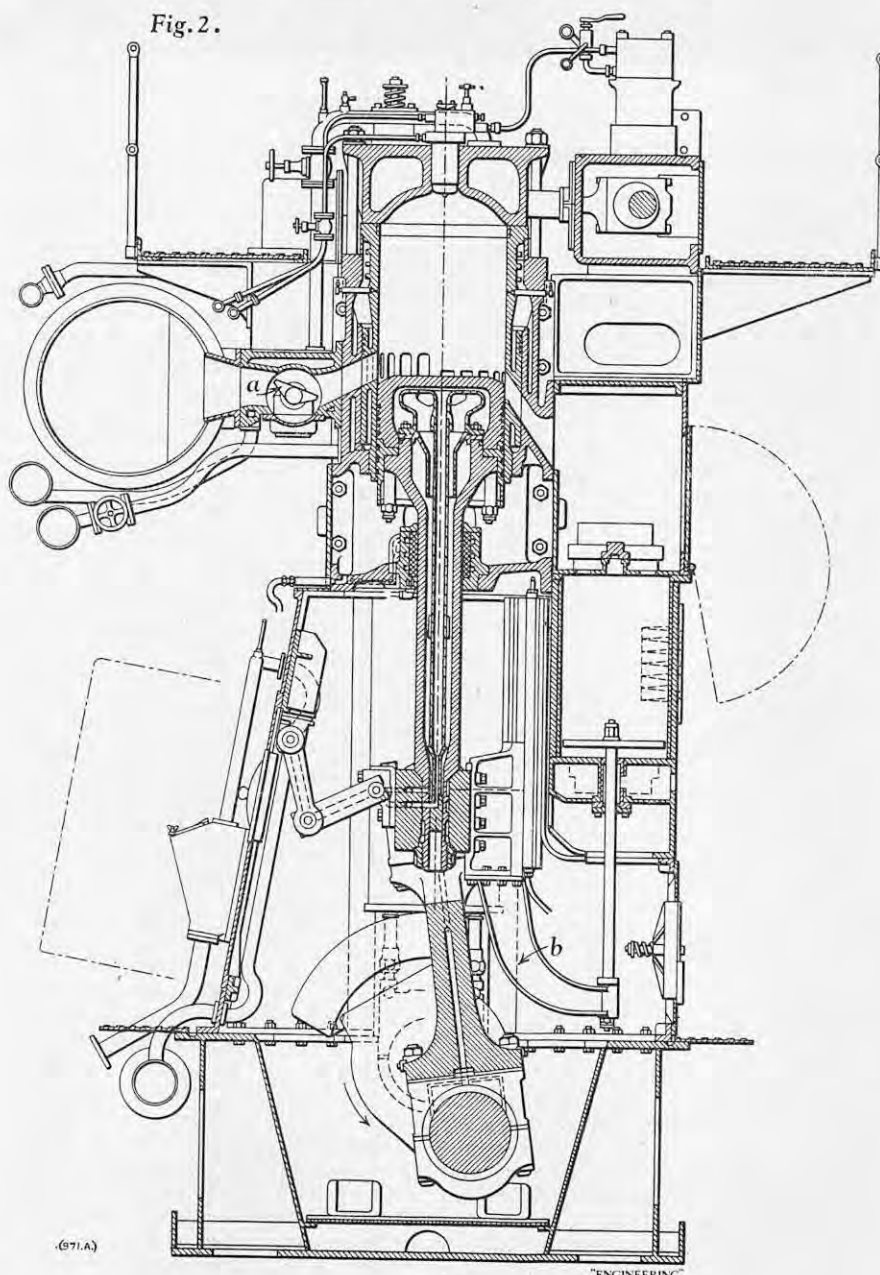


FIG. 1. ENGINE ON TEST-BED AT WINTERTHUR.



(971.A)

"ENGINEERING"

DIESEL ENGINE FOR M.V. "MIDDLESEX."

SULZER BROTHERS, LIMITED, WINTERTHUR, SWITZERLAND.

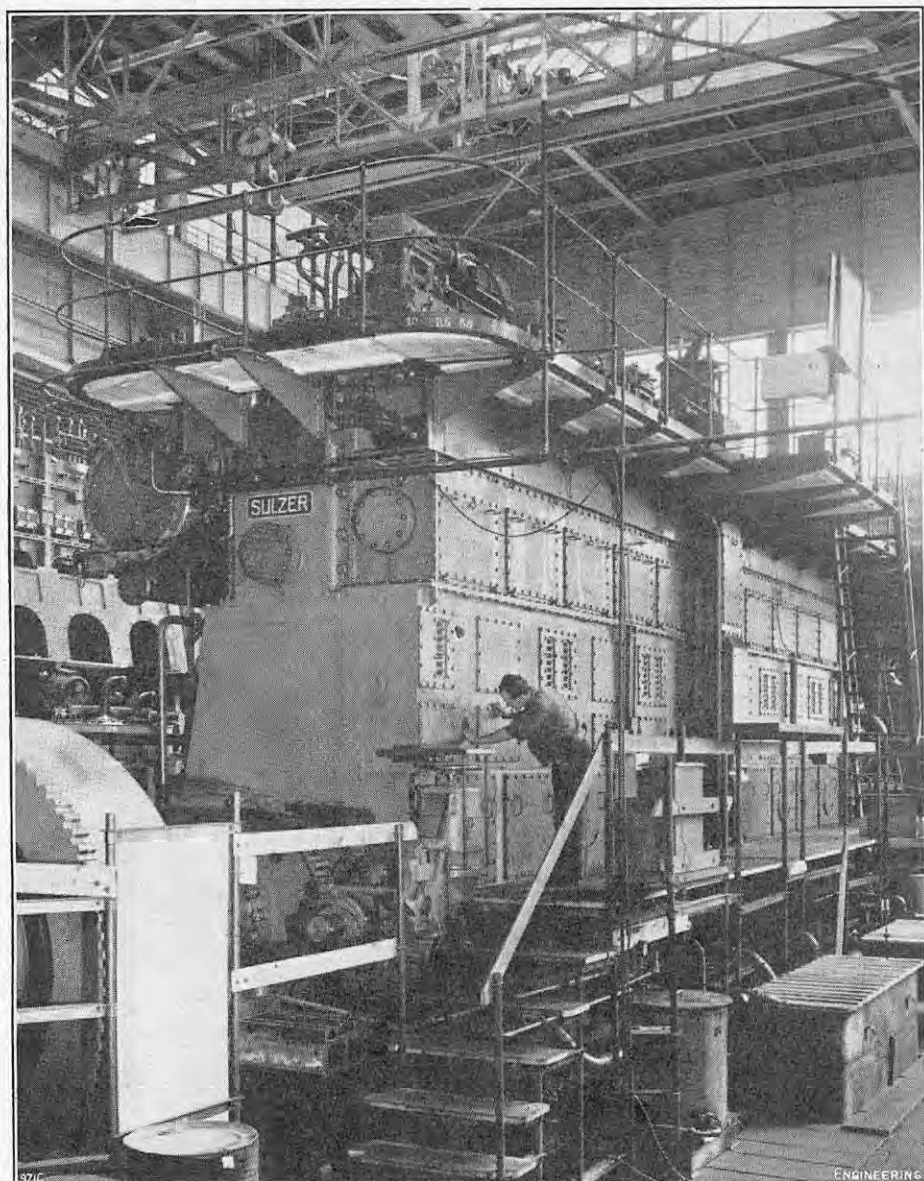


FIG. 3. SCAVENGE-PUMP SIDE OF ENGINE.

had an opportunity to inspect it. The engine is intended for Alexander Stephen and Sons, Limited, Linthouse, Govan, Glasgow, for installation in the *Middlesex*, a motor vessel under construction for the Federal Steam Navigation Company. This vessel will have a deadweight capacity of 10,780 tons and will be propelled by twin Diesel engines driving a single propeller shaft through electric couplings and reduction gearing. The second engine is being constructed by the shipbuilders, and it is understood that the vessel will go into service towards the end of this year.

The new engine is by no means a simple variant of the cast design, as the opportunity was taken to incorporate many new features and the final design bears little relationship to its contemporaries. Full details will not be available until the tests are completed, but a general impression of the design can be obtained from Fig. 2, opposite, which shows an athwartships cross-section through one of the cylinders, and from Figs. 1 and 3, which show the complete engine on the test bed at Winterthur. It is a two-stroke single-acting directly-reversible unit, having ten cylinders with a bore of 580 mm. and a stroke of 760. When installed in the *Middlesex*, the two engines will be rated to have a continuous output at sea of 9,000 brake horse-power at 225 r.p.m., with a corresponding propeller speed of 100 r.p.m. The weight of the propelling machinery complete with couplings, gearbox and associated auxiliaries, but excluding the generating plant, will be approximately 50 kg. per horse-power. The

weight of the bare engine is approximately 40 kg. per horse power.

As will be seen from the drawing, the engine is of the crosshead type. This form of construction was chosen because it relieves the pistons from lateral pressures resulting from the angularity of the connecting rod and enables the combustion chambers to be made entirely separate from the crankcase. The use of crossheads on Sulzer two-stroke engines is, of course, not new, their SD feature, for example, being so designed. An unusual feature of the new engine, however, is the absence of piston skirts to cover the scavenge-air inlet ports and the exhaust ports, an arrangement which permits the height of the engine to be decreased by the length of the stroke. This has been made possible by fitting stuffing boxes round the piston rods to seal the crankcase from the space below the pistons and installing oscillating exhaust valves between the exhaust trunk and each set of exhaust valves, which isolate the exhaust ports from the trunk during the latter part of the compression stroke and the first part of the expansion stroke. One of the oscillating valves can be seen in Fig. 2, where it is lettered *a*, and it will be appreciated that without them, the scavenge air would escape directly to the exhaust trunk each time the bottom edge of a piston uncovered its associated exhaust ports during the compression stroke. As the valves are located in the upper part of the engine, they are operated through suitable linkages from the fuel-pump camshaft, which extends along the top of

the engine, the linkages incorporating springs which permit a degree of flexibility and prevent the valves from being damaged should they be prevented from closing by any loose debris, such as a broken piston ring. Use of these valves also makes it possible to dispense with the upper row of scavenge ports provided in other Sulzer marine engines so as to obtain a degree of supercharging. Extra charging in the new engine is achieved by closing the valves while the scavenge ports are still open, the cylinders, in consequence, being filled with air at the scavenge-trunk pressure.

As in most other Sulzer two-stroke engines, individual scavenge pumps are used, discharging into a common receiver, or trunk, a separate pump being actuated by each connecting rod. Instead of being operated by rocking levers from the crossheads, however, the piston rod in each case is connected to one end of a horn-shaped beam, the other end of which is bolted directly to the corresponding crosshead, suitable provision being made for simple but accurate lining up of the piston rods and pistons in their cylinders. One of the horn-shaped operating beams is visible at *b* in Fig. 2, and it will be apparent that the scavenge pistons have the same stroke as the main pistons. The receiver is situated immediately above the cylinders and it is understood that, when the engine is running, the scavenge air pressure is in the neighbourhood of 4.40 lb. per square inch. The cylinder block for the scavenge pumps is of welded construction, the complete assembly being bolted as a single unit to a "bench" formed by the engine columns and crankcase. The cylinder block also serves as a support for the crosshead guides of the main pistons.

The fuel-injection pumps are situated along the top of the engine and are actuated by a camshaft, chain-driven from the crankshaft. Spill valves are used to control the amount of fuel injected and the operating mechanism is arranged so that injection is completed while each follower is on the flank of its associated cam, thereby ensuring sharp injection. Fresh-water cooling is employed for the cylinder jackets and heads, the liner being sealed by rings in the normal manner. The fuel valves also are water-cooled, but the pistons are cooled by oil taken from the main lubricating system. These features render the engine eminently suitable for operation on heavy oils and the unit illustrated is fitted with the necessary heating pipes, etc., applicable to this purpose.

Although the engine for the *Middlesex* has ten cylinders, engines can be supplied with from four to twelve cylinders, the output per cylinder for continuous operation at sea being 450 h.p. at 225 r.p.m. For less arduous duties, however, this rating can be increased to 500 h.p. per cylinder. Messrs. Sulzer have also designed a larger version of this engine, having a bore of 760 mm. and a stroke of 1,550 mm., the output per cylinder for continuous operation in this case being 900 h.p. at 115 r.p.m. One of the outstanding features of the new engines is the low height obtained by dispensing with the piston skirts; the engine illustrated, for example, has an overall height of 5,505 mm. (18 ft. approximately), while the additional height required for the removal of the liners is 775 mm. (2 ft. 6 in. approximately). The overall length and width also are small in comparison to the output, the length being 12,175 mm. (40 ft. approximately) and the width 3,430 mm. (11 ft. 3 in. approximately), the latter dimension excluding the top platform. We were informed that at present engines of the new type, under construction at Messrs. Sulzer's own works and in the works of their licensees, amount in all to 102 cylinders. The firm propose to introduce a stationary version of this engine in the near future, which will also be suitable for marine propulsion in combination with electrical transmission. Full details of the complete new range of engines will, it is understood, be given in a paper to be read before one of the engineering institutions later this year.

"SUPER CONSTELLATION" AIRCRAFT FOR K.L.M. DUTCH AIRLINES.—The delivery of the first of a fleet of 13 Super Constellation 1049C air liners, for the Atlantic services operated by K.L.M. Royal Dutch Air Lines, is expected early next year.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

SCOTTISH INDUSTRIES EXHIBITION.—A Scottish industries exhibition following the pattern of that staged at the Kelvin Hall, Glasgow, in 1949, is to be held in September, 1954. The exhibition will be sponsored by the Scottish Council (Development and Industry) and will be of the same general character as that of 1949, bringing up to date the display of Scottish industrial enterprise and craftsmanship.

LOSS ON OPERATION OF SCOTTISH DOCKS.—During 1951, the operation of the Scottish docks incurred a loss of 22,000*l.*, according to the fourth annual report of the British Transport Commission, published on July 12. Grangemouth was responsible for a surplus of 89,000*l.*, and there was also a surplus of 12,000*l.* on "sundry packet ports," but the deficits recorded included 33,000*l.* at Bo'ness, 22,000*l.* at Burntisland, 28,000*l.* at Methil, 18,000*l.* at Ayr, and 15,000*l.* at Troon. Referring to the Inglis report on Glasgow's passenger transport, the Commission felt that an important contribution to the solution of the problem had been made, but that before such a "costly scheme" could be adopted the closest examination of all its aspects was required.

CONGESTION OF OIL TANKERS AT FINNART.—Application is being made to the Minister of Transport by the Clyde Pilotage Authority for permission to extend the part of the anchorage specially reserved for oil tankers coming to the Clyde to discharge at Finnart, Loch Long. The wharf can accommodate only one vessel at a time, and, on several occasions recently, there have been six or seven vessels lying at the Tail of the Bank, causing some congestion.

CANCELLATION OF ORDER FOR HOSPITAL SHIP.—It is officially stated that, on account of a change of circumstances, the Admiralty have decided to cancel the contract for the construction of a hospital ship, placed with Barclay, Curle & Co., Ltd., Glasgow, in April.

EDINBURGH TRAMWAYS.—The abandonment of Edinburgh's tramway system in favour of motor 'buses was proposed in a recommendation which came before the Edinburgh Civic Amenities and Works Committee on July 15. Mr. W. M. Little, the transport manager, reported that the entire tramcar fleet would need to be renewed by 1972, and, over a period of ten years, to bring the fleet, tracks, etc., up to date would cost 2,350,000*l.*, whereas a conversion to 'buses in the same period would cost only 1,850,000*l.* The matter was referred back for consideration by the transport sub-committee.

ELECTRICITY GENERATION IN FIFE.—A hitch in the Fife County Council's plan to generate electricity at the reservoir they are building at Upper Glendevon was reported to Fife Water Supplies Committee at their meeting on July 16. Some differences of opinion in financial arrangements had arisen between the Council and the North of Scotland Hydro-Electric Board. It was agreed to arrange a meeting with the Board to try to reach an agreement on the points in dispute.

RECORDS OF OLD COLLIERY WORKINGS.—The Scottish Division of the National Coal Board are asking for the co-operation of legal firms, estates, and other professional firms, who may hold plans of old colliery workings, to make these available to help to bridge the gap in documented records. An offer is made for records to be inspected with a view to acquiring or copying them, with payment where necessary.

ENGINEERING WORKS TO CLOSE.—The Newmans works of Coltness Holdings, Ltd. (formerly Coltness Iron Co., Ltd.), are to close within the next six months. The employees, numbering over 400, were informed of this decision by the management on July 14. No more orders are to be accepted, and those on hand should be completed in about six months. It was explained that the works, comprising steel foundry, iron foundry, and engineering shops, are not equipped with plant to compete in general markets. The works were originally a department servicing the company's collieries, which were taken over by the National Coal Board on nationalisation.

COAL EXPORTS.—A rise of almost 40 per cent. in Scottish coal exports during June, as compared with May, brought shipments to 123,429 tons. This was the highest total since October, 1949, when the post-war peak of 150,221 tons was reached. Consignments

aggregated 89,114 tons in May, and 96,288 tons in June, 1951.

ALEX. MATHIESON & SONS.—A meeting of the shareholders in Alex. Mathieson & Sons, Ltd., engineers and tool-makers, Glasgow, is being held to-day to consider the winding-up of the company. The business was founded 160 years ago.

ROAD BRIDGE OVER THE FORTH.—The construction of a single-span road bridge over the Forth at Queensferry, at a cost of about 6,250,000*l.*, could now be begun, but for the country's financial difficulties, it was stated on July 16 by Councillor J. P. Robson, one of the Edinburgh Corporation representatives on the Forth Road Bridge Joint Board. Contractors' tenders for the foundations could be put out within three months and work on the bridge could proceed without interruption, as the foundations would take over a year to construct, by which time all plans would be ready.

CLEVELAND AND THE NORTHERN COUNTIES.

INDUSTRIAL POSITION OF THE NORTH-EAST.—The joint annual report of the North-East Development Association and the Northern Industrial Group, Newcastle-on-Tyne, states that it had been expected that, after the post-war boom in the home market, there would be a trade recession, but as far as the North-East is concerned, the demand for coal and steel and the full programme in the shipyards continues. The basic industries of mining, shipbuilding, engineering, metal manufacture and chemicals, which employ 40 per cent. of the insured population, remain active. In coalmining there are no signs of unemployment in the foreseeable future, but in shipbuilding, although order books are full, there is some lack of confidence in the future owing to falling freights. The engineering industry, particularly that concerned with metalworking, is in a peculiar position and there is some uncertainty about its future. It has to meet an increase in the export trade and, at the same time, has to bear the heavy burden of re-armament, and is finding difficulty in obtaining the labour and the materials to do both. Despite the supply position, the iron and steel industry is in a healthy state. Unemployment in the area is low, although it is higher than that of Britain as a whole. There is a feeling, however, that the present apparently strong position in the heavy industries may not last.

TYNE TRAFFIC STATISTICS.—Shipments of coal and coke from the River Tyne during June aggregated 688,045 tons, or 51,507 tons less than in June, 1951, and 264,766 tons, or 27.8 per cent., less than the figure for June, 1938. For the first half of the year, however, shipments at 4,746,275 tons were 391,967 tons, or 9 per cent., more than for January to June last year but 1,572,762 tons, or 24.9 per cent., under the total for the first six months of 1938. This year's shipments included 789,806 tons sent to foreign ports, compared with 547,292 tons last year. Bunker shipments at 166,283 tons were also up by 1,883 tons on those for 1951. For the five months ended May, exports of general merchandise totalled 153,497 tons, against 160,643 tons in the corresponding period of last year, and 116,498 tons in that for 1938. Imports of general merchandise for the same period were 1,066,623 tons, against 958,605 tons last year and 926,955 tons in 1938.

LABOUR POSITION IN DARLINGTON.—A report submitted to a meeting of the Darlington District Employment Committee states that steady employment is being maintained in the manufacturing industries of the town. There is a scarcity of skilled engineering and foundry employees, and skilled operatives are also needed for the building and civil-engineering industries. The steel shortage has caused some short-time working, and, although most firms have well-filled order books, they are uneasy concerning steel supplies.

NORTH-EASTERN ELECTRICITY BOARD.—The quarterly report of the North-Eastern Electricity Board, recently submitted to a meeting of the North-Eastern Electricity Consultative Council, states that 80 new substations have been put into operation and 90 farms supplied with electricity. During the quarter, the Board have approved estimates amounting to 1,134,512 for developments, including 79 schemes for housing and 35 for rural electricity supplies. The report adds that housing authorities have been asked to give the Board earlier notification of housing plans so that adequate preparations for providing electricity supplies can be made.

NEW SHIPBUILDING BERTH AT NEWCASTLE.—The Tyne Improvement Commission has approved plans submitted by T. F. Burns and Partners, consulting engineers, of Newcastle-on-Tyne, for a shipbuilding

berth, crane gantry and jetty extension at the Wallsend shipyard of Swan, Hunter and Wigham Richardson, Ltd. The new berth will replace the present No. 4 berth and will be situated about 185 ft. west of the fitting-out jetty. It will accommodate vessels of about 30,000 tons deadweight.

LANCASHIRE AND SOUTH YORKSHIRE.

ELECTRICITY LOAD-SPREADING.—The Regional Board for Industry for the East and West Ridings of Yorkshire have called for an electricity load-spreading of at least 10 per cent. It is urged by the chairman, Mr. G. H. Bagnall, that all industrial undertakings in the area and commercial concerns using more than 22 kW should comply with the request. Peak hours will be the same as last year, namely, 8 a.m. to 12 noon, and 4 p.m. to 5.30 p.m. The period affected is on weekdays from November 1 to January 31. Mr. Bagnall states that, though generating capacity is expected to increase, there will still be a potential peak-hour deficiency.

COAL EXPORTS DOUBLED.—During the first half of the year, South Yorkshire collieries exported twice as much coal as during the first half of 1951. By the end of June, the North-Eastern division of the Coal Board had exported 894,000 tons, whereas for the whole of 1951 the total was only 1,092,000 tons. Exports still fall below the level of 1950, when the area exported 2,075,000 tons. This year's exports include not only deep-mined coal but a considerable quantity of slurry.

EXTENDED HOLIDAYS.—The cutlery trades of Sheffield generally are so short of orders that extended holidays have been arranged. Some firms will close for two and a half weeks and, in some instances, there will be a four-weeks' holiday, to include a fortnight with pay and a fortnight without pay. It is hoped, meanwhile, to clear some of the stocks at easier prices.

HUNCOAT POWER STATION EXTENSION.—The British Electricity Authority have received the consent of the Minister of Fuel and Power to the extension of the Huncoat power station, Accrington, by the installation of a fifth 30,000-kW turbo-generator set. The Huncoat station was designed originally to house four such sets, the first of which went into service last month.

THE MIDLANDS.

TRADING ESTATE AT BROWNHILLS FOR LIGHT INDUSTRY.—The urban district council of Brownhills, Staffordshire, have bought 30 acres of ground to establish a trading estate, and sites are now being made available for light industry. Brownhills is about 12 miles from Birmingham and six from Walsall, and considerable numbers of Brownhills residents travel daily to these nearby industrial centres; the only occupations available to them in their own district at present are in coal mining or agriculture. A Birmingham firm of brass founders, S. Timmings & Co., Ltd., have moved already to the new site. The council claim that there is plenty of labour available, particularly female labour suitable for light engineering, and say that the land will be fully developed, with roads and all services.

USE OF PULVERISED-FUEL ASH.—Over the past twelve months, Dr. J. W. Rees, of Birmingham University, has been conducting experiments on the utilisation of the ash from pulverised fuel. An acre of ash on the tip belonging to the Hams Hall "A" power station, near Birmingham, has been enclosed and divided into plots of equal size. Various forms of top dressing, mainly of sludge from local sewage disposal plants, have been applied to the plots, and different kinds of grass have been sown. Two harvests have now been taken from the plots, and the results have been studied. It has been found that it is possible to obtain good hay crops from ash treated with sewage sludge. A plot dressed with sewage sludge from the Coleshill plant, which treats domestic sewage, gave the best results; the average yield from this plot was 15 to 16 tons of grass (weighed as cut) per acre. Experiments are also taking place to determine what plants of commercial value will grow in ash alone.

THE PRICE OF GAS IN THE MIDLANDS.—Mr. G. le B. Diamond, chairman of the West Midlands Gas Board speaking at the official opening of the new carbonising plant at Tipton gas works on July 16, said that there would soon be another increase in gas prices in the Midlands. The commissioning of new plant such as that at Tipton, he said, should mean that some reduction in price was possible as a result of the improved thermal efficiency, but the Gas Board were

faced with many additional charges which were beyond their control.

PROJECTED MOTOR-CAR PLANT IN BRAZIL.—The Standard Motor Co. Ltd., of Coventry, have under consideration the establishment of a motor-car assembly plant in Brazil. Assembly of cars from imported parts would be undertaken at first, but manufacturing of components would commence as soon as local steel supplies became available. The most likely site for the new factory is near Rio de Janeiro.

CANAL TUNNEL LIGHTING.—The electric lighting plant at Netherton Tunnel, on the Dudley section of the Birmingham Canal, has been converted from water-turbine to electric-motor drive. The tunnel, which was opened in 1858, is 3,027 yards long—the longest canal tunnel still in use in Great Britain—and was originally lighted by gas. About 1910, a water turbine was installed to drive a direct-current generator delivering at 150 volts, and 30 lamps were fixed in the tunnel. The water was taken from the Wolverhampton level of the canal, which is 473 ft. above sea level, and, after passing through the turbine, was discharged into the Birmingham level of the same canal system, which is at 453 ft. The higher level crosses the lower by a brick aqueduct near the tunnel entrance, and less than 20 ft. of pipe was needed to convey the water to the turbine. Troubles with dirt and foreign matter in the water, coupled with the fact that the higher level of the canal suffers from shortage of water, led to the decision to discontinue the use of the turbine. Taking current directly from the mains would have involved re-wiring the whole length of the tunnel, so the original generator has been retained, and it is now driven by an electric motor through V belts.

GOVERNMENT HELP FOR EXPORTERS.—Mr. F. C. Limbrey, deputy regional controller for the Ministry of Supply, speaking in Birmingham on July 15 after a meeting of the Midland Regional Board for Industry, said that the Ministry would give special assistance to between 200 and 300 selected Midland engineering firms to help them to increase exports. The Ministry was paying particular attention to firms which show good prospects of developing overseas markets, and would try to ensure that all their raw material requirements are met. Assistance would also be given to those who wanted to obtain licences to build extensions.

SOUTH-WEST ENGLAND AND SOUTH WALES.

EMPLOYMENT ON THE TREFOREST ESTATE.—A conference of local authorities, called to discuss redundancy on the Treforest trading estate, passed a resolution urging that 25 per cent. of the national defence sub-contracts should be directed to the South Wales development area. Factories on the estate submitted a variety of reasons for the present redundancy, including the textile slump, Australian import restrictions, purchase tax, hire-purchase restrictions, and competition in overseas markets. Mr. J. H. C. Molyneux, chairman of the Treforest Manufacturers Association, replying to a question, said that firms were undoubtedly being handicapped by the rise in the bank rate and by credit restrictions. A Board of Trade representative said that the matter was receiving the close attention of his department. An analysis showed that 80 per cent. of the redundancies were caused by restriction of trade. Some factories in surrounding areas had increased their labour strength and had absorbed many who had left the estate.

BUNKER COALS.—A cut in the price of South Wales coals for use as bunkers in foreign-going ships, which will take effect on August 1, has been interpreted by some operators on the Welsh steam-coal market as the first step in a general review of the price structure of the industry. This will be the first downward movement in coal prices for a long time. The reduction, similar to those made for all British coals, is understood to be from 6s. to 10s. per ton, according to quality. For some time past, local shippers have been meeting increasing competition in foreign markets in selling coals. Some Continental competitors cut their prices some time ago, and a sharp drop in shipping freights has resulted in American coals being available in Rotterdam and Italy at lower prices than Welsh coals.

MINERS' TRAVELLING EXPENSES.—A meeting of No. 1 Area of the National Union of Mineworkers, at Swansea, decided by a narrow majority to defer consideration of the question of tendering notices over the high cost of bus fares. There were a number of complaints about high fares, and it was stated that, in some instances, miners had to pay up to 12s. per week. The National Coal Board were reported as having offered to pay half the difference between 5s. and the actual figure paid, but the South Wales Area Executive declined the offer.

BRITISH STANDARD SPECIFICATIONS.

The following publications of engineering interest have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 24, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Milk Piping and Milk-Pipe Fittings.—A new specification, B.S. No. 1864, on the subject of milk piping and milk-pipe fittings, covers milk pipes of stainless steel and tinned copper, and fittings of stainless steel, tinned bronze and tinned gunmetal. The fittings are of the compressible-ring joint type. Five nominal outside diameters of pipes are covered, namely, 1 in., 1½ in., 2 in., 2½ in., and 3 in., and the material, dimensions and tolerances, manufacture and finish, are specified. The clauses laid down for fittings concern dimensions and tolerances, the diameters and thicknesses of ring joints, material, finish, and screw threads. The symbols to be used to indicate bends, cocks, T-pieces, unions and blank caps are quoted. In the appendices is given a specification for rubber rings to be used in the joints. [Price 5s., postage included.]

Solid-Drawn Copper-Silicon Tubes.—Another new specification is concerned with solid-drawn copper-silicon tubes for general purposes. Its clauses relate to chemical composition, manufacture, dimensions, inspection and testing, and tolerances on the outside diameter, thickness and length of tubes are tabulated. Methods of carrying out the mechanical tests and of making a mercury-nitrate test are indicated. The number is B.S.1866. [Price 2s., postage included.]

Bitumen-Base Filling Compounds for Electrical Purposes.—A new specification, B.S. No. 1858, combines in one publication two older specifications, B.S. Nos. 688-1936 and 803-1938, which are now withdrawn. The new publication applies to compounds of a bituminous nature suitable for use as filling compounds which are subjected to electrical stress in service. Oils and oil-resisting compounds are not covered. The compounds dealt with in the new specification are classified according to their softening points. Electrical and physical properties are also specified and full details of the tests required to determine these properties are given. The tests employed are based, as far as possible, upon those described in the "Standard Methods of Testing Petroleum and its Products," a publication issued by the Institute of Petroleum. The main differences between the two specifications now withdrawn and that just issued are that the minimum permissible values of penetration have been reduced, the tolerance in the softening points has been slightly increased, the acidity test is now optional and the test for resistance to moisture has been omitted. [Price 6s., postage included.]

CONTRACTS.

During June, the British Electricity Authority placed contracts for equipment for power stations amounting, in the aggregate, to 9,290,000l. The principal contracts include a 60,000-kW turbo-generator, condensing and feed-heating plants and transformers for Brunswick Wharf, with the METROPOLITAN-VICKERS ELECTRICAL CO. LTD.; 6,600-volt switchgear for Hackney, with the GENERAL ELECTRIC CO. LTD.; a 30,000-kW turbo-generator for Woolwich, with the GENERAL ELECTRIC CO. LTD.; and condensing and feed-heating plant for this set with WORTHINGTON-SIMPSON LTD.; two 60,000-kW turbo-generators for Marchwood, near Southampton, with the BRITISH THOMSON-HOUSTON CO. LTD.; two 180,000-lb. per hour boilers for East Yelland, near Barnstaple, with JOHN THOMSON WATER TUBE BOILERS LTD.; two 300,000-lb. per hour boilers for Goldington, Bedford, with CLARKE CHAPMAN & CO. LTD.; two 30,000-kW turbo-generators for this station with the BRITISH THOMSON-HOUSTON CO. LTD., and the requisite condensing and feed-heating plants with G. & J. WEIR LTD.; three 60,000-kW turbo-generators for Hams Hall "C," Birmingham, with the GENERAL ELECTRIC CO. LTD.; a 60,000-kW turbo-generator for Ince, near Ellesmere Port, with the GENERAL ELECTRIC CO. LTD., and the condensing and feed-heating plant with HICK, HARGREAVES & CO. LTD.; two 550,000-lb. per hour boilers for Keadby, near Scunthorpe, with the STEIRLING BOILER CO. LTD.; and two 30,000-kW turbo-generators and generator transformers for Huncoat, Accrington, with the GENERAL ELECTRIC CO. LTD., and the main auxiliary and control cables and connections for this power station, with W. T. GLOVER & CO. LTD.

BULL'S METAL AND MELLOID CO. LTD., Glasgow, have received an order from John Cockerill S.A., of Hoboken, Belgium, covering the complete outfits of sidelights and windows for five ships which Messrs. Cockerill are to build for the Compagnie Maritime Belge.

PERSONAL.

HER MAJESTY THE QUEEN has been graciously pleased to grant her patronage to the ROYAL INSTITUTION OF CHARTERED SURVEYORS, 12, Great George-street, London, S.W.1, so continuing that first conferred upon the Institution by King George V in 1922.

PROFESSOR SIR ALFRED EGERTON, F.R.S., has resigned his appointment as a vice-president of the governing council of the British Iron and Steel Research Association, 11, Park-lane, London, W.1. Mr. H. H. BURTON, C.B.E., has been elected in his place.

MR. P. V. HUNTER, C.B.E., Hon.M.I.E.E., has relinquished his position as a deputy chairman of British Insulated Callender's Cables Ltd., as from August 31. At that date, Mr. Hunter will be in his 70th year and he is desirous of reducing his commitments.

MR. IVOR RICHARD COX, D.S.O., B.Sc., M.I.Mech.E., A.M.I.C.E., managing director of Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17, has received the degree of Doctor of Science, *honoris causa*, from the University of Wales in recognition of his services to the electrical industry.

MR. E. HOWARD, city lighting engineer, Nottingham, has been elected President of the Association of Public Lighting Engineers, 22, Surrey-street, Strand, London, W.C.2. He is to be inducted in September.

MR. C. B. NIXON, chairman and governing director of Leyland Motors Ltd., Leyland, Lancashire, has been appointed a member of the North West Electricity Consultative Council by the Minister of Fuel and Power. W. BARTHOLOMEW & CO. LTD., P.O. Box 96, Freetown, have been appointed official agents for the firm in Sierra Leone, British West Africa.

MR. T. GAMMON, O.B.E., M.I.Mech.E., manager of the firm's Weybridge Works, and Mr. W. D. O'HER, M.I.Mech.E., works superintendent, Crayford Works, have been appointed additional members of the board of directors of Vickers-Armstrongs Ltd., Vickers House, Broadway, London, S.W.1.

MR. A. G. H. PRITCHETT has been appointed general sales manager of Chamberlain Industries Ltd., Staffa Works, Leyton, London, E.10. His deputy is Mr. D. S. JORDAN. The activities of the firm in Scotland are being handled by GERARD WAKEHAM, LTD., Carlton House, 26, Blythwood-square, Glasgow, C.2.

MR. F. GRAUCCOB, managing director of Nu-Swift Ltd., Elland, Yorkshire, has been elected chairman in succession to Mr. A. HARLAND, who has relinquished the appointment owing to advancing years and has been made President. Mr. E. E. C. CAWOOD, M.B.E., general manager, has been appointed technical director.

MR. T. G. RODGER, formerly commercial manager of the Whitehead Iron and Steel Co., Ltd., has been appointed general manager of H. L. Reynolds Ltd., Old Leeds Steel Works, Balm-road, Leeds, 10.

MR. R. B. SAWREY-COOKSON has relinquished his post as public relations officer of the British Road Federation and has taken up an appointment with the Esso Petroleum Co. Ltd., as head of the Press and B.B.C. section of the public relations department.

MR. N. R. REANEY, A.S.A.A., and Mr. P. P. C. DRABBLE have been appointed directors of Geo. Salter & Co., Ltd., West Bromwich.

A. A. JONES AND SHIPMAN LTD. inform us that the telephone number of their London office, 5, Vandon-street, Buckingham-gate, S.W.1, has been changed to ABBey 5908.

The BRUSH ABOE GROUP of Companies has formed a Petroleum Industry Division, to provide a continuous liaison between the petroleum industry and companies of the Group making electrical products and gas and oil engines. Mr. F. D. LANGLEY, A.M.I.Mech.E., formerly London manager of the National Gas and Oil Engine Co., Ltd., has been appointed manager of the new division which will operate from the Group's head office, 32, Duke-street, London, S.W.1.

RICHARD THOMAS & BALDWIN LTD., and THE STEEL COMPANY OF WALES LTD., jointly announce the formation of RTSC HOME SALES LTD., for the purpose of effecting and carrying through, as principals, sales in all parts of the United Kingdom and Northern Ireland, of the flat rolled-steel products manufactured by the two steel firms. The first directors of the company will be Mr. H. F. SPENCER and Mr. E. JULIAN POPE. The registered offices of the new company will be 47, Park-street, London, W.1.

Among recent appointments to the Colonial Engineering Service in Tanganyika are those of Mr. A. J. C. SMALL, A.M.I.C.E., A.M.I.Mun.E., and Mr. P. J. FRETHER as assistant engineers (the latter in the Water Development Department) and that of Mr. C. K. WHITELEY, B.Sc., A.M.I.Mun.E., as executive engineer.

MATISA EQUIPMENT LTD., 78, Buckingham-gate, Westminster, London, S.W.1, announce that their telephone number has been changed to ABBey 4555.

APPRENTICE-TRAINING SCHOOL FOR ROLLS-ROYCE WORKS AT DERBY.

(For Description, see Page 107.)

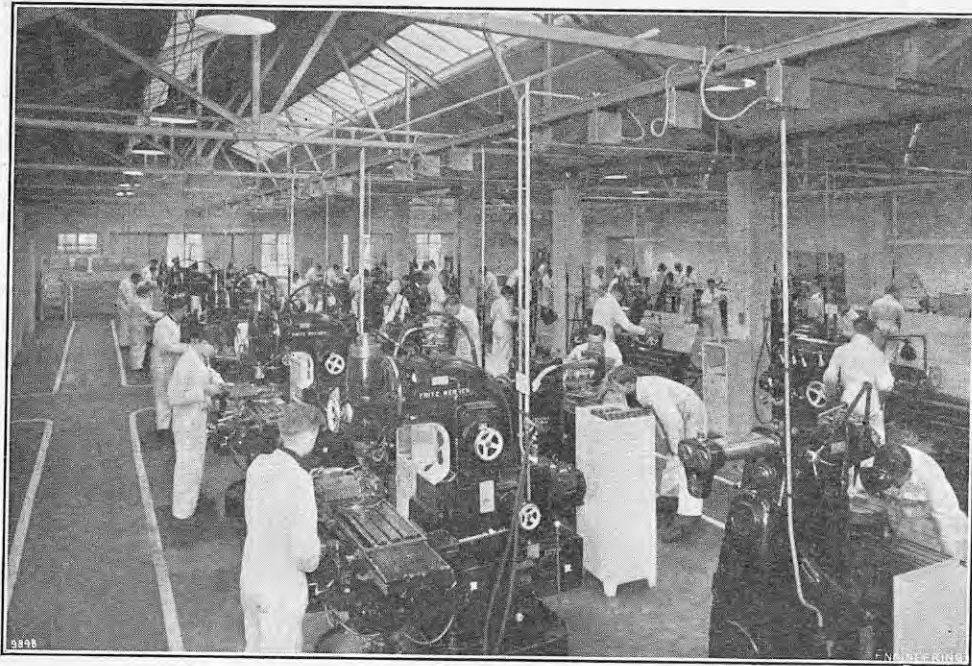


FIG. 2. GENERAL VIEW OF MACHINE SHOP.



FIG. 3. FITTING SECTION.



FIG. 4. ELECTRICAL SECTION.

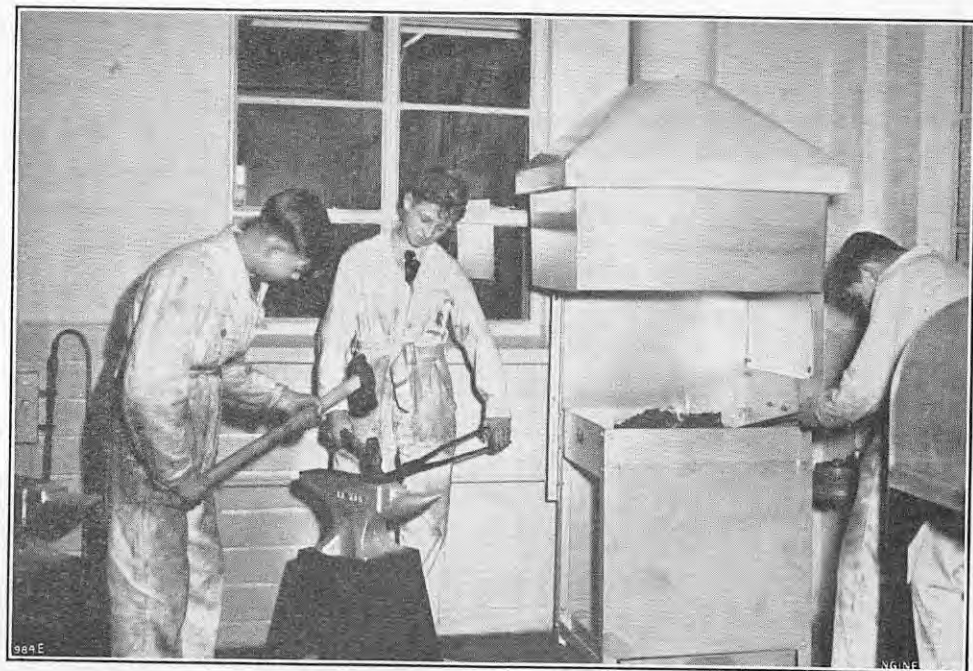


FIG. 5. HAND-FORGING SECTION.

ENGINEERING

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

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ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for insets, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2½ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10s. for the first four lines or under, and 2s. 6d. per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30s. per inch. If use is made of a box number the extra charge is 1s. per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33½ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

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

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 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.

INDEX TO VOL. 172

The Index to Vol. 172 of ENGINEERING (July-December, 1951) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, copies of the Index are being distributed only in response to such applications.

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ENGINEERING

FRIDAY, JULY 25, 1952.

VOL. 174.

No. 4513.

THE ELECTRIC CABLE
"MONOPOLY."

THE manufacture of insulated electric wires and cables is the second branch of the electrical industry to come under examination by the Monopolies and Restrictive Practices Commission; and the results of the Commission's investigations into the organisation and practices of those concerned are to be found in a lengthy report,* recently published by H.M. Stationery Office. This report examines in great detail the types of goods manufactured, which range from the fine insulated wires used in many varieties of apparatus to underground power and telecommunication cables; and includes a general survey of the history of the industry, with special reference to the various associations which have been formed to deal with such questions as standardisation, prices, costs, profits and quotas. In the end, certain conclusions were reached, which are duly set forth. In many ways, the report is a valuable document, since it contains some information which is not otherwise easily obtainable. It is, however, much too diffuse and would gain in force by a fairly drastic abbreviation. It is a little difficult, also, to ascertain for whom it is intended. The technical reader may find a few plums, but to uncover them requires some labour, as there is no index. The non-technical reader, on the other hand, may easily be discouraged by the mass of detail. The conclusions also suffer from the fact that they were to some extent pre-judged, though that was, perhaps, inevitable from the nature of the Commission's terms of reference.

* The Monopolies and Restrictive Practices Commission: Report on the Supply of Insulated Electric Wires and Cables. H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 5s. net].

The evidence indicates that there are 60 makers of electric wires and cables in this country, of whom 22 are members either of the Cable Makers Association (C.M.A.) or of the Covered Conductors Association (C.C.A.) or of both; while seven others are connected with members of these associations. The member firms of these two associations, in 1948, were responsible for 82.1 per cent. of the whole home output of electric cables by value, for 100 per cent. of the submarine, telegraph and telephone cables, and for the same percentage of the land telephone cable and the mains cable for voltages over 33 kV. They were also responsible for over 90 per cent. of the cables insulated with cotton, silk, enamel, glass and asbestos, and for about three-quarters of the mains cables for voltages up to 33 kV and of the rubber and thermoplastic cables. In addition, the Independent Cable Makers Association (I.C.M.A.), with 13 members, was responsible for 9.6 per cent. of the output of cable for the home market. Evidence was also produced which, in the Commission's view, made it clear that members of the Cable Makers and Covered Conductors Associations, as well as their subsidiary and associated companies, conduct their affairs in such a way as to restrict competition in supply of cable. Since the members of these Associations make more than a third of the insulated electric wires and cables in the United Kingdom, their activities fall within Section 9 of the Monopolies and Restrictive Practices (Inquiry and Control) Act, 1948.

Carrying an examination of the activities of this monopoly, or quasi-monopoly, a step farther, evidence is found which shows that members of the Associations concerned agree to sell their products only under common conditions, and at prices which, apparently, are as unalterable as the laws of the Medes and Persians. The result is that "the whole system of competitive tendering with all its accepted advantages from the point of view of the consumer is vitiated." It is admitted that the drawbacks of this "closed shop" mitigate the danger that price competition might cause a deterioration of the quality, which the Cable Makers Association now maintain by regular performance tests on their members' products. This careful control of quality has, in fact, been of great benefit to the consumer.

Further analysis of the situation discloses a curious fact: not only is there a concentration of production in the hands of a few manufacturers, but some classes of their output are absorbed by a very small number of customers. For instance, super-tension cable is produced by only six firms, all of whom are members of the Cable Makers Association, and nearly 90 per cent. of this product is sold to one consumer—the British Electricity Authority. Over 90 per cent. of the telephone cable manufactured is sold to the Post Office, while submarine telegraph cable is not only made entirely by one firm, but is practically all sold to Cable and Wireless, Limited, and the Post Office. Such a situation is not without importance from the point of view which concerns the Commission, since there would appear to be a monopoly on both the selling and buying sides by these branches of the industry. However, the position is not so difficult in practice as appears at first sight. By agreement, the costs of six types of Association power cables are being investigated by an independent firm of accountants with a view to establishing a schedule of reasonable prices; and although the system by which the Post Office places bulk orders for land telephone cables is not commended, the Commission recognise that it ensures a steady level of production for individual firms, and, it is claimed, makes possible progressive savings in both costs and prices.

It would seem, therefore, that, in spite of concentration of manufacture, the large consumer is protected from exploitation, at least to some extent.

To ensure similar protection to those with smaller requirements, it is suggested that the prices charged for super-tension and mains cables to other consumers should be directly related to those which the British Electricity Authority pay. As regards the supply of rubber-insulated cable, which is so largely used for wiring premises, it is held, on the other hand, that the system of common prices is contrary to the public interest and should be terminated. This type of cable represented just over one-third of the output of all cable on the home market in 1948, and members of the Cable Makers Association accounted for 76 per cent. of the total. Unlike the other sorts of cable mentioned above, it is purchased by a number of different classes of consumer; and the inference is, therefore, that the risk of exploitation is greater. In this connection, it is interesting to note that independent cable manufacturers welcome the "common prices" of the Cable Makers Association and fix their own just below them, so that price-fixing of some kind is universal. It is also of interest that there is little or no mention in the report of complaints by independent consumers. In fact, the main purchasers of telephone cable—the Post Office, Ministry of Supply, British Electricity Authority, and Railway Executive—seem to have been naively unaware that their orders were being allocated between the members of the Association; and one buyer, while objecting to the system, said that his objections would not be so strong if he was able to satisfy himself that the quoted prices were fair and reasonable. In fact, the consumer, as a rule, seems to be reconciled to the possibility that he may be suffering exploitation.

As was to be expected, perhaps, the Commission attack the arrangements which each section of the Cable Makers and Covered Conductors Associations has for sharing business by means of quotas. They admit that these quotas, the details of which are given in full, do not necessarily restrict the total output of the industry, although it is considered that they interfere harmfully with the activities of the most efficient producers. It is recommended, therefore, that all such arrangements for sharing out available business should be brought to an end. It is also recommended that certain of the arrangements under which rubber cable is sold, and which involve exclusive-dealing discounts and rebates of various kinds, should cease in the interests of independent competition; and that, when the present control of copper by the Ministry of Supply comes to an end, the fact that members of the Cable Makers and Covered Conductors Associations could (though they do not) control the supply of copper to independent cablemakers should not be forgotten in making fresh arrangements.

The outstanding conclusion that must be reached from a study of this report is that the electric cable industry has emerged from the ordeal, if not unscathed, at least unshaken. This is best indicated, perhaps, by the almost casual statement in the report that the net profits of the members of the Cable Makers and Covered Conductors Associations and their associates, expressed as percentages of both sales and capital employed, were on the average rather lower in 1948 than in 1938. On the other hand, those of the independent manufacturers were considerably higher. The questions then remain, as in the case of the similar inquiry into the electric-lamp industry: Can the recommendations of the Commission be implemented and, if they can, what will be the result? Will the removal of the restrictions that have been criticised result in the public being provided with a better-quality article at a lower price? Is it possible that the same result could be obtained in a better way? It is upon the answers to these questions that the justification for the conclusions reached by the Commission must depend.

THE BICENTENARY OF "THE PHILADELPHIA EXPERIMENT."

"WHEN I disengaged myself from private business, I flatter'd myself that, by the sufficient tho' moderate fortune I had acquir'd, I had secured leisure during the rest of my life for philosophical studies and amusements." So wrote Benjamin Franklin in his *Autobiography*, and though the latter part of his long life was to be spent in the service of his country in the political sphere—which, possibly, provided the amusement—the years between 1746 and 1753 were largely devoted to the pursuit of natural philosophy. Franklin's interest in electricity was aroused by a lecture given by a Dr. Spence, from Scotland, which he attended when visiting his native city of Boston in 1746. Shortly after his return to Philadelphia, he received a parcel forwarded by Peter Collinson, London agent of the Library Company of Philadelphia and a Fellow of the Royal Society. This included a glass tube, with instructions for its use in performing electrical experiments. Franklin eagerly seized the opportunity thus afforded of repeating the experiments that had so fascinated him, and, with the aid of similar tubes made locally, spread his enthusiasm among his circle of friends. "I never before," he wrote early in 1747, "was engaged in any study that so totally engrossed my attention and my time as this lately has done." Collinson was kept informed of the progress of these experiments in a series of letters which he read before the Royal Society, without, at first, attracting any serious attention. In one of the earliest of these, Franklin put forward his "one-fluid" view of the nature of electricity, which ascribed positive electrification to an excess of this hypothetical fluid and negative electrification to a corresponding deficit, and which, in certain respects, anticipated the electron theory. With his essentially practical outlook, Franklin quickly realised that nothing was more practical than a sound theory capable of furnishing a rational interpretation of the phenomena of frictional electricity.

His fame in the field of science, however, rests mainly upon his demonstration that the lightning flash consists of an electrical discharge between clouds or from cloud to earth, differing in scale, though not in kind, from that generated in the laboratory; together with his immediate application of it in the lightning conductor to protect buildings during thunderstorms. Decisive confirmation of these views by the method indicated by Franklin himself was first obtained in France in 1752. To commemorate the 200th anniversary of the "Philadelphia Experiment" and of Franklin's invention of the "lightning rod," the May issue of the *Journal of the Franklin Institute* was devoted to "Lightning Protection." It contains two historical surveys, by B. F. J. Schonland and I. Bernard Cohen, respectively, followed by articles on "Lightning Protection Since Franklin's Day," by K. B. McEachron, and "Experimental Lightning Research," by Harold Norinder.

In reply to an inquiry as to how he had arrived at his fundamental idea that the lightning flash is simply an electric spark on a grand scale, Franklin quoted an extract from his minute-book of November 7, 1749. This consisted of a list of twelve points of resemblance between "the electric fluid" and lightning, and ended as follows: "The electric fluid is attracted by points and we do not know whether this property is in lightning. But since they agree in all the particulars wherein we can already compare them, is it not probable that they agree likewise in this? Let the experiment be made." A series of investigations on the discharging power of pointed conductors, carried out in collaboration with Hopkinson, suggested to

Franklin a means for carrying out the experiment by using a vertical iron rod sharply pointed at its upper end to draw down the lightning, so that its effects could be compared directly with those produced by electrical discharges generated in frictional machines. The rod was to project some 20 to 30 ft. from "a kind of sentry box," housing the observer and placed "on the top of some high tower or steeple."

The first suggestion, that buildings could be protected against damage from lightning strokes by fixing to their summits pointed iron rods and continuing the conducting path by rods down the outside of the building and into the ground, was put forward by Franklin in 1750. Both these proposals were published in England in pamphlet form in May, 1751, and in a French translation during the same summer. The latter was due to the interest of the Count de Buffon, who persuaded M.d 'Alibard to set up the sentry-box apparatus in the garden of his house at Marly, where, on the afternoon of May 10, 1752, when a storm cloud was passing overhead, his servant Coiffier attracted "sparks of fire" from the down lead. D'Alibard's report to the Académie des Sciences created a sensation, and the sentry-box experiment was repeated throughout Europe and in England. Franklin did not himself attempt the experiment, as observation had indicated that nearly all storm clouds passed over the plain in which Philadelphia is located at a height of several hundred feet; which, as that city did not then possess any church with a steeple, he fancied would put them out of reach of any collecting rod he could erect. He found, however, that in this he was mistaken, for later he devised a scheme for testing the sign of the charge on thundercloud bases and an automatic device to notify him of the approach of charged clouds. An insulated iron rod was run from the chimney of his house to a point opposite his chamber door and separated by about 6 in. from a wire leading to an iron water pump. To either end of the gap was attached a little bell and between these bells a small brass ball, hanging from a silk thread, was alternately attracted and repelled as soon as the rod became charged and thus gave an audible signal.

But before news of the success of the Marly experiment reached America, Franklin had hit upon a beautifully simple and direct method of verifying his great discovery. This was the celebrated kite experiment, first performed during the summer of 1752 and communicated to Collinson in a letter dated October 19 of that year. The kite itself was made from a silk handkerchief, and to the end of the length of twine leading to it a length of silk ribbon was tied, which was kept dry by being held under cover. At the junction between twine and silk, a key was fastened, from which Franklin drew sparks by approaching his finger to it when, during a thunderstorm, rain had wetted the twine and rendered it conducting.

In common with many epoch-making discoveries, those of Franklin encountered considerable opposition. The Abbé Nollet, the leading French authority on electricity, went so far as to persuade himself that Franklin was a myth and that his pamphlet had been circulated by enemies in Paris to undermine his own reputation. When he could no longer deny Franklin's existence, he asserted that rods used in the manner advocated by Franklin were both useless and dangerous. To these attacks Franklin made no reply, leaving his reputation in the hands of less prejudiced members of the Académie. Controversy arose concerning the precise function of the lightning rod. Franklin's first conception was that these pointed rods would "probably draw the electric fire silently out of a cloud before it came nigh enough to strike"; but, in 1755, he wrote "I find I have been but partly understood in this matter. I have mentioned it in several letters and except once always in the

alternative, viz., that pointed rods erected on buildings and communicating with the moist earth would either prevent a stroke or, if not prevented, would conduct it, so as that the building should suffer no damage." The second function of the rod, he insisted, was of equal importance, and he protested against instances where the rods had protected houses by conducting the lightning when there was a stroke, being quoted as instances of conductors being unsuccessful. Another matter that occasioned protracted debate concerned the superiority of blunt conductors over pointed conductors, claimed by Benjamin Wilson of the Royal Society and the Abbé Nollet.

Though "Franklin's rods" were first installed at Philadelphia in 1753, and their use soon became widespread throughout the American colonies, their introduction into Europe was often resisted; and such was the prejudice of the ignorant populace against them that many of those that were erected had to be taken down. It was not until 1773 that Franklin was able to write from London that "conductors begin to be used here." Those who regarded the awe-inspiring displays of lightning as supernatural manifestations, expressly sent to alarm and to arouse, if not to destroy, sinners, were not disposed to accept them as electrical phenomena subject to natural law. In fact, notwithstanding numerous fatalities among bell ringers, the pealing of church bells to dissipate thunderstorms persisted in some countries until the middle of last century. Churches with high steeples, the most prone to damage and the most likely to benefit from the provision of lightning conductors, generally remained longest without them. Many spires were damaged and repaired two or three times without any form of protection. Gradually, however, prejudice was overcome and the annual toll in lives and material damage was substantially reduced.

Since Franklin's day, notable progress has been made in the knowledge of the mechanism of thunderstorms; yet, despite improvements in design and the use of new materials, such as thyrite, in modern forms of lightning arrester, Franklin's "lightning rod" is still employed in essentially its original simple form as a basic means of protection against lightning. Mankind owes much to self-taught men of keen perception and strong practical bent. Of these, Benjamin Franklin provides a conspicuous example. Joseph Priestley described his discovery as "the greatest, perhaps, that has been made in the whole compass of philosophy since the time of Sir Isaac Newton." and Immanuel Kant not unjustly acclaimed the discoverer himself as "the modern Prometheus, bringing fire from heaven."

NOTES.

ROLLS-ROYCE APPRENTICE-TRAINING SCHOOL.

As mentioned on page 107 of this issue, a new school for the preliminary training of apprentices for the Derby group of factories of the Rolls-Royce organisation was officially opened on Friday last, July 18, by the Minister of Labour and National Service, Sir Walter Monckton. In welcoming the Minister, at a luncheon following the opening ceremony, Lord Hives, chairman of the company, mentioned that the new school was merely an extension of a training scheme which had been expanded and improved at intervals since it was inaugurated at the time the firm was founded; it was regarded as a long-term investment. Much was heard about the shortage of scientists and technologists, but the country must never neglect the craftsman. His firm endeavoured to work in close co-operation with the Ministry of Labour and found it helpful to take men from the training centres. He also expressed appreciation of the help received from the trade unions, and paid a particular tribute to the valuable work of the Derby Technical College. The primary interest of the firm in training was, of course, in the "end products," and it was a noteworthy fact that the

majority of the executive posts in the company were held by Rolls-Royce trained men. They did not like to think, however, that there was a ladder to success in the organisation, but regarded training more as a broad staircase which people might ascend together. In his speech, the Minister of Labour said he thought the opening of the school was particularly timely at the present moment when the country was undergoing a severe ordeal in its economic and industrial life. At such times as these we were inclined to forget the traditions and lessons of the past when this country led the world in the fields of industry, trade and finance, and perhaps to become despondent about the future. He did not believe, however, that there were any genuine grounds for dejection. There were some things which could only be done by the Government, with the support of Parliament, but the nation itself, especially the large part of it engaged in industry and trade, must take a leading share in the common effort for recovery. Industry and trade still had at their command initiative, experience and adaptability, technical and scientific talent, craftsmen equal to any in the world, and systems of industrial and human relationship which were unrivalled in any country. From every point of view, the prestige of this country still stood high and we still had the capacity to regain and hold our position among the industrial leaders of the world. We could more than hold our own if we made the utmost use of the new blood coming into employment. A vote of thanks to Sir Walter Monckton was proposed by Mr. J. D. Pearson, general manager of the aero-engine division. Prior to the luncheon, the guests were shown over the company's training school for draughtsmen, and afterwards inspected the aero-engine school, where civil and military users of the engines can be given advanced instruction in their maintenance and handling. Of particular interest was the experimental and testing establishment for aero engines at Sinfen, which the guests were able to see in operation, and the visit concluded with a brief inspection of the machine shops at the Nightingale-road works.

UNIVERSITY LECTURES ON NUCLEAR REACTORS.

A course of 30 lectures on nuclear reactors will be given at the City and Guilds College, South Kensington, London, S.W.7, during the session commencing in October. The lectures will be given by visiting scientists from the Atomic Energy Research Establishment, Harwell. The first group of 12 lectures will cover the elementary nuclear physics of slow-neutron natural uranium reactors and the design and control of a simple graphite-moderated reactor, and will include a detailed description of the large pile at Harwell. Six lectures will be given on particular aspects of various types of reactor, and the associated metallurgical chemical, engineering, heat-transfer, and physical problems will be discussed. There will be three specialised courses, including five lectures, for mathematicians on more advanced slow and fast neutron theory, five lectures for engineers on heat transfer and reactor design, and a course for physicists on the experimental use of a reactor, including opportunities for practical work on neutron diffusion, and the measurement of neutron flux. The fee for the course is 10 guineas, except to students of the College and intercollegiate students, who may attend without charge.

INDUSTRIAL RESEARCH IN AUSTRALIA.

As a gesture of "loyalty, gratitude, and affection" to the people of Great Britain, in recognition of their "role in saving civilisation in the second World War," the people of Australia, through subscriptions to a British Memorial Fund in Victoria, are offering a fellowship, worth 1,000*l.* (Australian), in industrial research, to suitably qualified British men or women, who have resided for ten years in the United Kingdom, between the age limits of 25 and 35 years. The fellowship provides for ten months' study in Victoria, of any aspect of Australian industrial life, with special emphasis on Anglo-Australian and trade relations. Travelling and living expenses during that period will be covered. The fellowship is open to any well-qualified student of industrial management or

social science; to officers of any chamber of manufacturers, federation of employers, or junior chamber of commerce; to trade union officials; executives in industrial undertakings; and anybody with extensive industrial or general administrative experience. Similar fellowships, in natural science, virology, and agriculture, are also being offered by the Fund. Applications, which will be received during the next four weeks, will first be studied by a selection committee in London under the chairmanship of Sir John Lienhop. The committee will recommend three applicants to the fund organisers in Melbourne, who will make the final choice. Further particulars may be obtained from Sir John Lienhop, Victoria House, Strand, London, W.C.2.

STUDY COURSES IN MECHANICAL HANDLING.

A School of Materials Handling has been established recently, by a group of mechanical-handling engineers, in order to provide courses of study in materials handling, and the design and application of mechanical-handling equipment. At present, the school is able to provide correspondence courses in three groups: Group I, intended for estimators, designers, and draughtsmen, covers the application and design of conveyors and elevators for bulk and unit handling. The course is divided into a number of subjects, each treating one particular type of equipment, and each comprising from 10 to 20 lessons. Group II, for industrial executives and production engineers, deals with the applications and limitations of the various types of conveyors, elevators, trucks, hoists, cranes and ancillary equipment, in 100 lessons. In Group III, various special applications may be studied, in short courses ranging from 5 to 20 lessons; at present Group III courses include such subjects as coal and ash handling, foundry mechanisation, handling in the food-canning industry, handling hot bulk materials, maintenance, dust-explosion hazards, feeders, and stone and gravel grading plants. A fourth group of studies on power transmission is in preparation. The school will also maintain an advisory service on handling problems, available to industry generally. Ultimately, the organisers of the School of Materials Handling hope to found a college for full-time students and post-graduate studies, with a comprehensive library and facilities for experimental work and research, and a working-models section for demonstrating the potentialities of plant to industrialists who are considering mechanisation. Further particulars, and a detailed syllabus, may be obtained from the secretary, School of Materials Handling, Camellia House, Blackheath Hill, London, S.E.10.

ENGINEERING EXPORTS AND IMPORTS.

Figures of the United Kingdom's overseas trade in the first half of this year, issued by the Board of Trade, show that exports of metals were 24 per cent. higher than in the second half of last year. Exports of machinery were 13 per cent. higher (partly due to higher prices); the number of new cars shipped to the United States was more than doubled, from 4,286 valued at 1,800,000*l.* in the first quarter of this year, to 8,937 valued at 3,600,000*l.* in the second; and there was a substantial recovery in the export of cars to Canada, from 548 in the first quarter to 7,809 in the second. The latter figure, however, is still well below the quarterly rate of 12,371 for the first half of 1951. Though the adverse trade balance for the first half of this year was 186,000,000*l.* less than the 656,000,000*l.* of the second half of 1951, largely due to an 8 per cent. decrease in imports, increases in exports were by no means general throughout all the categories covered by the Board of Trade returns. Indeed, each of the export categories, with the exceptions of metals, was lower in the second quarter than in the first quarter. The decrease was 8 per cent. in the case of engineering products, but for textiles it was 26 per cent. Exports of vehicles during the two quarters fell from 138,900,000*l.* to 123,100,000*l.*, and exports of electrical goods and apparatus declined from 30,200,000*l.* to 27,300,000*l.* The total value of imported raw materials during the first half of this year showed a reduction of 15 per cent. from the high figure of the second half of 1951, but the imports of machinery, iron, steel, and non-ferrous metals were higher.

THE EDUCATION OF ENGINEERS IN SOME EUROPEAN COUNTRIES.*

By PROFESSOR S. J. DAVIES, D.Sc.(Eng.).

(Continued from page 71.)

THE schools with the last kind of emphasis, (c), the treatment of a single specialised branch, belong to more recent times, and have come into existence to satisfy a modern need. They cater for a small but important minority, namely, the qualified engineers who, in their professional work, require an exceptionally advanced knowledge of a particular speciality. A school of this type is the Institut Supérieur des Matériaux et de la Construction Mécanique at Paris, at which courses of one year's duration are given in strength of materials and machine design. Those entering it, in addition to having taken their diplomas as engineers, must have had at least one year's experience in a works. Other schools, at Paris, Lille, Marseilles, Strasbourg and Toulouse, give similar special courses in the mechanics of fluids for engineers from the aeronautical industry. At Paris, there are further specialist schools for foundry practice, for welding, and for rubber technology.

Worthy of mention is the Centre d'Etude Supérieure de Sidérurgie at Metz, at which the young qualified engineer passes one or two years of specialised study of the problems of the iron industries, only after he has taken a salaried post in that branch.

There are numerous other specialist schools which, while they may be regarded as of class (c), are not so rigidly differentiated, since they do not insist on the full qualification of an engineering diploma before entry to their courses, but also accept a science degree or licence. Such a school is the Ecole Nationale Supérieure des Moteurs d'Explosion, at Rueil-Malmaison.

As we have seen, the majority of engineers receive their diplomas after study at one school. One group of schools giving this complete preparation comprises those, numbering more than 30, connected with the provincial universities. Of these 11 were designated in 1948 as Ecoles Nationales Supérieures d'Ingénieurs, while retaining unchanged their old connection with their universities. This new status was conferred by the permanent Government commission set up to formulate a unified national policy on this matter, and constitutes recognition of the contributions made by these schools in the past, both as regards fundamental research and in relation to the more applied researches of value to the industries in the provinces in which the universities are situated, and of their growing importance from the national point of view. Engineers from industry are invited to take part in the teaching. The courses take only three years, but a high standard of knowledge of mathematics, physics, and chemistry is expected in the entrance examination. The emphasis of the courses is scientific rather than applied, and the majority of the students, concurrently with the engineering diploma, take, in the faculty of science of their universities, a science degree, the *Licence en Sciences*. The other schools of engineering in the universities, while following similar courses, have not yet gained this national recognition.

A second group of six schools, that are distinguished for their practical outlook, are those described as Les Ecoles Nationales d'Ingénieurs Arts et Métiers. They are, with their dates of foundation: Chalons-sur-Marne, 1806; Angers, 1814; Aix-en-Provence, 1843; Cluny, 1891; Lille, 1900; Paris, 1912. Under the present organisation, the 360 students admitted each year are distributed equally among the five provincial schools, where they spend the first three years of their courses; those who are successful then go to Paris for the fourth and last year, so that the students from all these schools form, at the end, a single unit. All schools are residential, the Paris

school having a new Maison des Arts et Métiers under construction at the Cité Universitaire. Entry is at the minimum age of 20, and the examination is at the level of the second mathematical *Baccalauréat*, together with a test of handwork and one of practical design, so that the candidates must already have received some technical education in addition to a good preparation in mathematics. In the tradition of the schools, abstract speculation is not encouraged—in contrast to the Ecole Polytechnique—but combined reason and experiment are regarded as fundamental, together with regular daily work in the workshops; the communal life of a residential school also plays its part in developing a strong community spirit.

France by which a candidate from the practical side may qualify as *Ingénieur diplômé*.

It is seen that there is a wide range of schools in France giving preparation for an engineering diploma, but only from the graduates of the Ecoles Nationales d'Ingénieurs Arts et Métiers and of the Conservatoire can any considerable practical ability be immediately expected. There is, however, a growing movement towards a better correlation of the academic education with some form of practical training. The increasing emphasis laid upon research, as shown by the increasing number of specialist schools and by the recent recognition of certain university faculties as Ecoles Nationales Supérieures d'Ingénieurs, was marked by the intro-

TABLE I.—BELGIUM: NUMBERS OF DIPLOMAS GRANTED IN 1951.

	B.	G.	Lg.	Lv.	M.	G. & A.	Total.
<i>Ingénieur Civil</i> —							
des Mines	12	2	30	28	3	0	75
des Constructions	16	15	16	17	0	0	64
Métallurgiste	0	0	8	3	11	0	22
Chimiste	0	4	11	4	0	0	19
Electricien	0	9	20	28	0	0	57
Mécanicien	2	5	18	23	0	0	48
Mécanicien et Electricien	22	0	12	13	24	0	71
des Constructions Navales	0	0	1	1	0	0	2
des Industries Textiles	0	0	1	0	0	0	1
Architecte de Constructions	0	3	0	0	0	0	3
Mécanicien ou Electricien	0	0	0	0	0	4	4
Total	52	38	117	117	38	4	366

Universities: B, Brussels; G, Ghent; Lg, Liège; Lv, Louvain; M, Mons. (Faculté poly.).

Ecole Royale Militaire: G and A = Génie (Engineers) and Artillerie.

Total, 366 = 352 Belgians + 14 Foreigners.

Particular mention must be made of an institution of quite a different type, the Conservatoire National des Arts et Métiers at Paris, which, since its foundation in 1819, has offered free instruction, without reference to special entrance qualifications, to all who wish it. To-day it offers 42 different courses, scientific, technical and in economics, that are taken by nearly 15,000 registered students, mostly subordinate employees in industry and commerce; a further large number of unregistered students, who do not take the annual examinations, attend lectures, admission being without formality. From all these, the Conservatoire prepares a small number, 20 to 25 a year, for its engineering diploma.

Many of these students come with considerable practical experience, and the instruction is framed to explain and illustrate the scientific aspects of this experience. They find the opportunity at the Conservatoire to study the fundamental sciences, mathematics, mechanics, physics, and chemistry. They may continue with certain of a wide range of more specialised subjects: metallurgy, industrial chemistry, dye chemistry, biochemistry, applied electricity, heat engines, machines, civil engineering. There are chairs of physics applied to electronics, of industrial heating, or photogrammetry, of spinning and weaving, works organisation, applied art, industrial safety, and even the history of engineering. Most of the professors direct laboratories that are centres both of research for industry and of practical instruction for qualified students.

Especially interesting is the curriculum for the small number of engineers taking the diploma, since it bears some resemblance to that followed by part-time students taking the London degree of B.Sc. (Eng.) externally. Annual examinations are taken in the principal subjects, and include tests in the relevant laboratory work. After four or five years of study on Saturday afternoons and Sunday mornings, and on four evenings per week, a student may take certificates of proficiency in two main subjects at diploma standard. After a further two years of study he may take the third subject. For example, a metallurgist must obtain certificates in metallurgy, general chemistry, general physics and the radiography of metals, and certificates covering practical work in metallurgy, and physics or industrial heat. He must generally carry out a special laboratory investigation and defend his thesis orally before a committee of professors. As here, the many candidates who fall by the wayside profit, nevertheless, from their studies, and look up to those who succeed in taking their diplomas. This is the only opportunity in

duction in 1932 of the research degree of *Docteur-Ingénieur*, open only to engineers with diplomas. This degree is gaining wider recognition, though its prestige is not yet equal to that of the older *Docteur en Sciences*, which is open only to those who have graduated in a university faculty of science, and is awarded for research in pure science rather than in applied science. It is estimated that there are about 110,000 engineers with diplomas in France, including chemical, metallurgical and mining engineers; in comparison, it may be noted that there are about 50,000 corporate members in our three Institutions of Civil, Mechanical and Electrical Engineers, and that the numbers of fully qualified engineers here in the other branches are proportionately very much smaller.

ENGINEERING EDUCATION IN BELGIUM.

In Belgium, as was mentioned earlier, the non-military engineering schools are constituted as faculties of universities, a minor exception being provided by the Ecole Supérieure des Textiles at Verviers. The universities are at Brussels, Ghent, Liège, and Louvain, while the Faculté Polytechnique at Mons is virtually a university with a single faculty. Graduates receive the legal status of *Ingénieur Civil*, a status also granted to the small number of graduates of the Ecole d'Application du Génie et de l'Artillerie, which forms part of the Ecole Royale Militaire. It is, however, open to all Belgians to apply to be examined for a diploma equivalent to that of a university, but, though candidates present themselves every year in languages, history, etc., it is extremely rare for one in engineering studies to appear.

The courses in the universities are controlled nationally and take five years, divided into two years of candidature, common to all branches of engineering and devoted to pure and applied mathematics, physics and chemistry, followed by three years for the diploma, in a specialised branch. Specialisation, however, is not carried to extremes; even in the last year the greater part of the courses is common to two or more branches. The entrance examination can only be passed by those who have successfully followed at school the courses designated: Latin-mathematics or modern-scientific; those with success in the courses Latin-Greek require a special preparatory year. During the university years, there are annual examinations; further, before qualifying, works training must be obtained during two long vacations by the student, who must present detailed reports on this training.

The principal data are given in Table I, herewith in which the first column sets out the nine branches

* Address delivered at the fourth annual meeting of the Regional Advisory Council for Higher Technological Education (London and Home Counties), held at Hastings on July 10, 1952.

SURVEY LAUNCH FOR RIVER MERSEY.

JOHN I. THORNYCROFT AND COMPANY, LIMITED, LONDON.



in which the diploma of *Ingénieur Civil* may be obtained, and the other columns give the numbers in 1951 taking diplomas at the four universities, at Mons, and at the Ecole Royale Militaire, respectively. The schools at Liège and Louvain are seen to be quite large, the others being less than half as big. There is a certain amount of specialisation in the different schools: for example, at Brussels, chemical engineering, naval construction, metallurgy and architecture are not done; at Brussels, Liège and Louvain, in addition to specialisations in electrical and mechanical engineering, a combined electrical-mechanical diploma may be obtained; at Mons, the only branches are mining, metallurgy, and combined electrical-mechanical. The only higher degree is the doctorate in applied science, for which a candidate must present a dissertation, based on researches carried out under a professor, and on which he must be examined publicly.

Before the war, many foreign students took diplomas, but in 1951, out of 366 diplomas, only 14 were gained by non-Belgians. The reduction is partly a reflection of social change in Belgium from a cheap to an expensive country for visitors. There are 10,300 qualified engineers in Belgium, which has a population of 8.5 millions, and the output of 352 graduates a year is hardly equal to present demand.

ENGINEERING EDUCATION IN GERMANY AND AUSTRIA.

I have placed Germany with Austria, the Scandinavian countries, and the Netherlands in the next group, since in all these countries engineers are trained in large technical high schools which work in parallel with, but independently of, the universities. The German *Technische Hochschule* may be taken as typical, though, as will be seen, it would be wrong to say that the other countries have taken this as a model for their schools. In virtue of its large population and its industrial strength, Germany, with its eight technical high schools, provides important evidence for our present subject. Before the war, it had also Dresden and Breslau, and study of the geographical distribution of the ten schools emphasises that they originated in the principal States which went to form the German Empire. The oldest of these, the Collegio Carolino, Brunswick, was opened as far back as 1745 by Carl I, Duke of Brunswick, but the great development of the German technical high schools belongs to the latter half of the Nineteenth Century.

The courses at all of these require attendance during a minimum of eight semesters, that is, four years, and are divided into two parts. The first part consists of four semesters of basic study, which, in addition to pure and applied mathematics, physics and chemistry, includes such subjects as strength of materials, theory of machines and machine drawing, thermodynamics, electrical technology, depending on the branch the student wishes to enter; at the end of this part, the *Vorexamen*, or preliminary examination, is taken. The second part leads to the *Diplom-Hauptprüfung*, the principal or diploma examination. In any one

branch, mechanical engineering, for example, a range of common subjects are studied, such as theory of machines, materials, electrical theory and testing, machine tools, works organisation, heat and power; and these subjects are combined with work in the student's chosen speciality, selected from, say, steam turbines, internal-combustion engines, railway mechanical engineering, hydro-electric power, textile machinery. In addition to written and oral examinations, and the examination of students' course work, each student must carry out a complete individual project, taking as much as half a year. Practical training during one year is a condition for the award of the diploma. At some schools, a half-year of training is necessary before entry, the remainder of the training being obtained during long vacations.

Before the war, a considerable movement of students, during their courses, took place from one school to another, mainly to enable a student to sit under a particular professor for his work in a specialised branch. The courses at all the schools had a certain degree of standardisation, and the individual student undoubtedly benefited from this flexibility; on the other hand, the loyalty commonly held here by a man to his university or college was not so strong. Housing and lodging difficulty since the war has prevented such movement. A further change is that much more importance is now attached in Germany to the provision of student amenities, a *Haus der Studentenschaft*, or Students' Union, often receiving a building priority over that of a laboratory. There is, as here, a consciousness of the need for engineers to be broadly educated, though the actual technical content of the courses remains much more specialised than in this country or in Belgium; broadening is effected by the students taking additional optional subjects.

An estimate of the total numbers of engineering diplomas awarded in each year in Federal Germany is given in Table II, herewith. If the total is multiplied by five, the very conservative value of 13,600 is obtained for the total number of engineering students in the eight schools, an average

TABLE II.—Engineering Diplomas Annually at Technical High Schools in Federal Germany.

Civil Engineering ..	830
Mechanical Engineering ..	700
Electrical Engineering ..	530
Mining ..	150
Metallurgy ..	200
Architecture ..	320
Total ..	2,730

of 1,700 per school. This number gives little allowance for failure, and, moreover, leaves out chemical engineers, engineering physicists, etc. It should also be borne in mind that this output has been realised in the face of great difficulty, since many of these graduates have gone through their courses during the rebuilding of the schools. In fact, rapid as the rebuilding has been, accommodation is still far from satisfactory at most of the schools. The pre-war number was much greater.

The technical high school is thus essentially a large organisation with a wide range of subjects, though all the branches of Table II are not dealt

with at all schools. Classes are normally large. Research has always figured largely in the work of the laboratories, and though a great deal of this is applied and is undertaken at the request of industry, contributions of a fundamental kind are numerous, since professors in Germany have, by tradition, considerable freedom in deciding what should be done in their laboratories. A large proportion of German engineers take the research degree of *Doktor-Ingenieur* (Dr.-Ing.). Many of these do a little laboratory and drawing-office teaching to keep themselves while carrying out their researches, and the *assistent* from the technical high school is in considerable demand for design and development work in industry. They constitute a valuable element among the qualified engineers. A similar tendency is, of course, now to be observed here, but so far on a much smaller scale.

(To be continued.)

SURVEY LAUNCH FOR RIVER MERSEY.

The survey launch Surveyor No. 5, illustrated here-with, has been constructed at the Woolston shipyard of Messrs. John I. Thornycroft and Company, Limited, for the Mersey Docks and Harbour Board; she successfully completed her trials early in July and is to go into immediate service on the River Mersey. The launch is 50 ft. in length overall, with a beam of 11 ft. and a maximum draught of 3 ft. 8 in.; her two six-cylinder Diesel engines give her a cruising speed of 12½ knots with a maximum of 13½ knots. The hull is of a round-bilge form, planked with a double skin of ½-in. mahogany boards laid on elm timbers; both the keel and stern post are of oak.

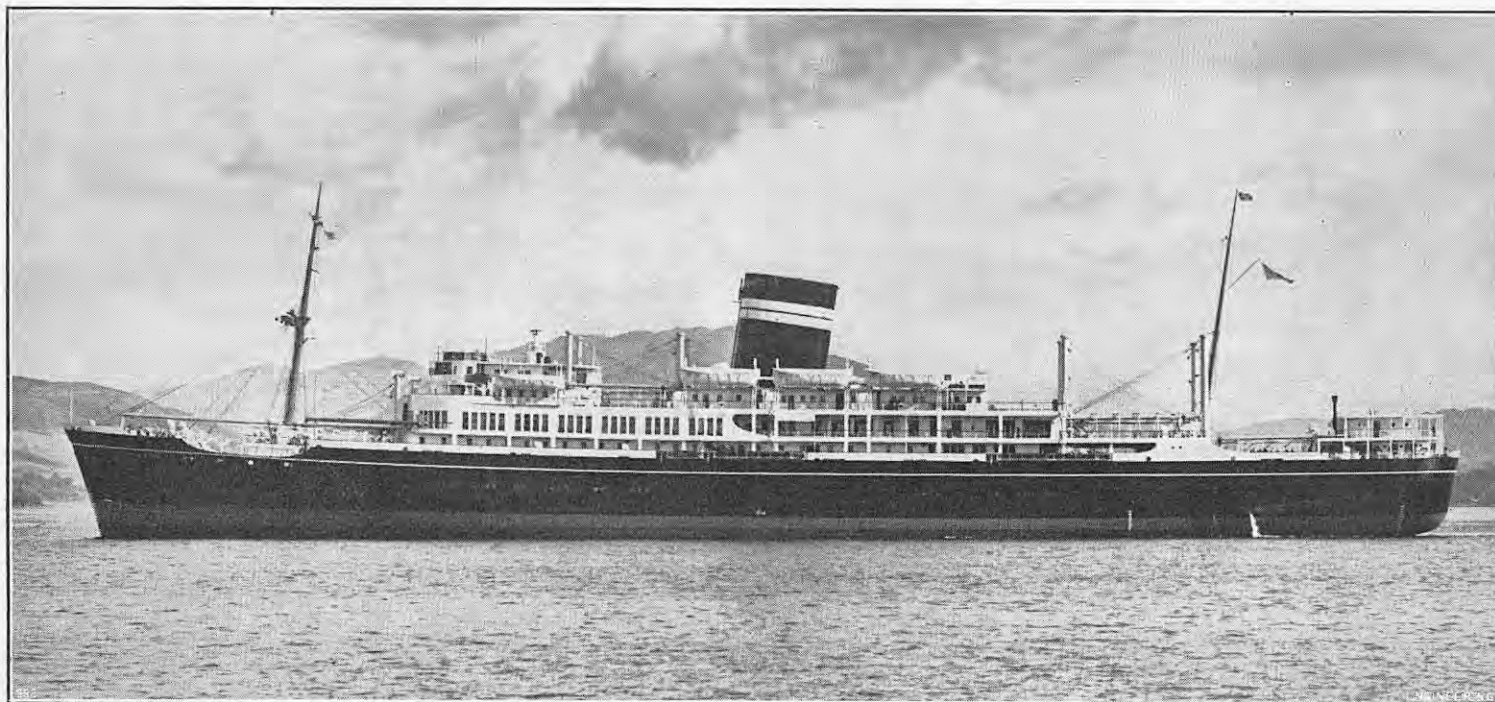
The propelling machinery consists of two Thornycroft type RNR six-cylinder Diesel engines, each capable of 90 brake horse-power at 1,600 r.p.m., driving twin propellers, 27 in. in diameter, through oil-operated reverse gears of the Self-Changing Gear Company's manufacture, and 2:1 reduction gears. The speed of each engine and the operation of its reverse gear are controlled from the wheelhouse by means of the Thornycroft combined single-lever control, a device dispensing with separate throttle control and so giving considerable advantages where frequent and rapid manoeuvres will be required. Fuel is carried in two 100-gallon tanks, sufficient for 24 hours' cruising, situated in the engine-room. The sea-water, after passing through the heat exchanger is injected into the motor exhausts. The operating gear for the twin rudders is housed in the aft-peak house. A Stuart Turner auxiliary lighting and charging set is installed forward of the starboard engine; it consists of a 1-h.p. single-cylinder Diesel engine coupled directly to a shunt-wound dynamo giving 500 watts at 25/35 volts.

The wheelhouse and chartroom is situated amidships, with observation platforms at each corner aft. The echo sounder recorder is between the platforms and against the bulkhead. The recorder unit, supplied by Messrs. Kelvin and Hughes, is of their type MS.21A, and consists of a self-contained recorder/amplifier unit, transmitting and receiving oscillator units permanently fitted to the hull, two remote "fix" marker hand switches (fixed to the ceiling above the observers) and a tachometer unit. The recorder is operated by either of two 24-volt batteries stowed beneath the chartroom flat. The transmission rate is 533 per minute, with an effective range from a few inches of water depth to a maximum of 90 fathoms. On the port side of the wheelhouse are the steering wheel, instrument panel and other controls; and mounted on the roof above the helmsman, and controlled from the interior, is a 9-in. searchlight.

Comfortable accommodation is provided for the crew and the surveyors, and adequate ventilation is ensured throughout by cowl and mushroom ventilators, ample windows and electrical extractor vents. Forward of the wheelhouse is the crew space and beyond the bulkhead is the forepeak containing the chain locker. Direct access from the crew space to the deck is provided by a ladder through an escape hatch. The galley is immediately abaft the engine room, with a saloon and cockpit beyond.

TWIN-SCREW PASSENGER AND CARGO LINER "UGANDA."

BARCLAY, CURLE AND COMPANY, LIMITED, GLASGOW.



THE PASSENGER AND CARGO LINER "UGANDA."

THE 14,500-ton twin-screw passenger and cargo liner Uganda, the latest addition to the fleet of the British India Steam Navigation Company, is now loading in London in readiness for her maiden voyage on August 2, when she will join her sister ship, the Kenya, on the United Kingdom-East African service. The Uganda was built and engined by Barclay, Curle and Company, Limited, at their yard at Whiteinch, Glasgow, and is the 65th vessel to be built by them for the British India line. The general appearance of the vessel will be seen from the illustration above. In most respects, she is similar to the Kenya, the only difference of note being that the Uganda's funnel is 12 ft. higher. A full description of the Kenya appeared in our issue of September 28, 1951 (vol. 172, page 393). The principal dimensions are: length overall, 540 ft., and, between perpendiculars, 517 ft. 6 in.; breadth moulded, 71 ft.; and depth moulded, to B deck, 38 ft. 6 in. She has been constructed to carry 300 passengers, 191 in the first class and 109 in the tourist class, with part of the accommodation arranged so that it can be interchanged between the two classes. There are five holds which provide 390,000 cub. ft. of general cargo space and 25,000 cub. ft. of refrigerated space. Propulsion is by two sets of Parsons steam turbines, developing 11,200 shaft horse-power and driving twin screws through double-helical gearing. Steam is supplied by three Babcock and Wilcox boilers. The service speed is 16 knots.

The passenger accommodation is on the promenade deck and on A, B and C decks. The promenade deck is devoted entirely to the first-class public rooms, and most of C deck is occupied by the galleys and dining saloons for both classes of passenger. The whole of B deck and most of A deck is occupied by cabins, part of A deck being used for the tourist-class public rooms. The first-class passengers are accommodated in single-berth and two-berth cabins provided with the usual amenities, such as mechanical ventilation and heating, hot and cold running water, etc. There are also a few *cabines de luxe*, which are specially decorated and furnished and have private bathrooms. The tourist-class cabins are for two, three or four persons and, in general, follow the lines of those in the first class, the upper berths in the three-berth and four-berth cabins being designed so that they can be removed when not in use.

The first-class public rooms consist of the dining

saloon, children's dining saloon, lounge, writing and card rooms, smoking room, cocktail bar and a ballroom. For the tourist-class passengers there is a dining saloon, a smoking room and a lounge. The first-class dining saloon extends the full width of the ship and provides seating for 176 passengers. There is a raised roof over the centre portion of the saloon, the sides of which are painted with murals. The first-class lounge is situated at the forward end of the promenade deck. For observation and as a decorative device, a raised false deck is built into the forward end, the step between this portion and the main part of the lounge being guarded by a low balustrade. The card room and writing room are situated at the port and starboard sides, respectively, of a trunked hatch aft of the lounge and between these two rooms and the smoking room is the first-class entrance hall with stairways down to A and B decks. The smoking room is amidships and is almost square in plan, with deep bay-window recesses at each side. Aft of the smokers room is the engine casing with the cocktail bar on the port side of the casing. Aft of this again is the verandah ballroom, both sides of which are fitted with sliding-folding glazed screens. The after end of the verandah opens out on to a large deck space, in the centre of which is a swimming pool.

The tourist-class dining saloon, like the first-class saloon, is situated on C deck, but at the after end. It also extends the full width of the ship and provides seating for 126 persons. The tourist lounge is arranged at the after end of A deck. Opposite the lounge on the port side is the smoking room, a pleasant room, comfortably furnished. Aft of these two rooms is the tourist-class swimming pool, which is flanked at each side by sports decks. Other amenities provided for the passengers include first-class and tourist-class children's playing rooms, ironing and drying rooms, a shop, a hairdressing saloon, hospital facilities and a laundry. The laundry can deal with all requirements of the ship's hotel services and of the passengers and the crew. It is all-electric and the equipment installed includes washing machines, hydro-extractors, dryers and ironing machines. Both electricity and steam are employed in the galley, which is equipped with the latest types of ovens, dish-washing machines, etc.

As previously mentioned, the propelling machinery consists of two sets of Parsons steam turbines arranged to drive twin screws through single-reduction double-helical gears, each set of turbines consisting of high-pressure, intermediate-pressure and low-pressure units. Each high-pressure turbine is of the impulse reaction type, the reaction

portion being fitted with stainless-iron end tightened blading. The intermediate-pressure and low-pressure turbines are fitted with reaction blading throughout, all the blading in the intermediate-pressure turbine being of the end-tightened type. The astern turbines are designed to develop 65 per cent. of the normal service power. There is a high-pressure astern impulse wheel in the intermediate-pressure ahead turbine casing and separated from it by a diaphragm, and a low-pressure astern turbine at the exhaust end of the low-pressure ahead turbine. The steam pressure at the manoeuvring valves is approximately 430 lb. per square inch and the temperature about 750 deg. F. The astern turbines are designed to take steam at this pressure and temperature, but attenuators are provided so that, when manoeuvring, the steam temperature can be reduced to approximately 600 deg. F.

The turbines are controlled by manoeuvring valves, supplied by Cockburns, Limited, and designed with the ahead and astern valves in one casting, and there is a separate master shut-off valve for the astern range. Aspinall governing gear is fitted; this operates through the forced-lubrication system used for supplying oil to the turbine and reduction-gearing bearings and to the sprayers, which direct the oil on to the gear teeth. The turbines are stopped automatically if their speed exceeds a predetermined value or if the oil pressure drops or the vacuum in the condenser is lost. There is also a hand-operated control valve so that the turbines can be shut down in an emergency.

Steam is supplied by three Babcock and Wilcox boilers designed for a working pressure of 480 lb. per square inch. They have a total heating surface of 21,117 sq. ft. and are arranged to burn oil fuel under a balanced-draught system. There are three forced-draught fans, one for each boiler, but only one induced-draught fan, which is capable of dealing with the waste gases from all three boilers. The induced-draught fan discharges through a Howden dry-type dust collector, to extract the grit and soot, which is directed into a hopper, flushed with sea water, the mixture subsequently being discharged below sea level. Messrs. G. and J. Weir's closed-feed system is employed, the system incorporating two motor-driven extraction pumps, one for each set of engines, and the usual air ejectors, gland-steam ejectors and condensers, drain coolers, etc. Turbine-driven feed pumps are installed, the turbines exhausting to the low-pressure feed heater. Two stages of feed heating are employed, the high-pressure heater being supplied with steam bled

from the intermediate-pressure turbine at a pressure of 90 lb. per square inch absolute.

The auxiliary machinery, such as the main circulating pumps, forced-lubrication, ballast, bilge, fresh-water and sanitary pumps, etc., is electrically driven, those pumps which discharge overboard having push-button stops on the boat deck so that they can be stopped when the lifeboats are being lowered. Power for operating the pumps, etc., in the engine room and for the ship's hotel services is provided by five Diesel-driven generators, each rated at 390 kW, which were constructed by W. H. Allen, Sons and Company, Limited, and are installed in a separate compartment situated between the engine and boiler rooms. Three generators are capable of meeting the maximum load, so that the two stand-by machines give an ample margin of safety.

LARGE BRITISH TRANSFORMERS FOR THE UNITED STATES.

As mentioned briefly in last week's issue, on page 78, *ante*, Messrs. Ferranti, Limited, Hollinwood, Lancashire, have been awarded a contract by the United States Army Corps of Engineers for the supply of nine 33½-MVA, 13·2/230-kV transformers. These transformers will be arranged in three 100-MVA banks, and each of these banks will be connected to an 80-MVA hydro-electric generator in the Garrison Dam station, 77 miles from Bismarck on the Missouri River; the ultimate capacity of the station will be 400 MW.

At first sight this award may not seem surprising, since Messrs. Ferranti's bid was 887,000 dols., compared with the lowest American offer of 1,063,100 dols. As the Ferranti price included 85,100 dols. duty, there was therefore a possible saving to the purchasers—the U.S. Government—of 261,200 dols. Matters, however, are not so simple as that, since the "Buy American" Act places difficulties in the way of accepting foreign tenders, however favourable. Fortunately, in this case the regulations of the United States Army require that where a foreign offer strictly complies with the specification and is at least 5,000 dols. less than the lowest American tender, the matter must be referred to Secretary of the Army. If he then considers that the American price is "unreasonable" and "not in the public interest," he is authorised to accept the foreign offer.

In making their submission in this particular case, Messrs. Ferranti not only stressed the price difference and their complete compliance with the specification, but pointed out that their bid was an important attempt to earn dollars for this country. Attention was also drawn to the after-sales service that could be provided by the engineers of their Toronto factory and to the technical competence of the firm in the high-tension transformer field, since they had been making transformers since 1889, and had manufactured the first 230-kV units. Moreover, they had, at the present time, 15,000 MVA of transformers for over 66 kV under construction. These arguments, we are glad to say, were successful, and the whole of the contract was awarded to Messrs. Ferranti, Limited, on Friday, July 18.

It is of technical interest to record that the Garrison Dam will be over 2 miles long and more than 200 ft. above the bed of the stream. It will therefore be one of the largest earth embankments in the world. The dam will impound a reservoir over 200 miles in length and more than 14 miles wide in some places, the maximum depth being over 200 ft. along the former channel. It will ensure flood control and improve navigation on both the Missouri and Mississippi Rivers, while the water will be used both for power generation and irrigation.

COUNCIL OF THE INSTITUTION OF ELECTRICAL ENGINEERS.—Colonel B. H. Leeson has been elected President of the Institution of Electrical Engineers for the 1952-53 session, and Messrs. J. Eccles and T. E. Goldup vice-presidents. Mr. H. W. Grimmit becomes honorary treasurer and, as the result of a ballot, Messrs. C. Dannatt, O. W. Humfreys, Professor M. G. Say, H. R. L. Lamont, G. Lyon and C. R. King have been elected to the Council.

THE WATER SUPPLY OF GLASGOW.

THE present water consumption of the city of Glasgow is about 87 million gallons daily, of which about 82 million gallons are obtained from Loch Katrine; between 1919 and 1932, because of the long depression in trade, the demand fell, but since 1932 it has been increasing steadily and shows no sign of abatement. The Corporation's Water Department, of which Mr. Stanley D. Canvin, B.Sc. (Eng.), M.I.C.E., M.I.W.E., is chief engineer and general manager, have found it necessary, therefore, to seek additional supplies to augment the Loch Katrine works. A scheme has been prepared to develop the Glen Finlas catchment area for this purpose and offers have been accepted recently by the Corporation for the sinking of exploratory boreholes on this site, with the advice of Dr. J. E. Richey, of Edinburgh, as consulting geologist. Meanwhile, the Corporation, at their meeting on June 26, accepted the tender of Messrs. McKean and Company (Glasgow), Limited, amounting to 61,699l., for the laying of a 48-in. siphon pipe in the Endrick valley to supplement the existing five 48-in. pipes and one 36-in. pipe and so to bring the capacity of this portion of the aqueduct up to the full capacity of the tunnel sections, which are about 19 miles long.

The Endrick Valley pipeline is about 2½ miles long and will be laid in spun bitumen-lined steel pipes with Viking Johnson coupling joints. The pipes have been on order since 1949 and some 250 tons, out of the total of 1,500 tons, have been delivered. The Department of Health for Scotland has promised iron and steel authorisation for most of the remaining pipes, and it is expected that the work will be completed in about a year's time. The full capacity of the aqueduct between Loch Katrine and the Milngavie service reservoirs will not be developed, however, until a further siphon pipe is laid across the Blane Valley, the length of 48-in. pipes required in this case being about two-thirds of a mile. The Blane Valley contract is planned to commence early in 1953. On its completion, it is hoped that the aqueduct will be able to carry 110 million gallons per day from Loch Katrine to Milngavie. The additional siphon capacity is necessary in order that sections of the aqueduct may be closed down when necessary for repairs and maintenance, and also to prepare for the increasing demands of the city during the next decade. The engineering work on the scheme is being carried out by the Water Department staff under the direction of Mr. Canvin.

The modified Glen Finlas scheme, for which the boreholes are to be sunk, is designed as a temporary augmentation of the Loch Katrine supply works until such time as it becomes necessary to develop the Glen Finlas catchment area by constructing a large impounding reservoir. The present scheme consists of a low intake weir and a tunnel aqueduct, about 2½ miles long. To ensure that the intake and tunnel works will be of use when the impounding reservoir is constructed, a full investigation of the site of the proposed dam is now being undertaken by Dr. Richey. When finally developed, the Glen Finlas scheme will augment Glasgow's supplies by 19 million gallons per day. The present scheme will provide about one-third of this quantity, which should give the Water Department a sufficient working margin for several years at the present rate of increase in consumption. The preliminary estimate of the cost of the intake scheme is only 600,000l., whereas it is estimated that the construction of the impounding reservoir at the present time would have involved an expenditure of over 2,000,000l. The Corporation will seek an Order from the Secretary of State for Scotland for carrying out the scheme, though they already possess certain powers granted by a Provisional Order obtained from Parliament in 1915, when the Glen Finlas scheme was first mooted. The original scheme was to have been carried out shortly after the first world war, following the refusal of Parliament to sanction the development of Loch Voil. It was subsequently found more expedient to increase the water supply, which was urgently required, by raising the level of Loch Katrine.

FORTHCOMING EXHIBITIONS AND CONFERENCES.

THIS list appears in the last issue of each month. Organisers are invited to send to the Editor particulars of forthcoming events.

UNION OF PAN-AMERICAN ENGINEERING SOCIETIES.—Monday, August 25, to Saturday, August 30, at New Orleans, Louisiana, U.S.A. Organised by the Asociacion de Ingenieros del Uruguay, Avenue Agraciada 1464, Piso 14, Montevideo, Uruguay.

INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING, FOURTH INTERNATIONAL CONGRESS.—Monday, August 25, to Friday, August 29, at Cambridge. For further information, apply to the secretary of the Association, Swiss Federal Institute of Technology, Zürich, Switzerland.

19TH NATIONAL RADIO AND TELEVISION EXHIBITION.—Tuesday, August 26, to Saturday, September 6, at Earl's Court, London, S.W.5. Organised by the Radio Industry Council. Apply to the secretary of the Council, 59, Russell-square, London, W.C.1. (Telephone: MUSEum 6901.)

FRANKFURT AUTUMN FAIR.—Sunday, August 31, to Thursday, September 4, at Frankfurt-on-Main. Agents: LEP Transport Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. (Telephone: CENTral 5050.)

THIRD INTERNATIONAL SPECTROSCOPY COLLOQUIUM.—Monday, September 1, to Wednesday, September 3, at London. Organised by the Industrial Spectroscopy Group of the Institute of Physics, 47, Belgrave-square, London, S.W.1. (Telephone: SLOane 9806.)

SUMMER SCHOOL ON PHOTO-ELASTICITY.—Monday, September 1, to Thursday, September 11, at University College, London. Apply to the secretary, University College, Gower-street, London, W.C.1. (Telephone: EUSTon 4400.) See also our issue of June 20, 1952, page 795.

59TH ROYAL NETHERLANDS INDUSTRIES FAIR.—Tuesday, September 2, to Thursday, September 11, at Utrecht, Holland. Agent: Mr. W. Friedhoff, 10, Grosvenor-place, London, W.1. (Telephone: WELbeck 9971.)

FLYING DISPLAY AND EXHIBITION.—Tuesday, September 2, to Sunday, September 7, at Farnborough. Open to the public on September 5, 6 and 7, only. Organised by the Society of British Aircraft Constructors, Ltd., 32, Savile-row, London, W.1. (Telephone: REGent 5215.) See also our issue of June 13, 1952, page 745.

FOURTH ELECTRONICS SYMPOSIUM AND EXHIBITION.—Tuesday, September 2, to Friday, September 5, at the Examination Hall, Queen-square, London, W.C.1. Organised by the Electrical and Electronics Section of the Scientific Instrument Manufacturers' Association of Great Britain, Ltd., 20, Queen Anne-street, London, W.1. (Telephone: LANgham 4251.) See also our issue of June 27, 1952, page 815.

BRITISH ASSOCIATION.—Wednesday, September 3, to Wednesday, September 10, at Belfast. Communications to Mr. D. N. Lowe, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1. (Telephone: REGent 2109.)

AMERICAN SOCIETY OF CIVIL ENGINEERS, CENTENNIAL CELEBRATIONS.—Wednesday, September 3, to Saturday, September 13, at Chicago, U.S.A. Particulars from the secretary of the Society, 33, West 39th-street, New York.

ASSOCIATION OF GERMAN ENGINEERS: GENERAL ASSEMBLY.—Thursday, September 4, to Sunday, September 7, at Stuttgart. Organised by the Verein Deutsche Ingenieure, Prinz-Georg-strasse, Düsseldorf, Germany.

19TH INTERNATIONAL GEOLOGICAL CONFERENCE.—Monday, September 8, to Monday, September 15, at Algiers. Convened by the Comité Algérien d'Organisation du XIX Congrès Géologique International. Apply to Professor R. Lafitte, Faculté des Sciences, Algiers.

WELSH INDUSTRIES FAIR.—Wednesday, September 10, to Saturday, September 20, at the New Pavilion, Sophia-gardens, Cardiff. Particulars from the offices of the Fair, 17, Windsor-place, Cardiff. (Telephone: Cardiff 23049.)

SWISS FAIR, LAUSANNE.—Saturday, September 13, to Sunday, September 28, at Lausanne. For further information, apply to Comptoir Suisse, Place de la Riponne 5, Lausanne, Switzerland.

ASSOCIATION OF PUBLIC LIGHTING ENGINEERS, ANNUAL CONFERENCE AND EXHIBITION OF STREET LIGHTING APPARATUS AND EQUIPMENT.—Tuesday, September 16, to Friday, September 19, at the Royal Hall, Harrogate. Communications to be addressed to the secretary, Association of Public Lighting Engineers, 22, Surrey-street, Strand, London, W.C.2. (Telephone: TEMple Bar 9607.) See also page 71, *ante*.

INTERNATIONAL MACHINE TOOL EXHIBITION.—Wednesday, September 17, to Saturday, October 4, at

Olympia, London, W.14. Organised by the Machine Tool Trades Association, Victoria House, Southampton-row, London, W.C.1. (Telephone: HOLborn 4667.) See also our issue of July 13, 1951, page 51.

MODERN BUILDING PLANT EXHIBITION.—Thursday, September 18, to Wednesday, September 24, at the Sophia Gardens Field, Cardiff. For further information, apply to the Ministry of Works, Lambeth Bridge House, London, S.E.1. (Telephone: RELiance 7611.)

ASLIB (ASSOCIATION OF SPECIAL LIBRARIES AND INFORMATION BUREAUX).—Friday, September 19, to Monday, September 22, Annual Conference at The Hayes, Swanwick, Derbyshire. Apply to the secretary of the Association, 4, Palace-gate, Kensington, London, W.8. (Telephone: WEStern 6321.)

NORTH-WESTERN BUSINESS EFFICIENCY EXHIBITION.—Monday, September 22, to Saturday, September 27, at St. George's Hall, Liverpool. Organised by the Office Appliance and Business Equipment Trades Association, 11-13, Dowgate-hill, Cannon-street, London, E.C.4. (Telephone: CENTral 7771.)

SYMPOSIUM OF MINERAL DRESSING.—Tuesday and Wednesday, September 23 and 24, at the Imperial College of Science and Technology, Prince Consort-road, South Kensington, London, S.W.7. Organised by the Institution of Mining and Metallurgy, Salisbury House, Finsbury-circus, London, E.C.2. (Telephone: MONarch 2096.) See also our issue of February 15, 1952, page 211.

COMMERCIAL MOTOR SHOW.—Friday, September 26, to Saturday, October 4, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148, Piccadilly, London, W.1. (Telephone: GROsvenor 4040.)

FOURTH INTERNATIONAL CONGRESS ON INDUSTRIAL HEAT AND APPLIED THERMODYNAMICS.—Saturday, September 27, to Saturday, October 4, in Paris. Apply to the general secretary of the Congress, 2, Rue des Tanneries, Paris, 13e.

18TH INTERNATIONAL NAUTICAL EXHIBITION.—Saturday, September 27, to Sunday, October 12, in Paris. Agents: Home and Overseas Trade Fairs, 40, Gerrard-street, London, W.1. (Telephone: GERard 5947.)

16TH METZ TRADE FAIR.—Saturday, September 27, to Monday, October 13, at Metz. Agents: Home and Overseas Trade Fairs, 40, Gerrard-street, London, W.1. (Telephone: GERard 5947.)

IRON AND STEEL EXPOSITION.—Tuesday, September 30, to Friday, October 3, at the Public Auditorium, Cleveland, Ohio, U.S.A. Organised by the Association of Iron and Steel Engineers. Apply to Mr. Albert W. Erickson, Junr., at the Association's offices, 1010, Empire Building, Pittsburgh 22, U.S.A. See also our issue of April 18, 1952, page 486.

PLASTICS EXHIBITION.—Saturday, October 11, to Sunday, October 19, at Düsseldorf. Organised by the Nordwestdeutsche Ausstellungen G.m.b.H. (Nowva), Ehrenhof 4, Düsseldorf, Germany. Agents: John E. Buck & Co., 47, Brewer-street, Piccadilly, London, W.1. (Telephone: GERard 7576.)

ENGINEERING INDUSTRIES ASSOCIATION, LONDON REGIONAL DISPLAY.—Tuesday and Wednesday, October 14 and 15, at the Horticultural Hall, Vincent-square, London, S.W.1. Apply to the secretary of the Association, 9, Seymour-street, Portman-square, London, W.1. (Telephone: WELbeck 2241.)

"THE MODEL ENGINEER" EXHIBITION.—Monday, October 20, to Wednesday, October 29, at the New Horticultural Hall, Vincent-square, London, S.W.1. Apply to the offices of the Exhibition, 23, Great Queen-street, Kingsway, London, W.C.2. (Telephone: CHAncery 6681.)

EXHIBITION OF MACHINERY AND APPARATUS FOR FOOD-PROCESSING, CHEMICAL AND PHARMACEUTICAL INDUSTRIES.—Tuesday, October 21, to Wednesday, October 29, at Rotterdam. Organised by the Royal Netherlands Industries Fair, Rotterdam, Holland. Agent: Mr. W. Friedhoff, 10, Grosvenor-place, London, W.1. (Telephone: WELbeck 9971.)

MOTOR SHOW.—Wednesday, October 22, to Saturday, November 1, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148, Piccadilly, London, W.1. (Telephone: GROsvenor 4040.)

PUBLIC WORKS AND MUNICIPAL SERVICES CONGRESS AND EXHIBITION.—Monday, November 3, to Saturday, November 8, at Olympia, London, W.14. Organised jointly by the Municipal Agency, Ltd. and the Congress Organising Council. Applications to the Municipal Agency, Ltd., 68, Victoria-street, London, S.W.1. (Telephone: VICToria 9132.)

27TH INTERNATIONAL CYCLE AND MOTOR-CYCLE SHOW.—Saturday, November 15, to Saturday, November 22, at Earl's Court, London, S.W.5. Organisers: British Cycle and Motor Cycle Manufacturers' and Traders' Union, Ltd., The Towers, Warwick-road, Coventry. (Telephone: COventry 62511.)

BREWERS' EXHIBITION.—Monday, November 24, to Friday, November 28, at Olympia, London, W.14.

Particulars obtainable from the organisers, Trades, Markets and Exhibitions, Ltd., 623, Grand Buildings, Trafalgar-square, London, W.C.2.

20TH NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING.—Monday, December 1, to Saturday, December 6, at the Grand Central Palace, New York. Organised by the American Society of Mechanical Engineers, 29, West 39th-street, New York 18.

LABOUR NOTES.

SEVERAL matters of outstanding importance to industry and the trade-union movement, in connection with the upward trend of wages, have occurred during the past week. On Friday last, it was announced that proposals for increasing the wage rates of more than a million employees in the distributive and allied trades, which had been submitted to the Minister of Labour, Sir Walter Monckton, in accordance with the requirements of the Wages Councils Act, 1945, had been referred back by him to the 12 Wages Councils concerned. In an accompanying note, Sir Walter drew the attention of the Councils to the statement made by the Chancellor of the Exchequer, Mr. R. A. Butler, to the National Joint Advisory Council on May 15, in which Mr. Butler explained that this country's economic circumstances were such that proposals for increases in wages must be considered with full regard to the national interest. Sir Walter asked that the proposals for increases put forward by the 12 Councils should be reconsidered by them in the light of that statement.

Wages Councils consist of representatives of employers and trade unions, together with independent members, who have a casting vote. Eight of the 12 Councils whose proposals have been referred back are concerned with retail distribution and the hairdressing trade, and the remaining four with laundry services and light manufacturing trades. Negotiations were commenced in January last on claims for an all-round increase of 20s. a week, which had been put forward by the Union of Shop, Distributive and Allied Workers. After discussions spread over several weeks, it was decided by the Councils that increases should be granted in exact proportion to the advance in the level of the index of retail prices, since the previous wage award in these trades, which was given early in 1951.

In a statement issued on Friday last by the Retail Distributors' Association, the employers' organisation, it was pointed out that the wage increases proposed by the Councils included advances of 10s. a week for men and 7s. 6d. a week for women in the retail drapery and food-distribution trades, and 9s. a week for men and 7s. 6d. a week for women in the retail furnishing trade. These suggested increases were quoted as being typical of the others. The agreements of the Councils were submitted to the Minister of Labour in due course, as required by the Act. The Minister has power either to accept the recommendations of the Councils and make an Order giving them statutory authority, or to send them back to the Councils concerned for further consideration. He cannot vary proposals put forward by Councils or reject them entirely.

The Union of Shop, Distributive and Allied Workers, as the union most concerned, issued a strong protest against the Minister's action immediately the reference back was made known. The matter was discussed at the meeting of the economic committee of the Trades Unions Congress on Tuesday last and again at the full meeting of the General Council of the T.U.C. on Wednesday, when it was decided to ask the Prime Minister to meet members of the General Council to discuss the whole subject. Although there are signs that some leading trade-union officials are not unduly perturbed at the decision of the Minister of Labour and the possibility of the present avalanche of wage claims being checked, there is some concern regarding the statement by Sir Walter in the House of Commons on Monday. This is considered to imply that it is the business of the Government to

examine critically the level of wages proposed by the Wages Councils. As Sir Walter stated in the House, his action in referring back proposals made by Wages Councils was in line with similar action taken by Mr. George Isaacs, the Minister of Labour in the previous Government, in 1948.

On Tuesday, the National Coal Board rejected outright the wage claim submitted by the National Union of Mineworkers for an all-round increase of 30s. a week. Some 700,000 miners are concerned in this claim, which, if it had been granted in full, would have meant an addition of over fifty million pounds a year to the industry's wage bill and an increase of about 5s. a ton in the price of coal. An official statement issued after a meeting of representatives of the two bodies on Tuesday briefly recorded that the parties had failed to reach an agreement and that the union's officials would report to their executive committee as soon as possible. The next meeting of the committee is due to be held on August 6.

Existing minimum rates of pay in the industry, 7l. 0s. 6d. for underground employees and 6l. 1s. 6d. for men engaged on surface work, were awarded in November last year, when the National Coal Board agreed to increases of 13s. 6d. and 11s. 6d., respectively. The average weekly earnings of miners, including underground workers and surface employees, for the first three months of the present year amounted to 11l. 2s. 2d., not including allowances in kind which were valued at 10s. 7d. a week. According to the national conciliation scheme for the industry, the next stage, should the N.U.M. decide to press their demand in its existing form, will be for the union to submit their claim to the National Reference Tribunal for the industry. This Tribunal, which is presided over by Lord Porter, G.B.E., is a statutory body and constitutes the coal-mining industry's final court of appeal.

Demands for wage increases in a number of other industries have also been rejected since Mr. Butler drew attention on May 15 to the dangers of inflation arising from the heavy demands for higher wages. The joint claim of the three principal railway unions for an all-round increase of 10 per cent. was turned down by the Railway Executive and will be considered by the Railway Staff National Council on Monday next. Demands by provincial omnibus employees have been rejected by their employers and are to be submitted to arbitration. The claims of a number of smaller groups of workpeople have been turned down. During recent weeks, agricultural employees alone, for whom an advance of 5s. a week is suggested, have been able to advance their wage aspirations.

Men employed at the shipbuilding yards of J. L. Thompson & Sons, Ltd., Sunderland, have refused a suggestion by the employers that some of them should carry on working during their two weeks' annual holiday, in order to have a 15,000-ton oil tanker ready for launching during August. The men expressed their willingness to work during the time proposed and to take their annual holidays later, provided the company made some compensatory payment. The company, however, did not agree to the request and the men's union said that because of this refusal, there would be no holiday work. Men employed at Wear shipyards will take their annual holidays simultaneously, during the two weeks commencing on July 25.

The index figure for all items of the interim index of retail prices rose by three points on June 17, to the new high level of 138, compared with 135 on May 13 last. The rise in the index level during the period was caused in the main by the higher prices of tea, meat, and meat products. Small increases also took place in the prices of a considerable number of other items, but the Ministry of Labour and National Service reports that the average levels of prices for clothing and household textiles were a little lower than on May 13. It may be recalled that the last occasion on which the index level rose by as much as three points in one four-weekly period was between April and May last year, when the figure increased from 121 to 124.

"MACHINING" HARD METALS BY ELECTRIC SPARK.

SPARCATRON, LIMITED, GLOUCESTER.

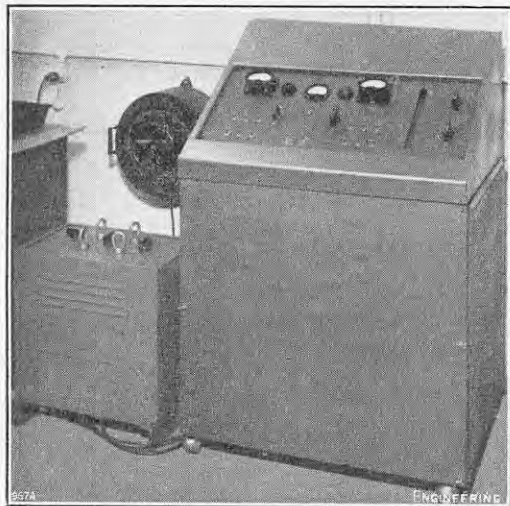


FIG. 1. ELECTRONIC EQUIPMENT.

LAUNCHES AND TRIAL TRIPS.

M.S. "SIBELLA."—Single-screw oil tanker, built by the Furness Shipbuilding Co. Ltd., Haverton Hill, County Durham, for Skibsaktieselskabet Avanti (Managers: Tschudi & Eitzen), Oslo, Norway. Main dimensions: 560 ft. between perpendiculars by 80 ft. by 42 ft. 3 in. to upper deck; deadweight capacity, 24,550 tons on a summer draught of 32 ft. 3½ in. N.E.M.-Doxford six-cylinder single-acting two-stroke opposed-piston oil engine, developing 6,800 b.h.p. at 116 r.p.m. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, 14 knots. Launch, July 8.

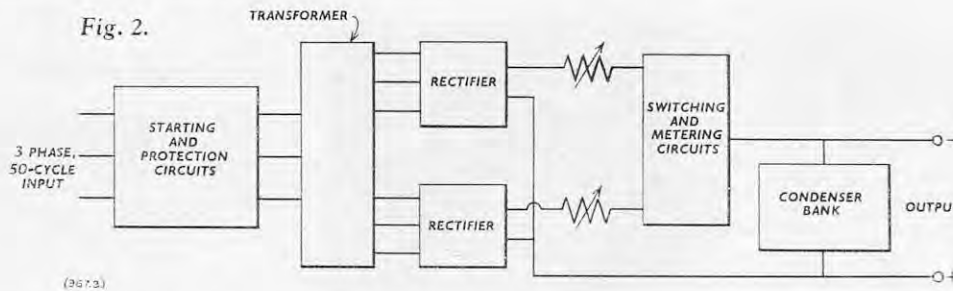
S.S. "NELEUS."—Single-screw cargo liner, built by the Caledon Shipbuilding and Engineering Co., Ltd., Dundee, for the Australian trade of Alfred Holt & Co., Liverpool. Main dimensions: 489 ft. by 64 ft. by 35 ft. 3 in. to upper deck; deadweight capacity, 9,500 tons. Three-cylinder cross-compound high-pressure impulse type steam turbine, developing a maximum output of 8,000 s.h.p. at 112 r.p.m., constructed by the Metropolitan-Vickers Electrical Co., Ltd., Manchester, and two Foster Wheeler single-furnace oil-fired boilers, constructed by D. Rowan & Co., Ltd., Glasgow. Service speed, 16 knots. Launch, July 8.

M.S. "JANITA."—Single-screw oil tanker, built and engineered by Harland and Wolff, Ltd., Belfast, for Anders Jahre & Co., Sandefjord, Norway. Main dimensions: 540 ft. between perpendiculars by 73 ft. by 39 ft. 3 in. to upper deck; deadweight capacity, about 18,500 tons. Harland-B. and W. six-cylinder two-stroke single-acting opposed-piston oil engine. Trial trip, July 8 and 9.

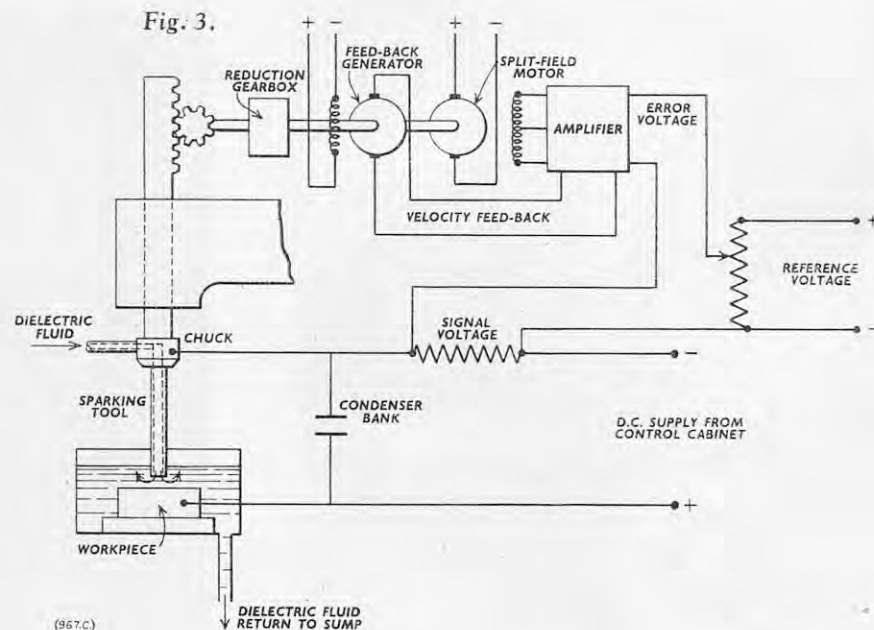
S.S. "VANESSA."—Single-screw trawler, built by Cook, Welton and Gemmell, Ltd., Beverley, Yorkshire, for the Atlas Steam Fishing Co., Ltd., Grimsby. Main dimensions: 178 ft. between perpendiculars by 31 ft. by 16 ft.; gross tonnage, about 675; fishroom capacity, 14,925 cub. ft. Triple-expansion steam engine, constructed by Charles D. Holmes & Co., Ltd., Hull, and one multitubular oil-fired boiler. Launch, July 10.

S.S. "UGANDA."—Twin-screw liner carrying 167 first-class and 133 tourist-class passengers, and cargo, built by Barclay, Curle & Co., Ltd., Glasgow, for the British India Steam Navigation Co., Ltd., London, E.C.3. Main dimensions: 540 ft. overall by 71 ft. by 38 ft. 6 in.; gross tonnage, 15,000. Two sets of steam turbines with single-reduction double-helical gears, constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne, and three oil-fired boilers. Service speed, 16 knots. Trial trip, July 16. (See also page 118.)

VICKERS-ARMSTRONGS "SWIFT" AIRCRAFT.—The prototype Vickers Supermarine Swift single-seat fighter aeroplane recently flew from London to Brussels, a distance of 200.38 miles, in 18 minutes 3.3 seconds, i.e., at an average speed of 665.9 m.p.h. Subject to confirmation by the Fédération Aéronautique Internationale, this constitutes an international speed record for the flight between London and Brussels. The Swift aircraft, now in production for the Royal Air Force, is designed and constructed by Vickers-Armstrongs Limited, Supermarine Division, Hursley Park, Winchester, Hampshire, and is powered by a Rolls-Royce Avon jet engine.



(967.3)



(967.C)

"MACHINING" HARD METALS BY ELECTRIC SPARK.

FOR machining materials that are difficult by conventional methods, Messrs. Sparcatron, Limited, Tuffley-crescent, Gloucester, have developed equipment which applies continuous electric spark discharges. The workpiece and an electrode are immersed in a liquid dielectric, which flows so as to carry away the disintegrated particles resulting from the sparks produced by the discharge of a condenser. The workpiece is connected so as to have positive polarity and the electrode is negative. Thus, the maximum erosion of the workpiece and the minimum erosion of the tool take place. A control cabinet, as constructed for the Sparcatron process, is illustrated in Fig. 1, on this page; Fig. 2 is a block diagram of the control-cabinet circuit; and Fig. 3 is a diagram of a complete equipment as used for drilling.

Referring to the basic circuit in Fig. 2, the energy absorbed during the discharge is derived from a charged condenser. The condenser prevents arc formation after the discharge, due to the decrease in voltage across it and, consequently, across the gap. The cycle of operations starts with the condenser charging when it is connected to a direct-current voltage source. Initially, this voltage, and the voltage across the spark gap, is zero, but it rises exponentially until it balances the supply voltage, which is sufficient to break down the dielectric medium slightly before the condenser is fully charged. The discharge is of an over-damped nature with a frequency dependent on the capacity and inductance associated with the discharging circuit. The electric discharge leads to the development of intense energy at the target point on the workpiece.

The cabinet actually contains several condenser units which, together with the appropriate resistors, allow the operator to adjust the circuit to control the stock removal and the finish required. A weaker spark is used for finishing cuts than for

roughing cuts. The circuit is designed to prevent the formation of a stationary arc, which would cause uncontrolled melting of the workpiece locally. The energy of the spark and, therefore, the amount of material removed, are directly proportional to the condenser capacity and the square of the applied voltage. Increasing the condenser capacity, however, also has the effect of increasing the time for charging the condenser, which results in no further improvement in stock removal. The rate of discharge varies from 12,000 to 100,000 sparks per second. The rate of removal of metal from soft workpieces is only economical at present when complex shapes and small quantity production are involved. However, on hard and unmachinable materials the process is of immediate economic interest in all fields of use.

The equipment illustrated in Figs. 1 and 2 is suitable for connecting to a three-phase mains supply. It transforms and rectifies the current, using a static rectifier. Resistors are included in the condenser charging circuit to limit the output. For fine finishing, very low capacities and currents are used. Fig. 3 shows the same circuit with a typical servo mechanism for controlling a "drilling" or excising operation. A similar arrangement is used for "turning" and for straightforward cutting of, say, a sheet. As shown in Fig. 3, and in the photograph reproduced in Fig. 4, on page 122, the tool is held in a chuck, the position of which is controlled by the servo mechanism so as to give the correct spark gap at each discharge. The dielectric fluid is pumped through the chuck and the tool on to the workpiece, and from the surrounding bath it is passed to a sump where it is filtered before being pumped again.

A signal voltage proportional to the discharge current is taken from across the resistor, and is backed off by a reference voltage of such a magnitude that the resultant error in the system is zero when the tool is correctly placed. If, however, the tool is not in the correct position, a positive-error or negative-error signal is produced according as the tool is too near, or too far from, the work-

“MACHINING” HARD METALS BY ELECTRIC SPARK.

SPARCATRON, LIMITED, GLOUCESTER.

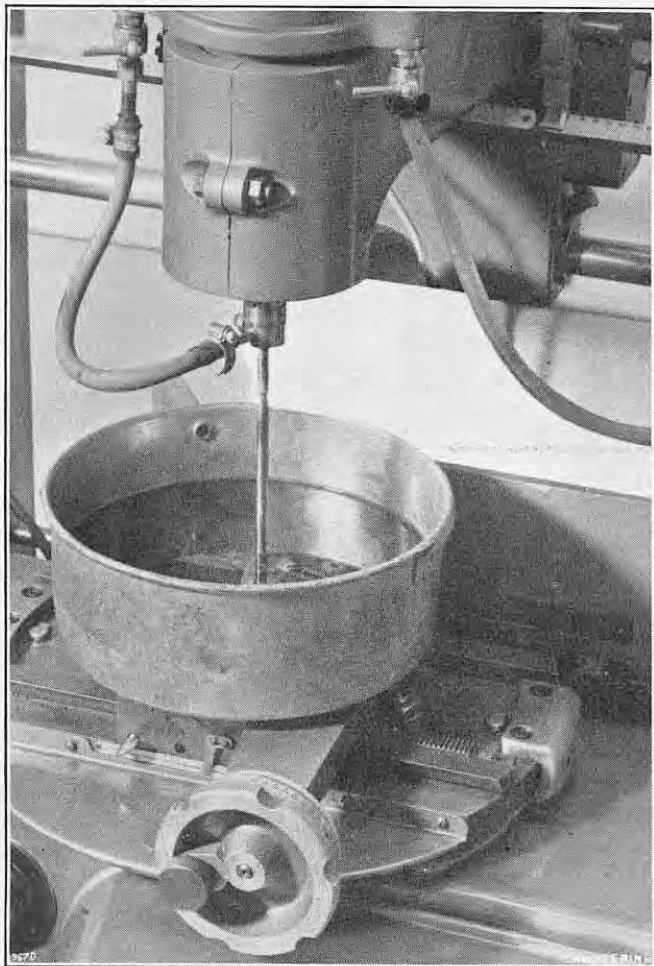


FIG. 4. “DRILLING” MACHINE.

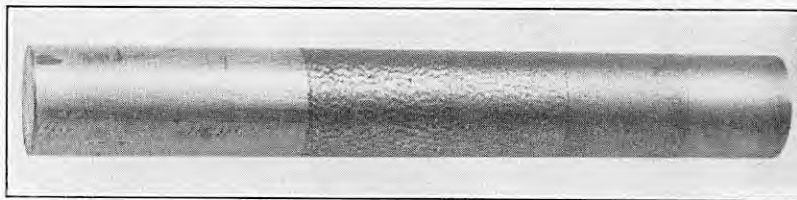


FIG. 5. “TURNED” BAR.

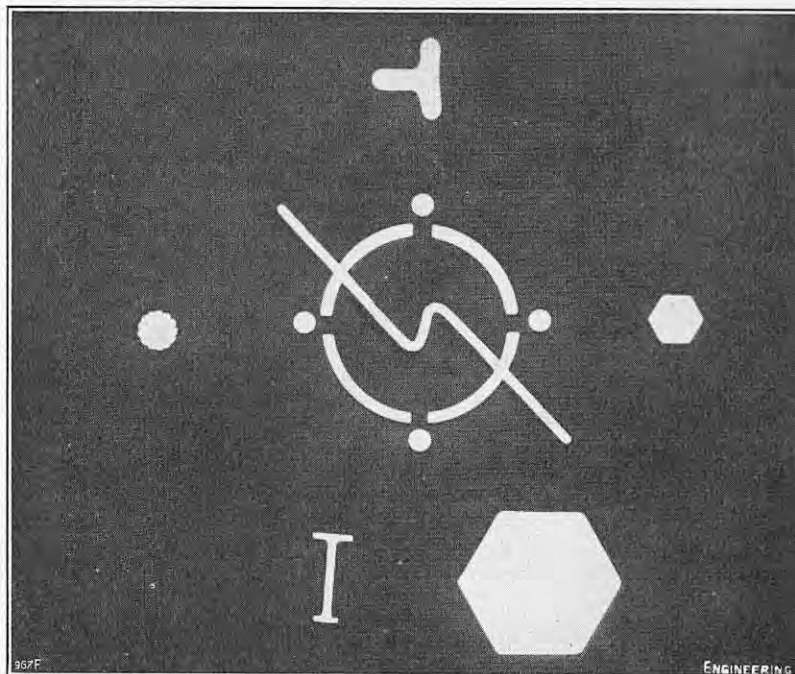


FIG. 6. HOLES CUT IN PLATE.

piece. In such a case, the error signal is fed into an electronic amplifier, the output from which energises the field of a split-field direct-current motor in a sense depending on the polarity of the signal. The output pinion of a reduction gearbox driven by the motor meshes with a rack which, being coupled to the tool, restores the latter to the correct position. There is a tendency to hunt, owing to time lags inherent in the apparatus, but it is corrected by a stabilising feed-back, proportional to the velocity of the system, which is obtained from a generator that is coupled to the motor, and also by a phase-advance or differentiating network which is included in the amplifier input. A solenoid arrangement can be used in place of the motor-driven mechanism if required.

A bar partly machined by the Sparcatron process is shown in Fig. 5. Approximately a third of it, to the left of the illustration, was not treated, but the four zones to the right represent four different qualities of surface finish. The finest has a finish of about 22 microns, though this is not the best that can be achieved. A workpiece of this type is supported in a rotating chuck; alternatively, the tool, which is in the form of a disc electrode, corresponding to the grinding wheel of ordinary machining, may be rotated. In the latter case the tool would be rotated at a peripheral speed of about 1,000 ft. per minute and the workpiece at 250 ft. per minute for a bar of the type shown in Fig. 5. The electrical connection is made through a slipping, and the dielectric fluid is delivered over the gap. A hard sheet with various holes cut out by the Sparcatron method is shown in Fig. 6. The metallurgical condition of workpieces is not affected by the process, since, though the sparks reach a temperature of 12,000 deg. C., their duration is extremely short and no appreciable heating of the metal occurs. The surface finish is non-directional; it consists of a series of very small pits which, in many applications, may be advantageous, e.g. for retaining lubricant.

TRADE PUBLICATIONS.

Manufacture of Telephone Equipment.—An interesting description of the industrial resources and commercial activities of Automatic Telephone and Electric Co. Ltd., Liverpool, is given in a well-illustrated booklet which we have recently received. The company is one of a group which is engaged in various ways in the development and production of telephone apparatus, electric cables and the operation of telephone systems, but the booklet is mainly devoted to a summary of what is being done in the telecommunications field. It will be useful as a work of reference.

Fractional-H.P. Variable-Speed Gears.—An illustrated folder, CJ2, has been issued by Carter Gears Ltd., Thornbury-road, Bradford, describing the uses and capacity of their hydraulic variable-speed gear units.

Wire and Strip Machines.—Automatic machines for the wire and strip industry, including machines for forming wire and strip, wire-straightening and rod-cutting, paper-clip production, lock-washer forming, ring-coiling, and mattress-, jack- and knotted-chain manufacture are described in an illustrated brochure, No. 2047, published by Heenan and Froude, Ltd., Worcester.

Electric Crabs, Trucks and Tractors.—Steels Engineering Products, Ltd., Crown Works, Sunderland, have issued two leaflets giving specifications of their electric crabs fitted, respectively, with hand-gear and electric travel, and ranging, in both cases, from 2 tons to 6 tons capacity. They have also issued an illustrated brochure giving specifications of their range of Electric Eel trucks and tractors.

Flameproof and Safety Equipment.—Descriptions of the wide variety of the electrical equipment made by them for use in mining and other industries, where hazard may be present, are given in a fully illustrated descriptive catalogue received from the General Electric Co., Ltd., Kingsway, London, W.C.2.

Low-Voltage Signal Apparatus.—A supplement to their catalogue issued by Arcoelectric Switches, Ltd., Central-avenue, West Molesey, Surrey, deals with the various types of low-voltage signal lampholders, lamps and switches manufactured by them.

Adjustable Magnets.—Donald Ross and Partners Ltd., 1-3, Arlington-road, London, N.W.1, have issued an illustrated leaflet describing their Trimmer adjustable

magnets, which comprise two magnetic blocks, connected by links, so that the block faces can be set and locked at any angle to each other. The leaflet also describes pot magnets for holding steel plate and magnetic clamps for use in welding.

Natural and Synthetic Rubbers.—We have received two pamphlets from Redfern's Rubber Works Ltd., Hyde, Cheshire. One of them gives data on the resistance of rubber and ebonite to the chemical action of various inorganic and organic substances. The other pamphlet shows a selection of extruded sections—channel, strip and tubing—in natural and synthetic rubber.

Magnetic Conveyor Head Unit.—Electromagnets Ltd., Boxmag Works, Bond-street, Birmingham, 19, have issued an illustrated leaflet giving the specification of their magnetic conveyor head unit, which is available for conveyor-band widths ranging from 12 in. to 36 in.

Railway Sidings.—A booklet on railway sidings for industrial use has been prepared by Thomas Summerson & Sons, Ltd., Darlington. It deals with the wide range of standard and special track components, including the latest British Railways type flat-bottom rails, which the firm use in the construction of sidings. Reference is also made to the inspection and maintenance services which they provide.

Preservation of Timber.—A booklet on the preservation of timber by vacuum and pressure impregnation and other methods has been issued jointly by Hickson and Welch, Ltd., and Hickson's Timber Impregnation Co. (G.B.), Ltd., Castleford, Yorkshire. It describes in some detail fungal decay and insect attack, the firm's Tanalith preservatives, methods of treatment, industrial applications of “Tanalised” timber, dry-rot repairs, flame-proofing, etc.

ELECTRICAL CONNECTION BETWEEN GREAT BRITAIN AND THE CONTINENT.—The British Electricity Authority have approved in principle an interim report on the proposed interconnection of the British and French electrical transmission systems, which was submitted by a Joint Committee of the Authority and Electricité de France. A development programme is to be undertaken and expenditure up to 125,000l. has been authorised for this purpose.

showing a slight advantage. For $\mu < 1$, the internal mechanisms have the better characteristics.

Modifications.—When discussing internal Geneva mechanisms, it was proved that the latter are unsuitable for modification. With internal star-wheel mechanisms, however, a limited range of modification is permissible. Formula (49), on page 58, *ante*, applies also to internal star-wheel mechanisms, and shows that in the case of one or two stations, $m_{\max} = \infty$. For any other finite number of stations, however, it is impossible to provide more than one group of driving rollers. Formula (50), on the same page, likewise applies to internal star-wheel mechanisms, and gives more detailed information. It was shown previously that two groups of driving rollers imply that $\alpha_0 \leq 60$ deg. As Table IX shows, only values of μ up to 0.5, and $\mu = \infty$ satisfy this condition. In Fig. 47, on page 91, *ante*, ($\mu = 0.3420$, $\epsilon = 0.5$), a second group of driving rollers is indicated by the dotted lines. Two further groups could be arranged, one in each quadrant. By (49), $m = \frac{n}{\epsilon} = \frac{2}{0.5} = 4$, so

that no standstill is left when there are four groups of driving rollers. The groups of driving rollers need not be spaced equally, and it is also possible to design internal star-wheel mechanisms with varying partial movements.

Design and Production.—The remarks on designing and machining external star-wheel mechanisms apply with appropriate modifications to internal mechanisms. In many cases the combination of elements giving uniform and non-uniform motion presents difficulties owing to restrictions imposed by space limitations and the arrangement of the bearings in internal gears. Internal involute gears, which are appropriate for imparting uniform motion in this case, are a difficulty in themselves as many workshops are not equipped for cutting them. Fortunately, in most cases of internal star-wheel mechanisms, the elements for imparting the uniform motion may be dispensed with.

The condition under which special elements for imparting uniform motion can be omitted is the same as that for external drives, namely,

$$\mu \left(\frac{2\pi}{n} - 2\beta_0 \right) < 2\alpha_0,$$

which can be transformed, as in the case of external drives, for $\mu < 1$ ($n = 1$ or 2), into

$$\mu > \frac{2 \sin \left(\frac{\pi}{6} \frac{2-n}{n} \right)}{2 \sin \left(\frac{\pi}{6} \frac{2-n}{n} \right) + 1}, \quad (52c)$$

and, for $\mu > 1$ ($n \geq 3$), into

$$\mu < \frac{2 \sin \left(\frac{\pi}{6} \frac{2+n}{n} \right)}{2 \sin \left(\frac{\pi}{6} \frac{2+n}{n} \right) - 1}. \quad (52d)$$

For $n = 1$, μ must exceed 0.5, so that no special elements for uniform motion are required for values of μ between 0.5 and 0.6302.

For $n = 2$, μ must be greater than zero, so that these elements can be dispensed with in all cases.

For $n = 3$, μ must be less than 2.8795; since this value exceeds $\mu_{\max}$, elements for uniform motion can be dispensed with in any case.

For $n = 4$, μ must be less than 3.4142. This value is identical with $\mu_{\max}$, so that special elements for the uniform motion are in all cases unnecessary. It is, however, advisable to incorporate them in the extreme case, to ensure the continuity of the motion. In Fig. 46, on page 91, *ante*, for example, there is one intermediate roller.

The ranges of μ for which elements for uniform motion can be omitted when the number of stations is higher than 4, are as follows:—

$n = 5$	...	...	3.1676 to 3.9563
$n = 6$	...	...	3.5434 „ 4.5016
$n = 7$	...	...	3.9219 „ 5.1673
$n = 8$	...	...	4.3011 „ 5.5973
$n = 9$	...	...	4.6830 „ 6.1461
$n = 10$	...	...	5.0643 „ 6.6953

Table VII, on page 92, *ante*, shows that each range occupies a considerable part of the corresponding full range of μ . The only exception is when $n = 1$. In contrast with the case of gears for uniform motion, therefore, it is possible to simplify a drive by the

SELF-ERECTING TOWER CRANE.

BRUN AND COMPANY, NEBIKON, SWITZERLAND.

(For Description, see Opposite Page.)

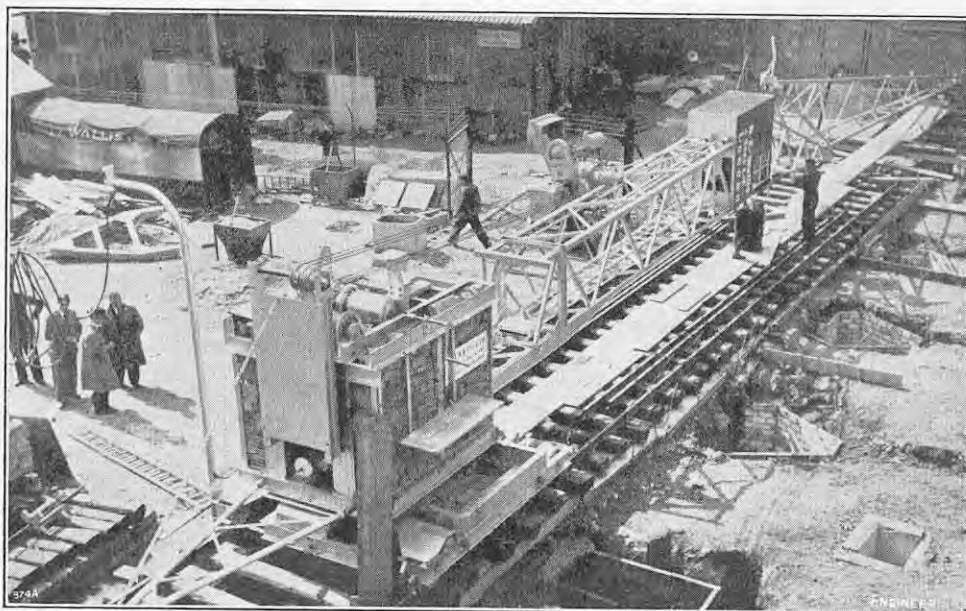


FIG. 1. CRANE ON TRACK BEFORE ERECTION.

arrangement of internal mechanisms. The three internal mechanisms shown in Figs. 45, 47 and 48, on page 91, *ante*, for instance, contain only elements for non-uniform motion, and the mechanism shown in Fig. 46 could be designed in the same way. If any of these mechanisms were replaced by an equivalent external star-wheel mechanism, special parts for imparting uniform motion would be required.

A milling device similar to that shown in Figs. 43 and 44, on page 58, *ante*, can be used for machining the hypocycloidal or pericycloidal slots, or the device can be designed to suit the requirements of external and internal mechanism. The difference lies mainly in the location of the bush which guides the milling cutter, and in the means for clamping the gear to be used as the driving involute gear.

INTERMITTENT GEARS FOR INTERSECTING SHAFTS.

In the previous sections, only gears connecting parallel shafts have been considered, comparable with spur gears for uniform motion. As is well known, the design of bevel gears for uniform motion is based on that of spur gears. The spherical surfaces on which the shape of the teeth should be determined are replaced by the back cones, in the usual manner, and the shape of the teeth is determined on the developed back cones. The shape at the large end is then determined as in the case of spur gears. The teeth are then made to converge towards the apex. It might be expected that bevel gears for intermittent motion could be designed in an analogous way. It must be remembered, however, that, although in the case of conventional bevel gears, meshing takes place in the proximity of the central position, the most important parts of intermittently working gears, those associated with the start and the end of motion, are in action at a considerable distance from the central position. Approximating to the cones by tangential planes, therefore, would be objectionable, and designing and machining such gears would be both difficult and expensive. The best policy, therefore, is to avoid intersecting shafts for transmitting intermittent motion. If this is not possible, bevel gears similar to those shown in Figs. 55 to 58, on page 123, can be used.

The large gear of that mechanism, the driving member (shown in Fig. 55) has 16 teeth, spaced by 15 uniform gaps; the sixteenth gap is abnormal since it occupies more than half of the circumference. The gear corresponds to a complete gear having 40 teeth. The small gear, the driven member, (an enlarged view of which is shown in Fig. 57) has

also 16 teeth and 16 gaps. One of the teeth occupies the space of two normal teeth so that the gear might be considered to be one with 17 teeth, with one gap not cut.

The driven gear completes one revolution during a part of one revolution of the driving gear, and the gears behave during the period of motion like gears of ratio 40 to 17. The standstill is secured by the rim *a* of the driving gear which locks the plate *b*, connected to the driven gear. Accelerating and retarding elements are omitted because of the difficulties mentioned above. The first impulse is given by the first tooth *c* of the driving gear, the tooth being shortened so that it can pass the tooth *d* of the still stationary driven gear. The last tooth of the driving gear is similarly shortened, since it must pass a tooth of the locked driven gear.

At the commencement of motion, the central gap of the 16 teeth of the driving gear is $8\frac{1}{2}$ pitches before the central position of engagement. At the conclusion of the motion, the central gap is $8\frac{1}{2}$ pitches beyond the central position. The motion thus occupies $2 \times \frac{8.5}{40} = \frac{17}{40}$ of one revolution of the driving gear, and the locking rim occupies $\frac{23}{40}$ or 207 deg.

In spite of there being only 16 teeth, both ϵ (the ratio of the angles covered by driving and driven gear during the period of motion), and ν (the proportion of motion in one cycle) are equal to $\nu = \frac{17}{40}$, that is, the ratio of the numbers of teeth of the complete bevel gears.

In cases where the number of teeth of the driving gear is large, it may be found that two teeth on each side of the driving gear must be shortened to enable them to pass the teeth of the driven gear. Another possibility, in such cases, is to make the abnormal tooth of the driven gear a threefold tooth by omitting to cut two gaps. Only one tooth on either side of the driving gear need then be shortened. The function of the gears is not affected.

It has been shown above that ϵ is equal to the ratio of the numbers of teeth of the complete driven and driving gears, and that the mechanism behaves in the period of motion like a pair of complete bevel gears. It follows that ϵ can never reach the value 1, because both gears would rotate uniformly. There is no lower limit for ϵ , and it can be chosen as low as required, provided that space for the resulting large driving gear is available. It is also possible to have a number of locking plates on the driven gear, and to impart only a fraction of

SELF-ERECTING TOWER CRANE.

BRUN AND COMPANY, NEBIKON, SWITZERLAND.



FIG. 2. HOISTING TOWER TO VERTICAL POSITION.



FIG. 3. RAISING JIB TO WORKING POSITION.

one revolution to the driven gear. With n equally spaced locking plates, $\nu = \frac{\epsilon}{n}$. The driving gear can also be equipped with more than one group of teeth, and with more than one locking rim. Gears as described above render quite good service, particularly at low speeds, when accuracy is not important. Their kinematic properties, however, will not withstand a critical investigation.

(To be continued.)

SELF-ERECTING TOWER CRANE.

THE tower crane illustrated on this and the opposite pages has the advantage that it can be easily erected by means of its own hoist and can travel to the site on rails. It was constructed by Brun and Company, Nebikon, Switzerland, and has been brought to this country by G. E. Wallis and Sons, Limited, 231, Strand, London, W.C.2, for use in the construction of a seven-storey office block at London Bridge-street, London, S.E.15. All the motions are normally electrically driven and controlled from a cabin near the top of the tower, but they can be hand operated if required. The time taken for the erection of the crane is about 50 man-hours and it can be dismantled in 45 man-hours. The weight of the crane in working order, complete with ballast, is 23½ tons. The principal operating dimensions, etc., are given in the accompanying table for four positions of the jib.

For transport, either by road or rail, the crane can be dismantled into five sections: the base, the tower, the jib, and the two undercarriages, no

one of which is wider than 7 ft. 4 in., thus allowing unrestricted movement by road. The heaviest section is the base structure, which weighs 6.7 tons but it can be fitted with pneumatic-tyred wheels and brakes so that it can be towed behind the lorry that is carrying the other sections of the crane. The base of the crane is a welded and bolted assembly of rolled-steel sections and plates, as shown towards the left in Fig. 1, and is suitably braced to support the roller path and to obtain general rigidity. On each side of the base structure there are lattice cages for 11 tons of ballast, using materials which can be procured and loaded at the site. Between these cages are the power units and the winch. Below the base frame are the travelling and slewing gears, both of which are readily accessible. Two undercarriages are bolted to the base, one on each side; they are fabricated from rolled-steel channels battened to form box sections, each housing two double-flanged rail wheels of alloy steel. The drive is transmitted by spur-gear rings bolted to one wheel of each undercarriage so that the crane is equally accelerated on both sides. The tower is an all-welded structure of rolled-steel sections and the cabin is built in angle framing and clad with sheet-steel panels.

At the front, the tower is connected to the base

Position of the Jib.	1.	2.	3.	4.
Working radius, ft. . .	53	43	28	20
Lifting capacity, tons . .	0.85	1.0	1.5	2.0
Height of pulley, ft. . .	59	84	97	100
Lifting speed, ft. per min. .	130	130	65	65
Travelling speed, ft. per min. . .	105	105	105	105
Slewing speed, r.p.m. . .	1.2	1.2	1.2	1.2

by a swivel pin, but at the back machined barrel bolts are used to complete the connection. A tubular steel ladder leading to the cabin is provided within the tower structure and the main uprights of the ladder contain the cables of the electrical system. The jib is welded from seamless tubes and is of triangular cross-section, thus offering little resistance to the wind. The intermediate sheave is housed in the tail of the jib, together with the balance of the safe-load indicator, and in the nose of the jib the point sheave and the hoist limit switch are fitted.

The hoist is driven by an 11-h.p. electric motor though, as already noted, hoisting can be done by hand, as, for example, during erection. The hoist has two speeds giving a lifting rate of about 130 ft. per minute for loads under 1 ton and about 65 ft. per minute for greater loads. The drum of the hoist, fabricated from steel plate, rolled into shape and welded, is of sufficient length and diameter to accommodate the whole of the rope in a single layer and it has a helical groove machined in the surface for the rope to bed into. The rope is of high-tensile plough-steel wire and is of the non-rotating type. An electromagnetic brake, operated by a solenoid, is fitted to the hoist, but the brake may also be foot-controlled from the cabin. The travelling gear is driven by a 6-h.p. motor through a shaft carried in self-aligning bearings located at close centres. No brake is fitted to the travelling motion as abrupt braking has been found to cause the load to swing, but due to the high gear reduction the crane comes smoothly to rest due to the resistance of the transmission, etc. The slewing gear is driven by a 3-h.p. motor through a worm-gear reduction unit incor-

HIGH-PRESSURE GREASE LUBRICATOR.

C. C. WAKEFIELD AND COMPANY, LIMITED, LONDON.

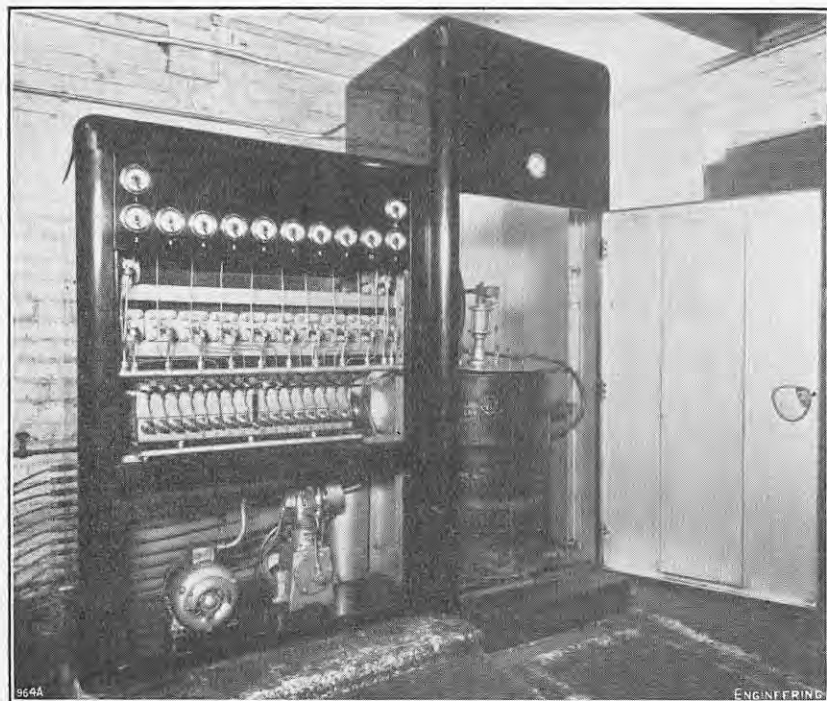


FIG. 1. "ROLL MILL" LUBRICATOR BATTERY.

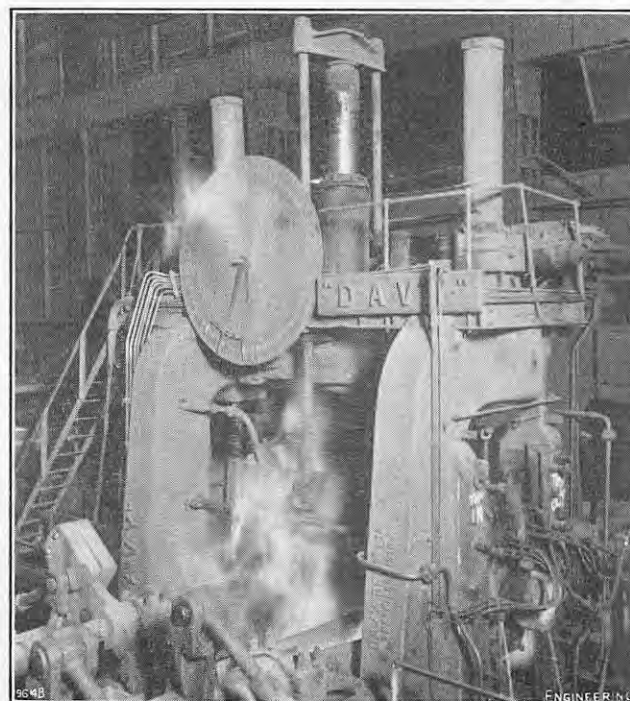


FIG. 2. GREASE-LUBRICATED SLABBING MILL.

porating a friction clutch; the slewing rack is of steel bar, rolled into a ring and welded, the teeth then being milled out of the solid. As in the travelling gear, no brake is fitted to the slewing mechanism, control being effected through the clutch. In a high wind the crane will slew into the wind, thereby reducing its resistance to a minimum.

All the gearwheels have machine-generated teeth and run in oil-baths; their shafts are carried on ball bearings. The pulley sheaves are packed with grease and need no further lubrication if greased when the crane is dismantled. All the grease points in the base are readily accessible, the nipples being arranged in batteries. Safety devices are fitted at all crucial points. Over-winding is prevented by a hoist limit switch fitted to the jib point and tripped by the hook block. Main circuit-breakers are also fitted in conjunction with the safe-load indicator, which works on the balance principle. A travel-limit switch is available which can be fitted on the base structure to prevent the crane over-running the rails; rail clamps are also provided to secure the crane when it is not in use and during stormy weather.

When assembling the crane the base is run over the rails and then raised up by two 3-ton jacks, so as to allow the wheels and axles to be removed. Using the crane's hand-operated winch and a small jib temporarily fixed on the front of the base structure, the undercarriages are bolted on to the sides of the base, which is then lowered on to the rails, where it stands on its own wheels; the base can then be traversed and slewed by hand. The tower and the jib are made ready on the ground, using the hand-operated winch on the base, and the front connection is made with the swivel pin between the tower and the base. Using a separate erection rope, the tower is pulled into the vertical, as shown in Fig. 2; when finally plumb, the tower is bolted in its working position. The erection rope is replaced by the crane lifting rope and the jib raised on the hook block until it reaches the working position, when the jib chain is securely anchored to the tower in the cabin. The crane is then ready for work. In order to change the working position of the jib, the hook is lifted right up to the point of the jib, the jib chain released and the jib moved to a new position by the hoisting rope working on low speed; the chain is then re-anchored to the tower and the hook returned to a normal position.

GREASE LUBRICATOR FOR HEAVY PLANT.

To meet the lubrication needs of large plant such as rolling mills in steelworks, Messrs. C. C. Wakefield and Company, Limited, 46, Grosvenor-street, London, W.1, have introduced the improved form of automatic grease-lubrication battery illustrated in Figs. 1 to 6, herewith. The first model, built on the basis of data obtained from a thoroughly-tested prototype, has been operating at the works of the Appleby-Frodingham Steel Company, at Scunthorpe, Lincolnshire, since November, 1951; it has been responsible for the lubrication of the main rolling-mill bearings and breast rolls of their 42-in. "Davy" reversing slabbing mill, illustrated in Fig. 2. The "Roll Mill" lubricator, as it is described, is unusually compact; though the equipment is as comprehensive as may be expected, it is completely housed in a steel cabinet of moderate size. The Appleby-Frodingham Company's engineers carried out the installation.

The design and operation of the lubricator are described below. The front and back panels and the door are completely removable for easy maintenance, and may be locked in place upon re-assembly. The principle of operation is by the well-tried method of feeding every bearing with grease by a piston which is actuated by oil under pressure. The grease output is claimed to be ample for all industrial purposes; and there is an automatic alarm and safety system, should the pressure in any of the grease lines exceed the permissible limits.

The internal arrangement comprises a fully automatic electrically-driven air compressor, an air-operated grease primer pump, a multiple-feed motor-driven oil pump, and the pressure cylinders, of which there is one per feed (12 in all); and there are the usual pressure gauges, switches, piping, etc. Each of the grease feeds can be individually regulated from maximum to zero. As the lubricator is totally enclosed, the grease is transferred from the grease barrels (holding $3\frac{1}{2}$ to 4 cwt.) to the terminal points without manual handling or exposure to atmosphere; the average consumption of grease is $2\frac{1}{2}$ barrels per week. There are no wearing parts likely to be affected by foreign particles in the grease. The main pipes are 1 in. in diameter, with a maximum length of 65 ft. and a minimum of 25 ft. For the lubrication of the main roll bearings there are eight feeds, two at the top and two at the

bottom for each side; and for the breast rolls there are four feeds, two on each side, making 12 points in all.

Referring to Figs. 3, 4 and 5, the compressor, *a*, supplies air to the primer pump, *b*, which in turn delivers the grease from the grease barrel to the rear ends of all the pressure cylinders (*d, d*). The multiple oil pump, *c*, then feeds oil, under pressure to the front or opposite ends of the pressure cylinders: through the medium of the hydraulic-type pistons inside the cylinders, this forces the grease to the grease outlets, *e*, under pressure. The pressure developed in each feed (maximum 1,500 lb. per square inch) is registered on individual gauges, mounted on the top panel of the cabinet.

The oil pump is driven by a fractional-horsepower geared motor, running at a speed of 25 r.p.m. At full feed, this ensures a grease output from each cylinder of 1 lb. 3 oz. per hour. This quantity can be reduced by means of the regulators incorporated in each pump unit, because any variation in the quantity of oil pumped by the pump will modify similarly the amount of grease fed from the pressure cylinders. When the grease in the cylinders has been totally expelled, they are automatically recharged with grease by means of a totally-enclosed valve gear contained in each cylinder. This operation takes only a few seconds, and the feed is resumed forthwith. The oil used to expel the grease is returned automatically to the oil pump, making a closed circuit. Only very occasional topping-up is required.

Should a stoppage occur in any individual feed line, causing an excessive pressure to be built up, an electric alarm bell, *g*, operates and a relief valve, *h*, reduces the pressure to safe limits. Suitable push-button switches, *f, f*, with overload releases for the control of the air compressor and oil pump motors, are fitted on an interior panel.

Referring to Fig. 6, opposite: grease is delivered by the air-operated primer pump at a pressure of 200-300 lb. per square inch into the pressure cylinder through a non-return valve, *i*, forcing the piston to the left. It is prevented from passing directly to the feed outlet by the valve and spring, *u*, which are set to open at about 500 lb. per square inch. During the charging stroke, the oil delivered by the oil pump, on entering the cylinder at *v*, is by-passed to the lubricator reservoir via the ports in the plunger valve, *w*. When the piston is near the left-hand side of the cylinder, it strikes the end of the plunger valve, so moving it to the left to close

HIGH-PRESSURE GREASE LUBRICATOR.

C. C. WAKEFIELD AND COMPANY, LIMITED, LONDON.

Fig. 6. SECTIONAL PLAN, PISTON AT BACK END.

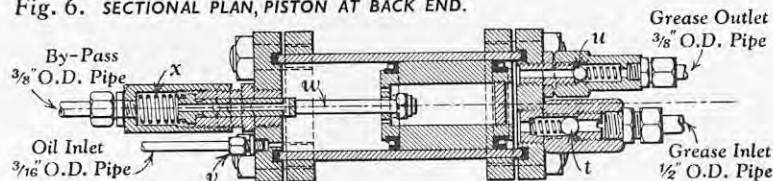
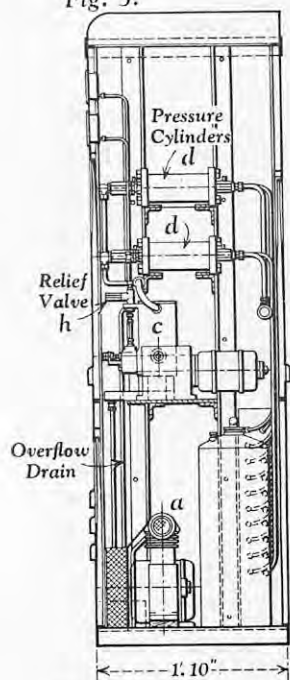


Fig. 3.



(96+C)

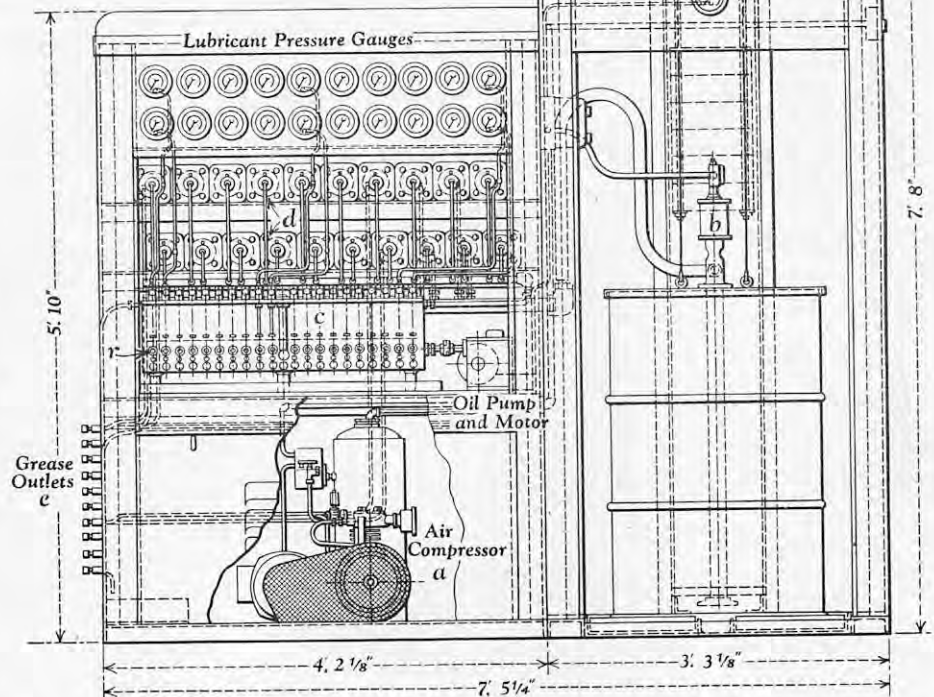
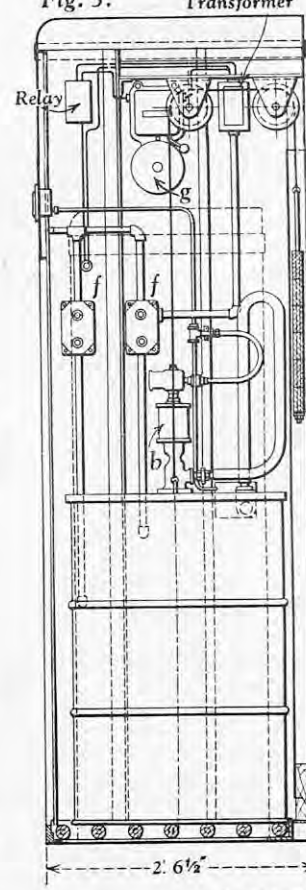


Fig. 5.



"ENGINEERING"

the ports. Oil from the pump then builds up pressure in the left-hand side of the cylinder. This forces the piston to the right, to deliver grease under a correspondingly high pressure through the outlet valve, *u*. The high pressure in the left-hand end of the cylinder retains the plunger valve *w* in its closed position during the delivery stroke. On nearing the end of the delivery stroke, the piston pulls the plunger valve *w* to the right until the port opens and reduces the pressure. The valve is then rapidly opened to its fullest extent by the spring *x*, the oil is again by-passed, and the pressure cylinder is rapidly recharged by the pressure from the primer pump, exerted continuously through the valve *t*. During the discharge stroke, the primer pump is unable to overcome the higher pressure built up by the oil pump and therefore "stalls" until the next charging cycle. Bleed valves are provided for releasing air during the initial charging of a new unit or a replacement cylinder.

TELCON METALS DIVISION.—The Telegraph Construction and Maintenance Co., Ltd., announce that arrangements are being made to move their Metals Division from Telcon Works, Greenwich, to the satellite town of Crawley, Sussex, where a new factory will be built for the production of their special alloys. This move is expected to double their present productive capacity. The first stage of the removal is not likely to take place for about 18 months.

PANEL-MOUNTING SIGNAL-LAMP HOLDER.—A holder for low-voltage screw-type bulbs of the torch type, which can be fixed in a single $\frac{3}{4}$ -in. diameter hole in a panel, has been produced by Arcoelectric (Switches), Ltd., Central-avenue, West Molesey, Surrey. The holder, which is listed as pattern SL88, is totally enclosed and is made of insulating material having a high resistance to electrical breakdown. It is fitted with a dome-shaped plastic lens which can be supplied transparent or translucent in any one of a range of colours. The design is ingenious, the lamp being readily accessible from either the front or the back of the panel without disturbing the mounting. A similar holder, intended for a neon tube, type T47, also manufactured by the company, is available for mains voltages. It incorporates a suitable resistance and may be connected directly to any supply of voltage between 200 and 250. Other models can be supplied for voltages between 80 and 500.

ANNUALS AND REFERENCE BOOKS.

F.B.I. Register of British Manufacturers, 1951-52.

24th edition. Kelly's Directories, Limited, 186, Strand, London, W.C.2, and Hiffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 42s., postage included.]

THIS "standard export reference book," as the publishers call it, is a directory of the member firms, and their products, of the Federation of British Industries, the largest association of manufacturers in this country. It is in seven sections, covering the firms' products and services; their advertisements (many of them in colour); an alphabetical directory of member firms, with their postal and telegraphic addresses, telephone numbers, lists of products, and in many cases their home and overseas branches, agencies, etc.; a list of other trade directories; F.B.I. member trade associations' brands and trade names; and trade marks. The notes on each section are in English, French and Spanish. Sir Archibald Forbes, President of the F.B.I., contributes a foreword, and there are notes on dollar sales, "mid-century reflections," and the Federation's aims, activities and overseas organisations.

Industrial Diamond Trade Names Index.

Compiled jointly by the Industrial Diamond Information Bureau and the Industrial Diamond Review, and published by N.A.G. Press, Limited, 226, Latymercourt, Hammersmith, London, W.6. [Price 3s. 6d.]

THIS publication, which was first issued in 1945 as an eight-page data sheet containing about 200 names and addresses, is now in its third edition and comprises 64 pages giving particulars regarding some 1,500 trade names. The book is intended for users of diamond tools, hard abrasives, sintered carbides and similar materials, and is divided into two main sections. The first is an alphabetical list of trade names of diamond tools and of such materials and equipment as abrasives, grinding compounds, tungsten and other carbide tools and tool tips, hardness-testing machines, jewel bearings and various precision instruments, machines, and tools. The trade name, or, in some cases, an abbreviation of a firm's name which has come to be generally accepted in the trade, is given in heavy type. Then follow a brief description of the material or product, and finally the full name and address of the producing or manufacturing firm. The second section of the book consists of a classified subject index. Some of the products referred to in the publication are manufactured abroad and the firm's representatives in this country are given where they are known.

Kempe's Engineer's Year-Book for 1952.

57th edition. Morgan Brothers (Publishers), Limited, 28, Essex-street, Strand, London, W.C.2. [Price 70s. for vols. 1 and 2; postage 1s. 6d.]

IN the latest edition of "Kempe's," the chapters on fuels, electrical engineering, railway engineering, and timber have been revised. The Fuel Research Station have been responsible for a substantial revision of the fuels chapter, bringing in some of the information and practices which have arisen in recent years to meet the requirements of changing conditions. In railway engineering, the main change is the inclusion of drawings, etc., of the flat-bottom track which is now standard on British Railways, details of bull-head rails having been omitted to make room for them. A drawing of the Ministry of Transport's requirements for railway loading gauges and structure clearances is also given. The timber chapter now includes a page on plywood, and the electrical engineering chapter has been revised to accord with the Wiring Regulations, 12th edition, of the Institution of Electrical Engineers, and the latest Codes of Practice.

Britannica Book of the Year 1952.

Encyclopædia Britannica, Limited, Panton House, Haymarket, London, S.W.1. [Price 63s.]

THIS is the fourth of the annual reviews published in London since the war. Like its predecessors, it records the previous year's news and developments; it is a supplement to the *Encyclopædia Britannica*, a bridge between the ephemeral newspaper form and the history books and text-books which will be written several years hence. Science, engineering and industry are treated reasonably well; there are, for example, articles on aircraft, bridges, canals, coal, docks and harbours, electric power and transport, gas, light and heavy engineering, gas turbines, radio, railways, shipbuilding and television. The customary section on new words gives, among others, cybernetics, airstop, convertiplane (an aircraft that takes off and lands like a helicopter and flies like a fixed-wing aeroplane), and stationman (-woman)—a term which London Transport introduced in 1950 to denote the men and women on underground-railway stations who look like porters but seldom do any portering, such is the discouragement that a passenger with heavy luggage receives from the staff and other travellers. The *Book of the Year* is edited by Mr. John Armitage, London editor of the *Encyclopædia*, who has the services of 505 contributors, the majority of whom are British.

NOTES ON NEW BOOKS.

Boulton, Watt and the Soho Undertakings.

By W. K. V. GALE, F.R.Hist.S. City of Birmingham Museum and Art Gallery (Department of Science and Industry), Newhall-street, Birmingham. [Price 2s. 6d.]

As Mr. Gale truly remarks in his introduction to this little manual, "much has been written about Boulton and Watt and the two Birmingham factories for which they were responsible"; but visitors to museums and historical collections, who are seldom able or willing to carry on their tours of inspection anything larger than a handbook, should welcome this compact account of the businesses which, with their famous proprietors, did more than any others to create the modern industrial "conurbation" that is Birmingham and its environs. The author writes succinctly, but with generous provision of the details that make history live, and the appendix by Mr. W. A. Seaby, F.S.A., entitled "A Note on Matthew Boulton's Fine Wares and Coinage," will bring to many an appreciation which they did not previously possess of the fine craftsmanship on which Boulton's fortune was primarily established and which enabled him to finance the construction of Watt's steam engines until the engineering undertaking became self-supporting. The scale of the book is too small to enable the full story to be told, but further details will be found in the works cited in the bibliography.

Woods Practical Guide to Fan Engineering.

By W. C. OSBORNE, B.Sc. (Eng.), and C. G. TURNER. Woods of Colchester, Limited, Brunswick Works, Colchester. [Price 10s. 6d. net.]

MESSRS. WOODS of Colchester have performed a useful service in commissioning the authors of this manual to assemble the considerable amount of information which it contains on the principles underlying the design, manufacture and installation of fans for operation under a variety of conditions. A study of this book should do much to prevent the wrong selection, incorrect installation, indifferent design of air ducts and other shortcomings too often encountered. After describing the air conditions necessary for human well-being and discussing such questions as humidity, solar radiation, the calculation of heat gains and ventilation and air velocities, the authors analyse in detail the various systems of ventilation available, and the problems of air distribution and cleaning, and dust extraction. The methods of cooling and types of coolers are next dealt with and a consideration of air flow measurement leads up to the important question of duct design. Details of the various types of fan and the considerations governing their selection are given, with the precautions needed when they are to be installed in dangerous atmospheres.

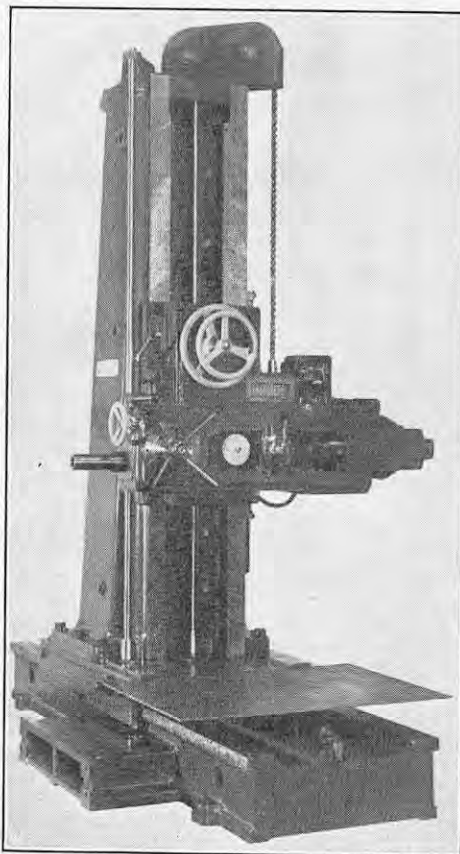
Strength of Materials.

By Professor GERNER A. OLSEN. George Allen and Unwin, Limited, Ruskin House, 40, Museum-street, London, W.C.1. [32s. 6d. net.]

THE author of this book, who is assistant professor of civil engineering in the City College of New York, has designed it to meet the needs of technical college students of modest mathematical attainments. The treatment, consequently, is elementary, but the derivation of formulæ without the use of the calculus has been achieved with a clarity that newcomers to the subject should welcome no less gladly than the author's clear exposition of the fundamental principles underlying force, stress and strain relationships. The subject matter includes an instructive discussion of welded joints, and deals along practical lines with shells, beams and columns, bending, torsion and combined stresses. The actual strength properties of structural materials, however, receive no more than incidental attention; and the omission of any account either of materials testing equipment and procedure or of reinforced concrete, unexpected in a book of this character, is by no means compensated by the present concluding chapter, on fatigue and stress concentration, which is disappointing. On the credit side, Professor Olsen's emphasis on the applications of his subject matter to practical engineering design is an attractive feature.

HORIZONTAL DRILLING MACHINE.

THE accompanying illustration shows a new horizontal drilling, boring and tapping machine, with a 2-in. diameter spindle, which has been introduced by Messrs. Kitchen and Wade, Limited, Halifax. The machine, No. H.4 on the maker's list, requires a floor space of 13 ft. 6 in. by 6 ft. 6 in. and has a weight of 6½ tons. The splined spindle has a minimum diameter of 2 in. and at the nose end is bored No. 5 Morse taper; it is supported throughout its 24 in. traverse by a large steel sleeve on which the feed rack is cut. Both fine and rapid hand adjustments are provided for the spindle, the former by the small handwheel at the side and the latter by the cross handles. Once the desired position has been reached, a slight pressure on the handles engages the power feed.



A 5-h.p. motor is built into the saddle and 12 changes of speed are available in one of four series from 1,500 to 45 r.p.m. down to 600 to 18 r.p.m. All the speed changes are obtained by a single lever, and the speed selected is directly indicated. The driving gears are of hardened nickel-chromium steel and are carried on high-tensile multi-splined shafts which run on ball bearings. A master electric control, conveniently placed, provides forward, stop, inch and reverse movements to the spindle, and a quick-reading dial on the front of the saddle gives speeds and feeds to be used for various metals within the capacity of the machine. The drilling capacity is 3 in. diameter from the solid in mild steel and 3½ in. diameter in cast iron. A built-in oil pump supplies lubricant to the saddle mechanism and a visual indicator is mounted on the front of the saddle. The column has a traverse of 5 ft. on four enclosed ball-bearing rollers which run on the bed slideways, and the saddle is balanced by a deadweight housed within the column. The locking and traverse motions for both column and saddle are operated from the saddle, which has 4 ft. of movement vertically.

REINFORCED ASBESTOS.—We have received a sample of metal-reinforced woven asbestos sheeting from the British Re-inforced Asbestos Co., Ltd., 24, New-street, Worcester. The sheeting is available in thicknesses of 1/16 in. and 1/8 in. Being flexible, it is an excellent jointing material, is suitable for use under high pressures or temperatures, and is resistant to water or spirit.

BOOKS RECEIVED.

Ministry of Transport. *Railway Accidents. Report on the Collapse of a Footbridge which occurred on 19th January, 1952, at Knowsley Street Station, Bury, in the London Midland Region, British Railways.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3s. net.]

Britannica Book of the Year 1952. Encyclopædia Britannica Limited, Panton House, Haymarket, London, S.W.1. [Price 3 guineas.]

Steelwork in Building. By WILLIAM BASIL SCOTT. E. and F. N. Spon, Limited, 22, Henrietta-street, London, W.C.2. [Price 25s. net.]

University of Illinois Engineering Experiment Station. Bulletin No. 398. *A Critical Review of the Criteria for Notch-Sensitivity in Fatigue of Metals.* By C. S. YEN and PROFESSOR T. J. DOLAN. [Price 50 cents.] No. 399. *A Study of Combined Bending and Axial Load in Reinforced Concrete Members.* By PROFESSOR EIVIND HOGNESTAD. [Price 1 dol.] University of Illinois, Urbana, Illinois, U.S.A.

University of Illinois Engineering Experiment Station. Circular No. 63. *An Economic Study of Fuels in Manufacturing.* By PROFESSOR WALTER H. VOSKUIL. [Price 40 cents.] No. 64. *What do We Know about Diagonal Tension and Web Reinforcement in Concrete? A Historical Study.* By PROFESSOR EIVIND HOGNESTAD. [Price 50 cents.] University of Illinois, Urbana, Illinois, U.S.A.

Workshop Calculations, Tables and Formulae. By F. J. CAMM. Tenth edition. George Newnes Limited, Tower House, Southampton-street, London, W.C.2. [Price 7s. 6d. net.]

The Traction Engine, 1842-1936. By F. W. GILLFORD. The Oakwood Press, Tanglewood, South Godstone, Surrey. [Price 5s.]

Note Succincte sur un Voyage de Mission dans l'Indochine (Octobre-Novembre, 1951). By J. LAMON. Laboratoire de Recherches Hydrauliques des Ponts et Chaussées de Belgique, Berchemlei 115, Borgerhout-Anvers, Belgium. [Gratis.]

Acoustics in Modern Building Practice. By FRITZ INGERSLEV. Architectural Press, 9-13, Queen Anne's Gate, London, S.W.1. [Price 35s.]

Portugal. *Ministério das Obras Públicas Laboratório de Engenharia Civil.* Publication No. 19. *Medição de Deformações com Extensómetros Mecânicos. Aplicações no Laboratório e nas Obras.* By JOÃO D'ARGA E LIMA. Laboratório de Engenharia Civil, Av. Rovisco Pais, Lisbon, Portugal. [Price 20 escudos.]

Wireless Fundamentals. By E. ARMITAGE. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 18s. net.]

The Colliery Year Book and Coal Trades Directory, 1952. The Louis Cassier Company, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 30s. net.]

Ministry of Transport. *Committee on Road Safety. Report to the Minister of Transport on the Bus Accident at Gillingham on 4th December, 1951.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3d. net.]

1952 *Addendum to the British Sawmilling Classification of Timbers.* The National Sawmilling Association, 14, New Bridge-street, London, E.C.4. [Price 2s. 6d. post free.]

Modern Marine Engineering. By D. W. RUDORFF. Temple Press Limited, Bowling Green-lane, London, E.C.1. [Price 9s. 6d. net.]

The Practical Motorist's Encyclopaedia. Principles, Upkeep and Repair. By F. J. CAMM. George Newnes Limited, Tower House, Southampton-street, London, W.C.2. [Price 17s. 6d. net.]

Soil Mechanics, Foundations, and Earth Structures. By PROFESSOR GREGORY P. TSCHEBOTAROFF. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 7 dols.]; and McGraw-Hill Publishing Company, Limited, McGraw-Hill House, 95, Farringdon-street, London, E.C.4. [Price 59s. 6d.]

Traité d'Irrigation. By V. BAUZIL. In two volumes. Editions Eyrolles, 61, Boulevard St. Germain, Paris (5e). [Price 5,500 francs.]

Waterworks, Byelaws and Fittings. By DELWYN G. DAVIES. The Colliery Guardian Company Limited, 30 and 31, Farnival-street, London, E.C.4. [Price 30s. net.]

Sailing Ships. Their History and Development, as Illustrated by the Collection of Ship-Models in the Science Museum. By the late G. S. LAIRD CLOWES. Part II. *Catalogue of Exhibits, with Descriptive Notes.* Fourth edition, revised by E. W. WHITE. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 6s. net.]

Alternating Current in Telecommunications. By W. T. PALMER. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 4s. net.]

Was der Siemens-Martin-Stahlwerker von seiner Arbeit wissen muss! By DIPL-ING. KARL MAYER. [Price 8.50 D.M.] *Was der Mann aus der Schmiede von seiner Arbeit wissen muss!* By ADOLF SCHWARZ. [Price 7.20 D.M.] Verlag Stahlseisen m.b.H., Breite Strasse 27, Düsseldorf, Germany.