# VEHICLE FOR RECORDING THE CONDITION OF RAILWAY TRACK.

It is understood that British Railways are giving close consideration to any advantages in economy and safety that might be derived from the use of a track recording coach. Several different systems of indicating and recording the condition of the track have been developed on certain overseas railways, and among those now being studied is the Matisa-Mauzin car, which has been adopted for regular service by the French National Railways. This vehicle is built according to the design of Mr. M. Mauzin, who was responsible for the prototype constructed in 1931, and its use in other countries is in the hands of Matériel Industriel, S.A., Lausanne, Switzerland. This firm, who are associated in the United Kingdom and the Commonwealth with Matisa Equipment, Limited, 78, Buckingham Gate, London, S.W.1, are known for their permanent-way machines, some of which have previously been described in ENGINEERING, notably the ballast cleaner, the ballast tamper, and the curve calculator.

The Matisa-Mauzin track inspection car, which is illustrated in Fig. 1, herewith, is a normal railway vehicle with two four-wheeled bogies, but with the addition of an extra eight-wheel bogie between them. This bogie shares the weight of the vehicle equally with the existing bogies. The vertical movements of the wheels as the car travels along the track are used to actuate recording styli on a moving band of paper in the car, and lateral movements are measured by means of feelers which bear on the insides of the rails. Fig. 2 shows the recording table and Figs. 3 and 4 are reproduced from typical charts. Considered as a mechanism, the chief feature of interest in the apparatus is the novel arrangement of tensioned cables and pulleys which couple the wheels and the feelers to the styli so as to transmit the appropriate movements. The use of so many axles—namely eight—largely overcomes the difficulty, inherent in any vehicle for examining railway tracks, of establishing a datum by which to measure the relative movements of the wheels used to measure irregularities in the track. A further advantage is that, as all the axles are equally loaded at about 6 tons, the track deviations recorded are those which occur when the track is under load, a load of 1½ tons per wheel having been established by the French Railways as sufficient to deflect the heaviest rail in use. If this condition did not obtain, voids under sleepers, for example, would not be detected.

The chief advantages of a track inspection car compared with the normal inspection by a permanent-way man walking along the track, are of course, the rapidity, accuracy and inexpensiveness with which whole railway systems can be surveyed. The Matisa-Mauzin car can be used at speeds up to 120 km. an hour; it can be coupled to any vehicle in any convenient train, fast or slow; and it produces identical records however it is so coupled. Track defects can subsequently be accurately located since the chart is marked with the kilometre (or mile) post positions; the chart marker for this purpose is synchronised with a post at the beginning of a run and is periodically checked, and adjusted, if necessary, as the recording proceeds. The recording chart is 21 cm. wide (about 8 in.) and copies of it are readily made up in loose-leaf book form. Such books are very convenient for permanent-way staff to carry along the track when correcting alignment, etc. Another run with the inspection car then reveals the effectiveness of the work.

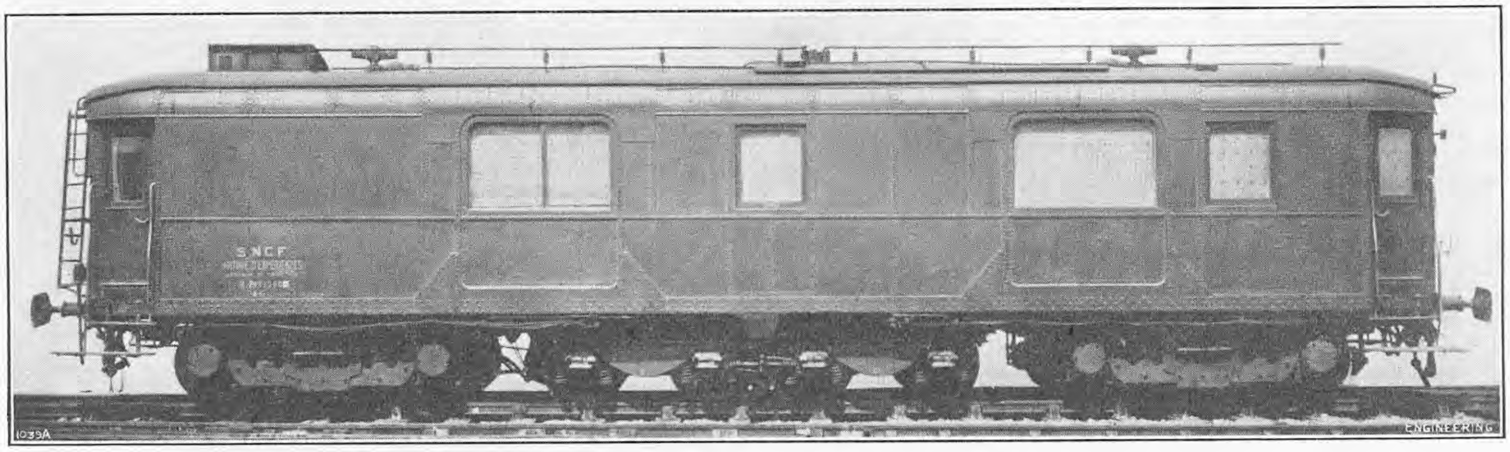



FIG. 1. "MATISA-MAUZIN" RECORDING CAR.

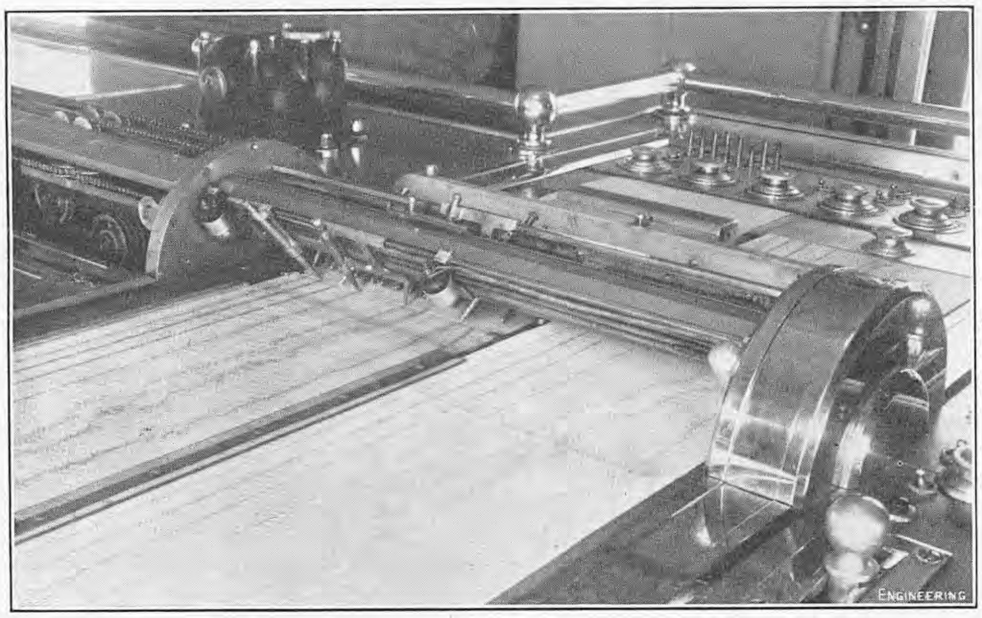



FIG. 2. RECORDING TABLE.

Fig. 3. RECORDING OF GOOD TRACK. Fig. 4. RECORDING OF BAD TRACK.

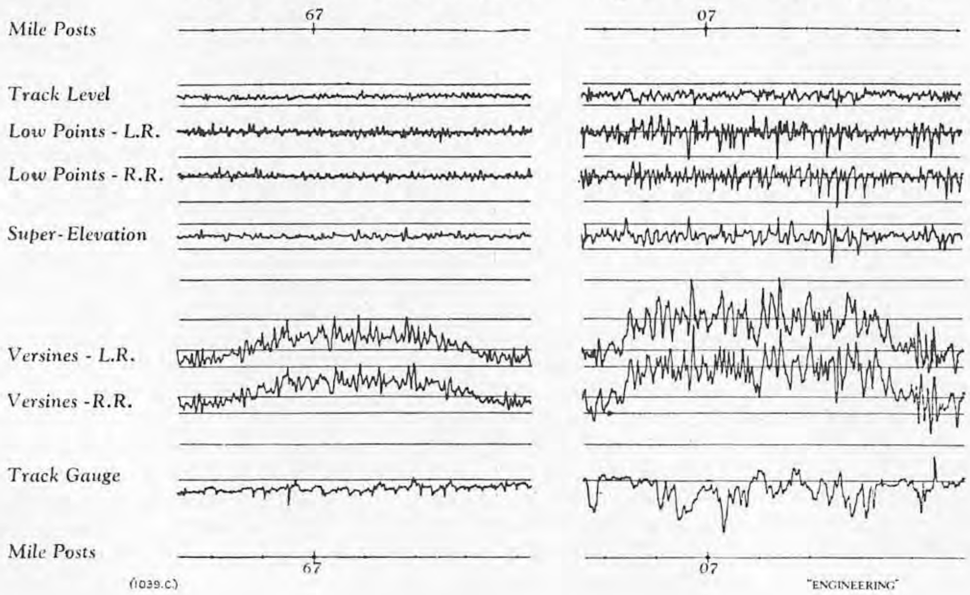
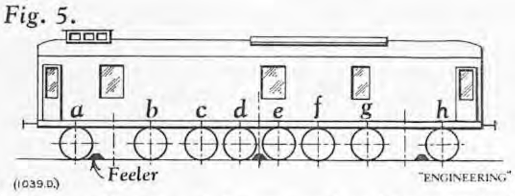



Fig. 5.



### Design of the Car.

The underframe, which is of steel construction, is supported near its ends by the two outer bogies in the normal way, and at the centre by a longitudinal beam, the ends of which are carried on spring cross-members of the two four-wheeled bogies in the middle. This beam is free to move transversely in relation to the body and can also turn (in plan). The wheelbase of the central eight wheels is as short as possible to minimise the transverse movement on curves. In surveying a track with the Matisa-Mauzin car, there are three sets of vertical co-ordinates and two sets of horizontal co-ordinates to be recorded. The three vertical co-ordinates are the rate of change of the relative levels of the two rails, the profile of the running surface of each rail, and the variation in super-elevation. The two sets of horizontal co-ordinates relate to the curvature of the track and the gauge. They are dealt with in that order below.

*Rate of Change of Relative Levels of the Rails.*—This is measured by the relative vertical movements of the four wheels on axles *c* and *e* (which are indicated in Fig. 5, on page 225). Irregularity in the track would be indicated if the rate of change of level of one of these wheels relative to the plane formed by the other three wheels exceeded a given amount. Fig. 7 shows the arrangement of cables that records such irregularities. Assuming, for the sake of description, that three of the cable ends do not move, a movement down, say, of the fourth causes a downward movement of the upper pulley that it passes over. This pulley is connected by other cables, which work over another pulley, to the recording stylus. Errors due to transverse movement of the car with respect to the axles are eliminated by a device mounted over each of the four axleboxes, as shown in Fig. 6. The cable is connected to a forked member which carries a roller; this roller is moved up and down by the axlebox to which it is connected by the horizontally-slotted member, but it is prevented from moving laterally with the axlebox by the vertically-slotted members.

*Vertical Profile of the Track.*—Here we require a record of any "bumps" or "hollows" in the individual rails. It would be possible to do this by measuring the vertical movement of the centre of one wheel in relation to a straight line joining the centres of the adjacent wheels on the same rail, but this method complicates the recording since, for example, a hollow is indicated not only by the drop of the centre wheel, but also by upward movements of the other two wheels. The chart would show a hollow; but it would also show two "bumps," half as deep, one just before, and the other just after, the hollow. In the Matisa-Mauzin car this difficulty is overcome by using all the eight wheels along each side of the car. Fig. 8 shows the ingenious arrangement of pulleys and cables that is used for this purpose. Four cable ends are connected to the mid-points of the four pairs of wheels; they are coupled, through the cable and pulleys shown, to a pulley *a* which serves as the reference point for the cable *b*, which actuates the stylus.

*Variations in Super-Elevation.*—When a train traverses a curve, a moderate deficiency or excess of super-elevation is not important, but if the super-elevation is irregular along the curve, the vehicles will roll. If, by chance, the irregularity is cyclic and corresponds to the natural frequency of rolling of one or more of the vehicles, dangerous rolling motions may be caused. In the Matisa-Mauzin car, irregularity in super-elevation is recorded by a cable and pulley mechanism that is coupled to the two sets of mehanisms used for recording variations in vertical profile (Fig. 8).

*Irregularities of Curvature.*—Here it is necessary to record the versines of each rail. This is done simply by six roller-mounted feelers, or shoes (three

## TRACK-RECORDING CAR.

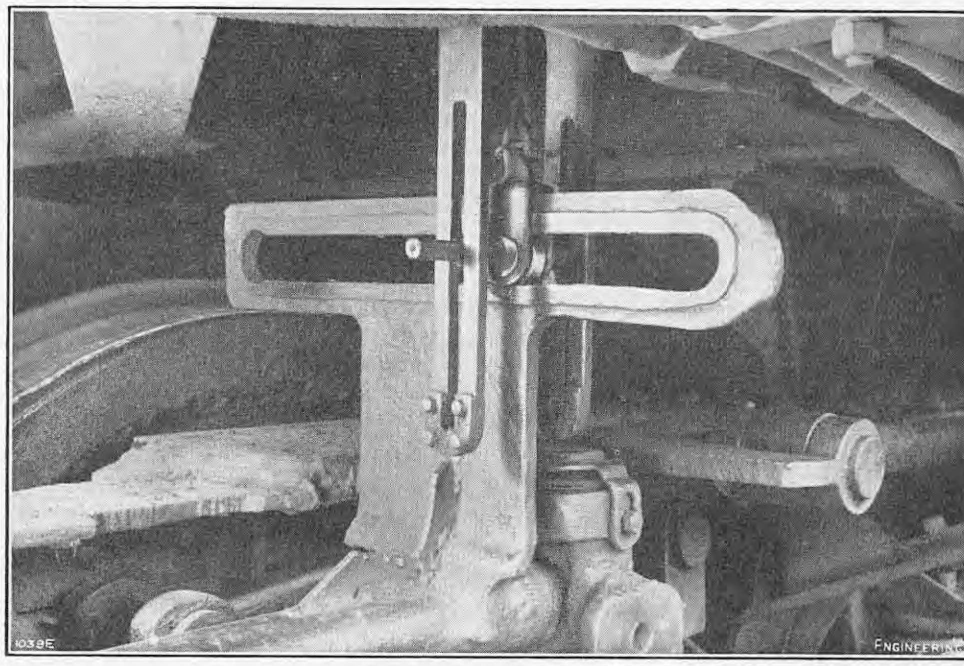



Fig. 6. Device for Eliminating Effect of Lateral Motion.

*Fig. 7.* RECORDING OF VARIATION OF PLANE.

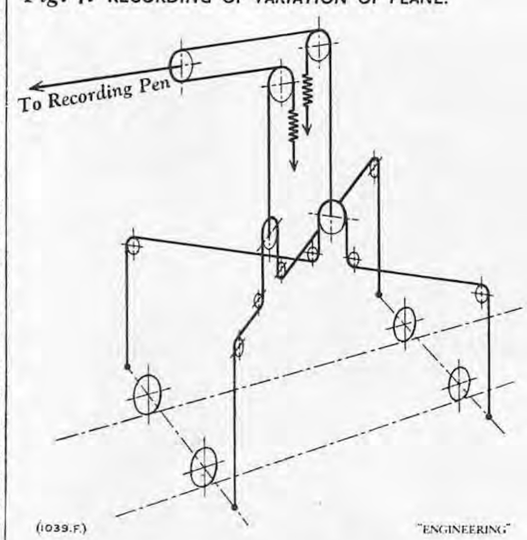
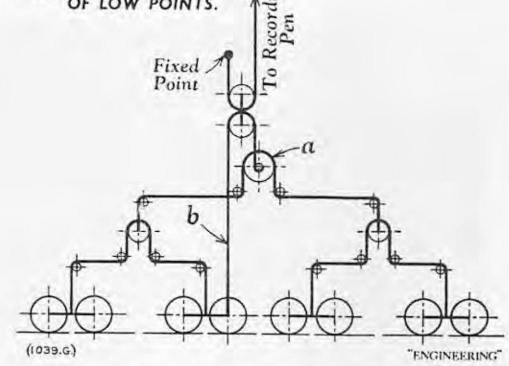



*Fig. 8.* RECORDING OF LOW POINTS.




of which are shown in Fig. 5), three along each rail. The versine is determined by the lateral movement of the centre feeler in relation to a line joining the two outer feelers, and the movement is recorded by a stylus operated by cables and pulleys. The feelers are provided with small rollers to reduce wear.

*Variation of Gauge.*—For this recording, a cable and pulley mechanism is connected to the two centre feelers (described in the previous paragraph), in such a way that variations in the distance between the two feelers is transmitted to the stylus.

### Recording Apparatus and Chart.

In the recording apparatus (Fig. 2), a roll of tracing paper is laid over a roll of carbon paper, so that the styli mark the underside of the tracing paper. The normal speed of the recording chart is 20 cm. per kilometre length of track, though alternative speeds of 50 cm., 1 m. and 2 m. per kilometre can be obtained by means of a gearbox which is between the driving spindle and the recorder drum. The drum is wide enough to accommodate, in addition to the chart, a chart which has been recorded previously on the same track, and a smaller chart, 4 cm. wide, on which may be noted the positions of level crossings, switches, bridges, etc. Thus, it is possible to make an immediate comparison between the conditions of the track on two successive inspections. Figs. 3 and 4 show the order, across the chart, in which the several recordings are made, namely, relative levels of the rails; profile of the left rail (L.R.); profile of the right rail (R.R.); variation in super-elevation; variation in versines of left rail; the same for the right rail; and variations in gauge. Datum lines automatically marked on the chart by fixed pens comprise the following: two lines, 8 mm. apart, on either side of the "track-level" pen, so that if the latter pen reaches one of the datum lines an irregularity of 4 mm. is indicated; a line representing zero variation in the vertical profile of the left rail, and another 1 cm. below it; a similar pair of lines for the right rail; two lines, 1 cm. apart, as a datum for variations in super-elevation; two lines, 7 mm. apart, for recording the versines of the left rail when on straight lengths of track; two lines above the latter two, one corresponding to the theoretical value of the versine of a 1,000-m. curve, and the other corresponding to a 500-m. curve; a similar set of four lines for the versines of the right rail; a line corresponding to a gauge of 1 m. 435 mm.; and, finally, a line for a gauge of 1 m. 465 mm. The advantage of using fixed datum lines, and then adjusting the styli to them by micrometer screws, is that a chart can be superimposed on an earlier chart of the same track.

When a recording has been made, the chart is cut into lengths corresponding to the lengths of track for which different administrative divisions of the railway are responsible. Copies of these lengths of chart are then made and issued to the staff concerned.

# LITERATURE.

*Structure in Building.*

By DR. W. FISHER CASSIE, M.S., F.R.S.E., M.I.C.E., M.I.Struct.E., and J. H. NAPPER, M.A., F.R.I.B.A., A.M.T.P.I. The Architectural Press, 13, Queen Anne's-gate, London, S.W.1. [Price 30s. net.]

As Mr. W. A. Allen, chairman of the Text and Reference Books Committee of the Royal Institute of British Architects, says in his foreword to this book, "there are plenty of books about structural design," but none which gives "the kind of information an architect has to have when he is starting on a design." The chief problem was to find the right authors, but the search was successful. They observe in their opening chapter that "Until the student achieves the ability to 'feel' how forces act and react in the support of buildings, he cannot hope to apprehend and put into practice the sculptural and volumetric conceptions of great architecture." Many early architects, and such great engineers as Telford, George Stephenson and Brunel, undoubtedly had this ability; but with increasing specialisation, some modern engineers have become so tied to mathematical methods, and many architects so accustomed to the idea that structural problems must be left to the engineer, that they have failed to acquire it. This book is a timely reminder that construction is an art no less than a science. It is addressed primarily to architects and to students of architecture, as an introduction to the study of structural design, but should be equally valuable to engineering students embarking on the study of the theory of structures. Its exemplary clarity of exposition may well be followed by teachers of structural engineering science at any stage of their work.

The first chapter is devoted to a survey of structural forms, beginning with traditional ways of using the older materials, and leading up to the conclusion that "architects, if they are to design buildings which are sensible and sensitive," when using the new metals of which the qualities can be guaranteed within narrow limits "must know at least the basic principles of design and calculation used by the engineers." The first step is to evaluate all the forces applied, to visualise a building structure as being "squeezed" between the applied loads and the foundation reactions, and to set the whole system of forces down clearly in a diagram. Having cleared the ground, the authors proceed to discuss the estimation of loads, the choice of materials, and the nature and treatment of simple and redundant structures. They summarise modern methods of soil investigation, their application to the choice of the best system of foundations, and the deformations to which structures are liable from various causes, including mining subsidence. Attention is drawn to the importance of understanding, at the planning stage, the nature and sequence of the building operations implied in the design. The final chapter reviews the possible structures for various types of building. The architect who has mastered this book should be able to select with discretion the structural form best suited to his requirements, functional and æsthetic. It will not make him an engineer, but he will be able to discuss his structural problems with his engineer in the knowledge that both parties speak and understand the same language.

A work such as this must inevitably cover controversial ground, and its treatment must be condensed and selective. It would be easy to pick on minor points of criticism. For instance, when the authors stress the important economy to be gained in designing long-span roofs with purlins widely spaced to carry a light covering of long-span roofing-sheets, it might have been well to point out the danger to men working on a roof covered with long-span sheets of light brittle material. Such minor points of criticism are, however, far outweighed by the merits of the book. To deal with structural design informatively, without mathematics, is not easy; but the authors have boldly faced the difficulty, and the result is not only technically sound, but readable—a virtue not always evident in works on this subject.

*Tensor Analysis: Theory and Applications.*

By PROFESSOR I. S. SOKOLNIKOFF. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 6 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 48s. net.]

THE question whether a logical deduction based on experimental data merits the name of a natural law is often determined by the generality of the deduction, and by its validity in a sufficiently wide class of systems of reference. This is intimately bound up with the possibility of expressing the deduction in the form of a tensor equation, since there is a theorem to the effect that, if the components of a tensor vanish in any one system of co-ordinates, they must vanish in every system of co-ordinates. Accordingly, the assertion that the components of a certain tensor vanish is a mathematical way of stating a physical fact without introducing such irrelevant matters as the choice of a system of reference. Professor Sokolnikoff very clearly indicates the utility of tensors by including, between the covers of this moderately-sized book, a large amount of material of value to mathematicians, engineers, and physicists. Of the six chapters of the book, the first is given to a discussion of linear transformations and matrices, in the course of which the reader's attention is drawn to the underlying ideas of geometry and physics. These considerations lead to a self-contained account of the algebra and calculus of tensors, where the student soon realises that mathematical physics is built about the corner-stone of the notion of invariance and the universality of physical laws. In accordance with the arrangement of the work, the author here departs from the customary practice of making geometry or relativity a medium for the development of tensor analysis.

The four remaining chapters treat, in turn, with applications of the tensor calculus to geometry, analytical mechanics, relativity, and the mechanics of deformable media. Although these chapters are independent, the first of them overlaps the others at certain places, in so far as it includes those geometrical topics that are of importance in analytical dynamics, portions of elasticity and plasticity which have to do with the deformation of plates and shells, and a substantial introduction to the subject of metric differential geometry. Chapters 4 and 6 will doubtless attract students of engineering and physics, for whom the author provides, in the first of these principal sections, a wide range of important topics, as, for example, a systematic extension of the formal analysis to Lagrange's equations in generalised co-ordinates, the principle of least action, the canonical equations of Hamilton, and the problem of two bodies, which lies at the basis of all considerations in astronomy. The general formulation of the fundamental ideas and equations of deformable media, in the final 35 pages of the text, is also noteworthy because the linearised equations of classical theory appear as special cases of non-linear expressions, so that, in studying these pages, the reader acquires a knowledge of the elements of the non-linear mechanics of elastic solids and fluids. To the student of physical science the great value of Professor Sokolnikoff's book lies in his informative discussion of a calculus which may now be regarded as an extremely powerful instrument of investigation into the essentials of a number of the applied sciences.

*Steelwork in Building.*

By WILLIAM BASIL SCOTT, M.I.Struct.E., M.Inst.W E. & F. Spon, Limited, 22, Henrietta-street, London W.C.2. [Price 25s. net.]

THE basis of this book, described as "A Commentary on the British Standard Specification on the Use of Structural Steel in Building Printed with the Specification," is the revised British Standard (No. 449 : 1948), on which the new section tables issued by the steel manufacturers are based. The author served on the technical drafting committee which prepared the document and is fully conversant both with its provisions as published and with the reasons for changing the former standard. As compliance with this Standard is a mandatory requirement of many statutory authorities, it is important that its requirements be clearly understood both by designers and by the officers who check structural calculations. B.S.449 covers very much the same ground as the British Standard Code of Practice C.P.113 on *The Structural Use of Steel in Buildings*, issued by the Codes of Practice Committee for Civil Engineering, Public Works and Building. Close collaboration was maintained between the two drafting bodies, and, with very minor adjustments one document might have served for both. Mr. V. H. Lawton, M.I.Struct.E., who served on both drafting committees, and as chairman for that on the Code, has contributed a foreword to Mr. Scott's book.

The divergences between B.S.449 and C.P.113 are set out and explained on pages 181 to 185. The chief difference is in the form of approach, the Code recommending procedure which should be followed as a matter of good practice, while the British Standard lays down minimum requirements which must be satisfied. B.S. 449 also includes clauses on loading, based on Chapter V of the Code of Functional Requirements of Buildings (C.P.4 : 1944) which C.P.113 covers by reference, and on welding, which C.P.113 leaves to another code. The principal innovations in the 1948 British Standard are the adoption of new loadings, particularly for wind, and the acceptance of the "Recommendations for Design" made in 1936 in the Final Report of the Steel Structures Research Committee, but not embodied in B.S.449 : 1937. The section covering details of construction is fuller than before, more tabulated data are included, and a distinction is drawn between three methods in the design of steel framework according to the connections provided between the component members, namely, simple design. semi-rigid design and fully-rigid design.

The unique part of Mr. Scott's book is the commentary, which follows each clause of the Standard, explains the text where the requirements are at all involved or novel, illustrates its application by examples and by line diagrams, expands some tables, and adds others. The author thus makes clear to the experienced designer why and how he may be called upon to modify old methods to meet the new requirements, and provides the less experienced designer with an invaluable aid towards developing a sound technique of design on the most up-to-date lines. The book deserves to be, and will undoubtedly become, the constant desk companion of many designers of steelwork for buildings.

IMPREGNATED PAPER CAPACITOR.—The British Thomson-Houston Co. Ltd., Crown House, Aldwych, London, W.C.2, have recently developed a range of capacitors with Permitol impregnated paper dielectric, which are housed in an all-welded leakproof aluminium case. These capacitors have clamp-type terminals to facilitate wiring and are fitted with discharge resistors. They are intended for use at ambient temperatures of about 70 deg. C. Permitol is a chemically-stable non-inflammable material with good insulating properties, including a high dielectric constant. Its use, therefore, enables a capacitor in which it is used to be made more compact than one of the jelly-impregnated type for the same rating.

# GRAVIMETRIC SAMPLING OF DUST IN COAL MINES.

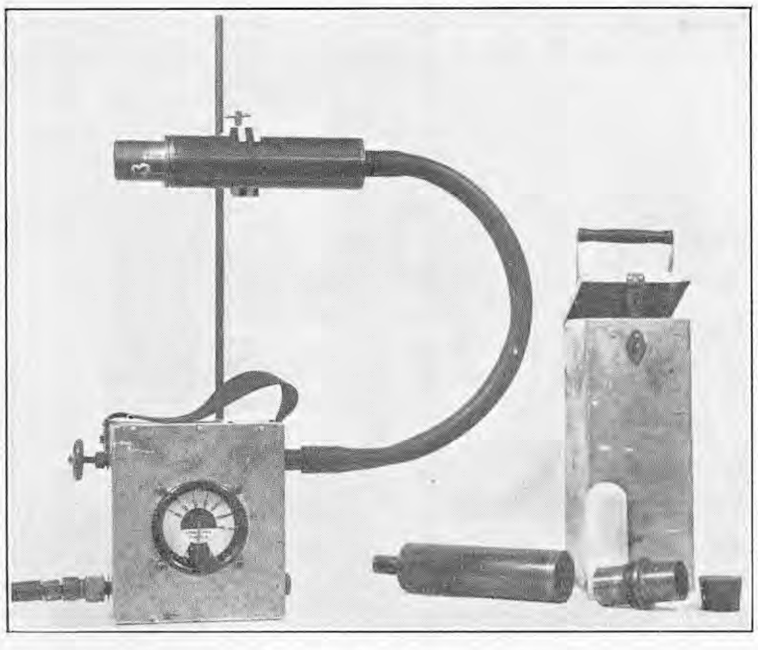


FIG. 1. DUST-SAMPLING APPARATUS.

Fig. 2.

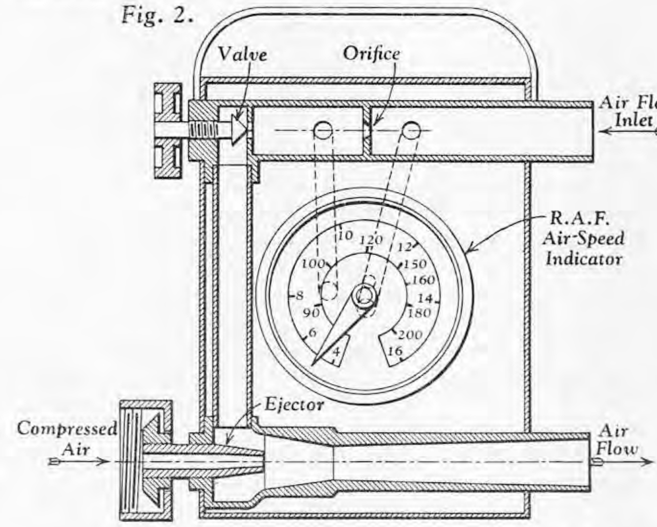
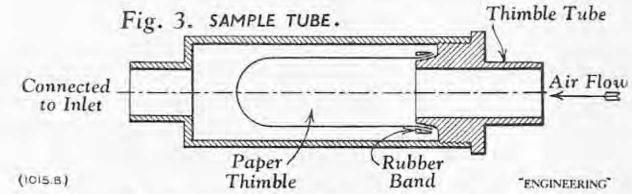



Fig. 3. SAMPLE TUBE.




(1015.B) "ENGINEERING"

## GRAVIMETRIC SAMPLING OF DUST IN COAL MINES.

By H. H. WATSON and T. G. MORRIS, Ph.D.

ACCURATE determinations of the concentration, particle-size distribution and composition of air-borne dust are often required, for the assessment of a health hazard, the establishment of the existence of a public nuisance, or for economic and technical reasons associated with an industrial process. This article considers some of the physical principles involved in the accurate sampling of dusts on a gravimetric basis, and describes an apparatus suitable for the purpose. The apparatus has been used extensively to collect samples of air-borne coal dust for the determination of its composition, this being an essential feature of a programme of work at the Pneumoconiosis Research Unit of the Medical Research Council at Llandough Hospital, Penarth, Glamorganshire.

When dealing with coal-workers' pneumoconiosis it must be remembered that the non-coal, or mineral, content of the air-borne dust produced by working and handling coal is only a fraction of the total; it is often about 10 per cent., but in our experience may vary from 4 to 40 per cent., depending on the type of coal, the adjoining strata and the method of mining. Therefore, if a detailed chemical analysis of the mineral matter contained in the air-borne coal dust is required, as much as 10 grammes of the original dust must be collected, even when semi-micro methods of analysis are used. Many instruments have been employed for collecting samples of air-borne dust in amounts large enough for analysis and, although differing in detail, they all contain a means of aspiration, a filter on which the dust is deposited, and a flow-rate indicator, or a flow integrator.

Sugar tubes, flat filter papers and soxhlet extraction thimbles have been used from time to time in coal-mines to collect relatively large amounts of dust. Briscoe *et al.** employed a pad of naphthalene as a filtering medium and a hand-pump to produce the air-flow, subsequently using micro-methods for a restricted analysis of the small amount of dust collected in this way. Compressed-air pumps, manual pumps and compressed-air ejectors are alternative methods for producing the air-flow. We decided, after considering the experiences of other workers, to use a compressed-air ejector as a source of suction, a large soxhlet extraction thimble as a filter, and a flow-rate indicator rather than a flow integrator. The apparatus had to be robust, simple, small, light in weight and capable of running for long periods to collect dust at as high a rate as possible.

* *Medical Research Council Special Report*, Series No. 244, by H. V. A. Briscoe, P. F. Holt, N. Spoor, J. W. Matthews and P. M. Sanderson. H.M.S.O. (1943).

### DESCRIPTION OF APPARATUS.

The apparatus consists of a small aluminium box, shown in the lower left corner of Fig. 1 and in Fig. 2, and contains a compressed-air ejector, a flow-rate indicator, and a control valve. The ejector, which is of a type described by one of the authors,* is connected to the compressed-air line by reinforced hose piping. A control valve is arranged between the inlet to the apparatus and the suction side of the injector. The flow-rate indicator is connected across an orifice, $\frac{1}{4}$ in. in diameter, inserted into the inlet tube, which is $\frac{3}{4}$ in. bore. This indicator is an R.A.F. air-speed indicator and is essentially a differential-pressure gauge. The dial is calibrated against a rotameter under conditions similar to those obtaining when the apparatus, is used. The calibration has been found to remain steady over a period of several months. To determine the amount of air passed through the apparatus as, for example, when the mass concentration of air-borne dust is required, it is necessary, of course, to measure the time of operation as well as the rate of flow.

The soxhlet thimbles, on which the dust is collected, are described as "fat-free, seamless, single thickness," and are 41 mm. in diameter and 123 mm. long. The thimbles are mounted in brass sampling tubes as shown in Fig. 3. The arrangement is essentially similar to that adopted by Griffiths and Jones.† A more satisfactory method of attaching the thimble to the sampling tube would be that suggested by Shaw,‡ in which the thimble is pressed tightly over the tube by a hollow cone in a screw-cap. Four of the tube assemblies can be carried in the aluminium box shown on the right-hand side of Fig. 1. The effective filtering area of the thimbles when mounted is about 140 sq. cm., corresponding to the area of a flat filter 13·3 cm. in diameter. Griffiths and Jones used thimbles 30 mm. in diameter and 80 mm. long, but we preferred the larger filters because they give a higher flow rate, and hence more dust per hour, for the same resistance (in., water gauge) to air flow, and because the effects of anisokinetic sampling (see below) are less marked the larger the sampling orifice.

* H. H. Watson, *Trans. Inst. Min. Met.*, vol. 46, page 155 (1936-37).

† J. H. Griffiths and T. D. Jones, *Trans. Inst. Min. E.*, vol. 99, page 150 (1939-40); see also 7th and 13th reports of the Coal Dust Research Committee of the Monmouthshire and S. Wales Coal Owners' Association.

‡ A. Shaw, contribution to discussion on paper by Griffiths and Jones.

Thimbles vary considerably in their clean dry mass and also in their resistance to air-flow, and we have found no correlation between mass and resistance. The range of dry mass we have found in over 1,000 separate thimbles is 3·71 gm. to 9·97 gm., but this variation is of no consequence in our particular application. The limits of resistance to air-flow found in 250 separate clean filters were 4·7 in. water gauge and 25·0 in. water gauge, measured at a flow-rate of 150 litres per minute, with the resistance of most filters falling within the range of 5 in. to 10 in. water gauge. We have found that the suction side of a thimble always appears clean and white after use, indicating that it is highly retentive for coal-mine dust. As dust accumulates in a filter the resistance to air-flow increases. This is of importance for two reasons: the limit of ejector power may be exceeded, so that the desired flow-rate may not be maintained; and the increased pressure drop will affect the calibration of the flow-meter, which is always working at the reduced pressure on the suction side of the filter. Under conditions of more than average dustiness in a coal mine (200 mg. per cubic metre) our standard flow-rate of 150 litres per minute can be easily maintained for half a shift, i.e., for three to four hours.

If the dust is being collected solely for analytical purposes, and the actual mass concentration in the environment is not required, then all that is necessary is to remove the dust from the thimble, which can be done readily, with no contamination by fibres, by shaking and tapping. Some 100 mg. of the dust still remain embedded in the filter, however, and are lost from the sample. For normal work this loss, which amounts to 3 per cent. when 3 gm. of dust have been collected, is probably not important, but where the amount of dust collected is small, e.g., in mines with low dust concentrations, or where size separation has been effected (as described below), it may be necessary to recover for analysis the mineral portion of the dust remaining in the thimble. For some coal dusts with a low content of mineral matter (say 5 per cent.), the weight of ash of the thimble itself (about 20 mg.) may greatly exceed that of the mineral matter present in the coal. To overcome this difficulty, it has been found convenient to use "ashless" thimbles made specially for us by Messrs. H. Reeve Angel and Company, Limited, 9, Bridewell-place, London, E.C.4. These are bonded with melamine resin and have an ash content of not more than 2 mg.

When a figure for the mass concentration is required, it is necessary to weigh the thimbles before and after use, and a technique which has been found to give a standard error of 2 mg. for a single weighing is as follows. The thimble is placed in an aluminium weighing bottle, provided with a closely fitted lid, and the whole is heated for two hours, with the lid removed, in an air oven at 105 deg. C. At the end of this time the bottle is removed from the oven, the lid replaced, and cooled for 40 minutes in a desiccator. The bottle is then weighed to the nearest mg.

TABLE I.—*Values of* $\frac{Q_s}{Q_o}$ *for Spheres.*

| Diameter of Sphere, microns. | $U_o$ cm. per sec. | | |
|---|---|---|---|
| | 50·8 | 203·2 | 304·8 |
| 1 | 1·00 | 1·00 | 1·00 |
| 5 | 1·00 | 1·00 | 1·01 |
| 10 | 0·99 | 1·00 | 1·05 |
| 50 | 0·74 | 0·99 | 1·35 |
| 100 | 0·49 | 0·97 | 1·42 |

It must be remembered that the flow-rate indicator is calibrated with a clean thimble in the air circuit. During sampling, the dust accumulated on the filter causes plugging and the indicator will then read too high, approximately in proportion to $\sqrt{\frac{p_0}{p_1}}$, where $p_0$ is the calibration pressure at the meter, and $p_1$ is the operating pressure. A filter containing 3 gm. of dust may have a resistance to a flow of 150 litres per minute as much as 70 in. W.G. (5.1 in. Hg.). At this resistance, when the indicated flow-rate is 150 litres per minute, the true flow-rate will be 139 litres per minute, and when the under-pressure is 10 cm. Hg., the actual flow-rate will be 125 litres per minute. To obtain a correct gravimetric measure of dust concentration, it is necessary to allow for this error due to the flow-rate indicator, one which is common to integrating meters as well. The error can be reduced by calibrating at an intermediate pressure.

### ANISOKINETIC SAMPLING.

Coal-mine dusts contain particles up to 70$\mu$, or more, mean projected diameter, and much care has often to be taken to sample isokinetically, if quantitative samples are to be obtained (Griffiths and Jones; and British Standard 893-1940). In many dusts there is a change of composition with particle size, and so quantitative collection of all sizes will be necessary if the subsequent chemical analysis is to give valid results. The sampling orifice is always arranged to face the oncoming dusty air, and the smaller the orifice the more serious will be the error introduced if the speed of sampling deviates from that of the passing air-current. From the operational point of view it was considered most undesirable to have to regulate the sampling rate according to the velocity of the passing air. Even if this ventilation velocity were measured at the beginning of a shift in a coal-mine, and isokinetic conditions for sampling arranged, frequent adjustments would have to be made to compensate for changing ventilation. As the coal on a face is worked off, the area of the open section increases, and so the ventilation velocity always decreases during the shift.

C. N. Davies has investigated the errors introduced under anisokinetic conditions of sampling. He states that the actual amount of dust collected, $Q_s$, is related to the amount, $Q_o$, that would be collected under isokinetic conditions, by the following expression:—

$$\frac{Q_s}{Q_o} = \frac{U_o}{U_s} - \frac{0\cdot 5}{p + 0\cdot 5}\left(\frac{U_o}{U_s} - 1\right) \quad . \quad (1)$$

when

$$P = \frac{d^2 \rho U_0}{18 \eta R} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$d$ = particle diameter.
$\rho$ = particle density.
$\eta$ = viscosity of air.
R = radius of sampling orifice.
$U_o$ = velocity in air stream.
$U_s$ = velocity in sampling orifice.

Thus errors in sampling are zero for gas molecules and become more important the larger the particle. Errors due to a given over-sampling ratio $\left(\text{when } \frac{U_o}{U_s} < 1\right)$ are smaller than those due to the same under-sampling ratio $\left(\text{when } \frac{U_o}{U_s} > 1\right)$, and the advantage of using a large sampling orifice is apparent. In Table I are given the values of $\frac{Q_s}{Q_o}$ for spheres of density 1·3 g. per c.c., with $U_s$ = 209·3 cm. per second (150 litres per minute through a sampling orifice 3·90 cm. in diameter), and $U_o$ = 50·8 cm. per second (100 ft. per minute), 203·2 cm. per second (400 ft. per minute) and 304·8 cm. per second (600 ft. per minute).

Rarely does the ventilation current at a coal face fall below 50 cm. per second (100 ft. per minute) or exceed 300 cm. per second (600 ft. per minute); usual values for many coal-faces lie between 75 and 125 cm. per second. We may consider, therefore, that the errors due to anisokinetic sampling at a coal-face would not be larger than those for $U_o$ = 50·8 cm. per second.

The above expressions are directly applicable only to spherical particles, so that when dealing with irregularly-shaped particles we must introduce an equivalent "aerodynamic" or Stokes' diameter. Air-borne coal-mine dusts are composed of particles up to about 70$\mu$ mean projected diameter and unpublished work (H. H. Watson) shows that the mean projected diameters of coal particles are on the average 1·34 times the corresponding Stokes' diameters. This figure was used in equations (1) and (2) to compute the actual overall catch of some typical dusts, using for the purpose detailed size-distributions determined with a microscope. The coarsest coal dust we have examined would be collected (according to our calculations) with an overall 90 per cent. mass efficiency under the rather extreme conditions considered ($\rho$ = 1·3 g. per c.c.; $U_o$ = 50·8 cm. per sec.; $U_s$ = 209·3 cm. per sec.). It would be beneficial to use a larger sampling orifice in such a situation. For most coal-mine dusts, however, the efficiency of collection would be closer to 100 per cent. (commonly about 95 per cent.).

Some experimental checks have been done with coal-dusts in the laboratory and underground. Two sampling units were set up side by side, the sampling tubes being arranged parallel to each other and about 6 in. apart, with their open ends facing the flow of dusty air. Some results obtained at a coal face are given in Table II for a range of $U_o$ of about 75 to 125 cm. per sec.

These results support the hypothesis that only small errors were to be expected, under the conditions of the trial, by not sampling isokinetically. The table shows also that the standard deviation of a single determination of mass concentration was rather more than 6 per cent. of the estimated value.

### SEPARATION OF RESPIRABLE DUST.

It is known that only particles smaller than the aerodynamical equivalent of spheres of diameter about 12 $\mu$ and unit density can penetrate the nose and reach the lungs, and thus to give rise to pneumoconiosis.* Thus, from an analysis of air-borne particles of all sizes (up to 70 $\mu$ at a coal-face) we do not necessarily obtain a true indication of the hazard of a mixed dust. In fact, only some 3 to 5 per cent. of the total mass of a coal-dust cloud entering the nostrils will reach the lung alveoli. For a number of reasons, it is not satisfactory to separate in the laboratory a "respirable fraction" of dust from the collected bulk sample of all particle sizes, and to analyse this fraction. Attempts are being made, therefore, by a number of laboratories, to develop separating devices which will trap the equivalent of the non-respirable fraction, allowing the smaller particles of the respirable fraction to pass to a filter and to be collected separately. Our sampling apparatus would be suitable, with stabilised flow, for the collection of the respirable fraction but, for the reasons previously given, it would be desirable to use the ashless thimbles, unless very long sampling times could be used. We have shown that with our apparatus errors due to anisokinetic sampling are negligible for particles of a respirable size (<12 $\mu$), so that it would be possible to use a higher flow-rate than the 150 litres per minute which we have normally used, in order to decrease the time required for the collection of a sample.

The apparatus has worked well under the arduous conditions underground in mines and elsewhere. It is readily portable and requires little maintenance. Where no compressed air is available to work the ejector, only slight modifications to the control box are necessary to allow an electrically-driven pump to be used to provide the suction. The calibration of the flowmeter remains steady over a period of time, but a periodic check is considered desirable.

TABLE II.—DUPLICATE SAMPLING AT A COAL-FACE.

| Run No. | Sampling Rate, Litres per Minute. (1) | Sampling Rate, Litres per Minute. (2) | Time, Minutes. | Concentration, Mg. per Cub. M. (1) | Concentration, Mg. per Cub. M. (2) | Ratio: $\frac{\text{Conc. 1}}{\text{Conc. 2}}$ |
|---|---|---|---|---|---|---|
| A. 1 | 145 | 145 | 90 | 242 | 263 | 0·92 |
| 2 | 140 | 145 | 90 | 173 | 212 | 0·82 |
| 3 | 145 | 140 | 90 | 232 | 262 | 0·88 |
| 4 | 140 | 145 | 90 | 315 | 307 | 1·03 |
| 5 | 140 | 145 | 90 | 226 | 241 | 0·94 |
| 6 | 140 | 145 | 120 | 174 | 160 | 1·09 |
| 7 | 140 | 145 | 120 | 178 | 156 | 1·14 |
| 8 | 101 | 107 | 90 | 285 | 273 | 1·04 |
| 9 | 101 | 107 | 90 | 274 | 271 | 1·01 |
| B. 1 | 145 | 42 | 90 | 168 | 152 | 1·11 |
| 2 | 145 | 42 | 90 | 98 | 101 | 0·98 |
| 3 | 145 | 42 | 90 | 223 | 224 | 1·00 |
| 4 | 145 | 42 | 90 | 172 | 178 | 0·97 |
| 5 | 140 | 42 | 116 | 238 | 278 | 0·86 |
| 6 | 140 | 42 | 100 | 273 | 279 | 0·98 |
| | | | Mean ratio (A) 0·99 ($\sigma = \pm 0\cdot 055$)<br>Mean ratio (B) 0·98 ($\sigma = \pm 0\cdot 061$) | | | |

* C. N. Davies, *Brit. J. Ind. Med.*, vol. 6 (1949).

# PARALLEL OPERATION OF PRIVATE PLANT AND PUBLIC ELECTRICITY SUPPLY SYSTEMS.

By O. HOWARTH, M.I.E.E.

IT is erroneous to suppose that the British Electricity Authority and the Area Boards are opposed to the installation of private generating plant or to the operation of this plant in parallel with the public supply. In fact, the capacity of private plant operating under these conditions at the present time is probably nearly 1,000 MW. It must, however, be pointed out that if an owner of private plant wishes to sell surplus energy to an Area Board, he must do so at a price which is competitive with that at which the Board itself buys from the Authority. This latter price is made up of a kilowatt charge, which is based on the highest demand the Board makes during the year, and a unit charge for all the kilowatt-hours supplied. If the owner of private plant can provide kilowatts during the morning and afternoon peak periods on the mains the Board will generally be prepared to pay him for them, provided they are available on every working day in November, December, January, February and perhaps in part of March. Such offers are, however, rare since private plant can usually only provide kilowatt-hours during off-peak periods, and then the price for them must be competitive with that charged by the Authority.

### OLD AND NEW SUPPLY AGREEMENTS.

Some misunderstanding of the Area Boards' policy with regard to private plant has also arisen owing to a statement in the House of Commons that all restrictions on the installation of such plant would be waived until 1959. In fact, the only restriction that has been lifted is that which requires the consumer to take the whole of his electrical requirements from the Board. This restriction was imposed to relieve the Board of any expense which they might have incurred had the consumer ceased to take the whole or part of the agreed amount within a short time, and is, it is considered, in the general interest of all concerned. When, however, a consumer with private plant approaches a Board for a supply he will certainly not have to guarantee to take all his requirements from it, although it may be suggested that it would be cheaper for him to do so. If he does not fall in with this suggestion, the Board will not refuse to enter into an agreement. The price offered will, of course, depend on the use it is proposed to make of the supply. If a stand-by for a whole or part of the load is the object, the agreement will provide for the equivalent of a rental on that part of a Board's equipment which will be idle when a supply is not being taken. On the other hand, if the private plant owner wishes to sell electricity to a Board at certain times, this can be arranged at a price depending on the price paid to the Authority less the cost of delivery to the point of usage.

### OPERATIONAL REQUIREMENTS.

Consumers who take a supply from a Board and also operate private plant can be divided into four groups. The first comprises those who normally generate their own requirements and receive a stand-by supply from the Board or, alternatively, receive a full supply from a Board and use their own plant as a stand-by. The second group is made up of those who normally generate less than their requirements and take a continuous supply from a Board; while the third consists of those who generally generate more than their own requirements and export the balance to a Board. In the fourth are those who generate not more than their requirements during peak periods and who export during off-peak periods. The consumers in the first group do not normally operate their plant in parallel with a Board's system, but utilise a change-over switch in combination with automatic protective equipment, both on the mains and on the generators. This is obviously the simplest arrangement. Consumers in the second group may, on the other hand, find it economical to run in parallel with the mains and thus to compensate for the fluctuations in the load on their generators caused by variations in their heat requirements. The third group comprises those whose heat requirements result in more electricity being generated than they themselves require, while the fourth take a supply from the public system during work hours and export to it during off-peak periods.

In all cases where privately-owned plant is operated in parallel with a Board's system, care must be taken not to jeopardise either the public or private supply, or to expose the operating staff to danger. To ensure against risk of accidental shock, stringent rules regarding safety must be laid down and the staff must comply with these when working on both high-voltage or low-voltage circuits which are normally alive. In general the Board's control engineer must be responsible for the switching programme and operators must implicitly obey his instructions. This also applies to the staff in charge of the private plant, who, in emergency, must be prepared to increase the load on it to a maximum or, alternatively, to reduce the supply to the factory.

Where a Board's mains are connected to a customer's substation in which the voltage of the mains supply is stepped down to that at which the private plant generates, all the protective metal work on the consumer's installation must be bonded together and earthed to the Board's neutral earthing connection. A neutral earthing connection must also be provided on the consumer's generating plant so that it can be run earthed when disconnected from the Board's system and unearthed when operating in parallel with that system. In normal circumstances, the power factor at which the plant is operating must not be less than an agreed figure.

### HIGH-VOLTAGE GENERATORS.

When the voltages at which the consumer's machines generate and at which a supply is given by the Board are the same, the consumer must provide a neutral earthing resistance and neutral earthing switch, so that the generating plant can be earthed when operating individually and unearthed when it is running in parallel with the mains. As, however, a high-voltage system must not be earthed at more than one point, the consumer's generating plant must normally be brought up to voltage with its neutral switch closed, synchronisation carried out and the switch opened. Arrangements must also be made so that the neutral switch is closed if the factory is disconnected from a Board's system.

If an earth fault occurs on a main which is being operated in parallel with private plant, the line, while becoming isolated from the system, may yet be alive. The private plant and installation it is supplying will then be operated with one phase earthed. To ensure that this dangerous condition does not persist, a voltage transformer must be connected across the neutral switch of the generators in the private plant with its secondary arranged so that a relay is energised and the neutral switch closed. The earth leakage protection on the incoming line from the mains will then open the switch on the consumer's premises and disconnect the faulty line.

Parallel running between the mains and private plant renders it essential for the consumer to provide satisfactory synchronising apparatus and to ensure that the breaking capacity of his switchgear is sufficient to deal with the sum of the fault current from the two sources of power. The governor characteristics must also be such that the private plant will operate satisfactorily in parallel with the Board's system.

It is further essential to ensure that the private plant is disconnected from the Board's system in the event of a persistent fault either on that system or the works installation. If the capacities of the Board's connection and the private generator are about equal, this can be effected by using simple automatic overload and earth leakage relays. These relays must, however, be installed on the switch connecting the two systems, as well as on those controlling the consumer's generator and circuits. On the other hand, where there is considerable disparity between the loads supplied by the Board and the consumer's generating plant, automatic devices of the reverse power type may have to be installed on one or more of the switches to ensure that the consumer's plant will not be shut down by a fault on the Board's system. When a consumer desires to export to the Board's system, heavier cables and switchgear than would otherwise be necessary may have to be installed.

### INDUCTION GENERATORS.

Although induction generators are simple to operate in parallel with other plant or with the mains which can provide the magnetising current, this supply may be at a very low power factor. Some special adjustment will therefore be necessary to meet the abnormal costs. Condensers could, of course, be installed by the consumer, but this would be an unnecessary complication.

Although the requirements laid down in this article for parallel running may seem complicated, they are essential, as are the provisions which are necessarily insisted upon in the agreement to implement them, for the expensive plant which goes to make up a public supply system must be adequately protected and the lives of the operators effectively safeguarded.

# INFLUENCE LINES FOR SUPPORT MOMENTS IN CONTINUOUS BEAMS.

By R. C. COATES, B.Sc.(Eng.), A.M.I.C.E., A.M.I.Mech.E.

THE use of "factors of constraint" may lead to considerable simplification in some cases of structural analysis. In the process of moment distribution, it is customary to define the stiffness of a beam in terms of the second moment of area of the cross section, I, about its neutral axis and the length L. Thus the stiffness of a beam A B is $\frac{I}{L}$ if the beam be fixed at B, and $\frac{3}{4}\frac{I}{L}$ if pinned, or otherwise simply supported at B. It has been suggested, therefore,* that the stiffness of a beam be represented as K V, where K is the ratio $\frac{I}{L}$, and V some "constraint factor" varying from 0·75 to 1, and dependent on the type of constraint provided by fixing, or continuity at its far end. In this case, the moment at the end of the beam required to produce unit rotation at that end will be 4EKV. Since carry-over from a rotating to a clamped end is also dependent on the degree of restraint, being 0·5 for a fixed end and zero for a pinned end, it will be expected that some relationship between the carry-over and constraint factors may be determined. It should be stressed that both carry-over and constraint factors are directional in nature and that the factors operative in the direction A to B, in the beam AB, are not necessarily identical with those in the direction BA.

In any structure, be it a rigid frame or a continuous beam, the beam ends, or feet, are assumed

* *Theory of Modern Steel Structures*, by L. E. Grinter, vol. II (revised), page 159. The Macmillan Company, New York (1949).

# INFLUENCE LINES FOR CONTINUOUS BEAMS.

Fig. 1.

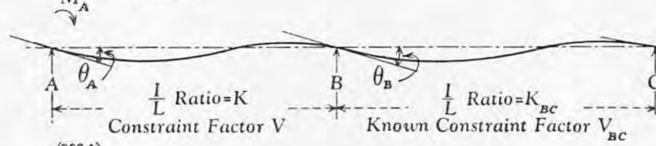



Fig. 2.

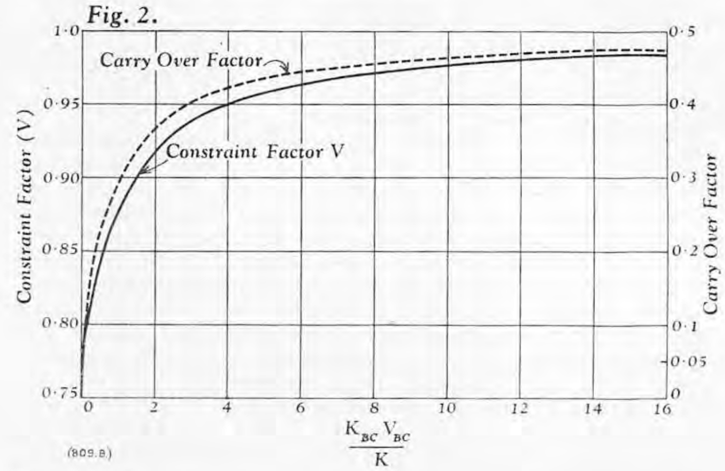



Fig. 3.

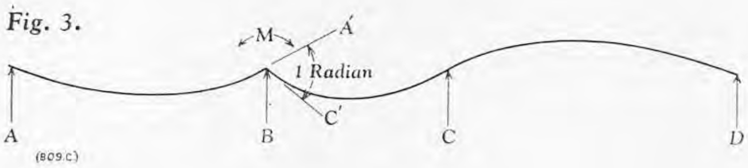



Fig. 4.

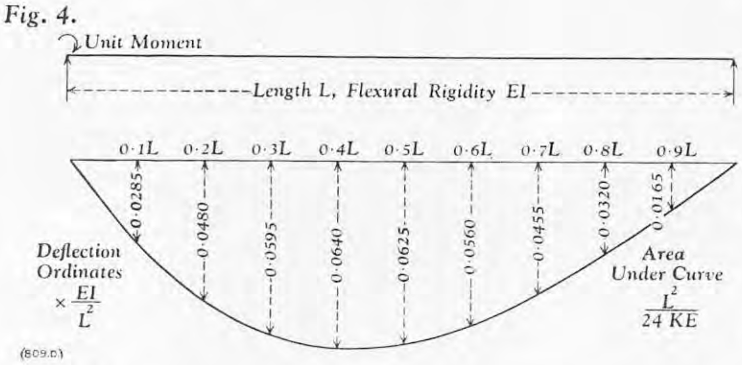



Fig. 5.

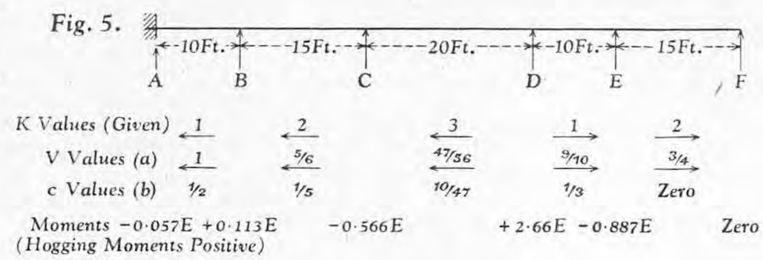
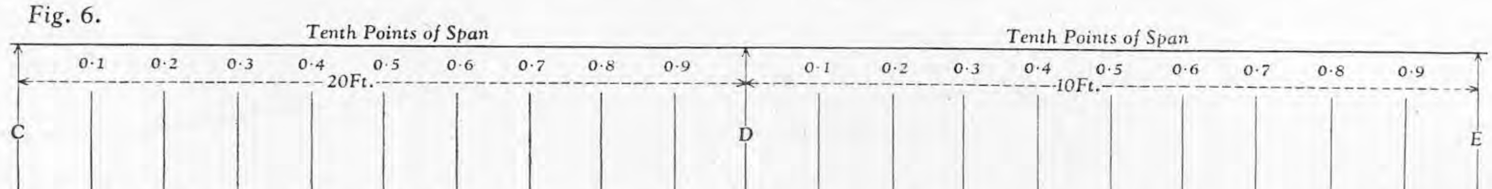



Fig. 6.




| | C | 0·1 | 0·2 | 0·3 | 0·4 | 0·5 | 0·6 | 0·7 | 0·8 | 0·9 | D | 0·1 | 0·2 | 0·3 | 0·4 | 0·5 | 0·6 | 0·7 | 0·8 | 0·9 | E |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (d) | 0 | −0·106 | −0·178 | −0·221 | −0·237 | −0·242 | −0·208 | −0·169 | −0·119 | −0·061 | 0 | 0·758 | 1·278 | 1·582 | 1·702 | 1·662 | 1·490 | 1·210 | 0·851 | 0·438 | 0 |
| (e) | 0 | 0·292 | 0·568 | 0·807 | 0·993 | 1·109 | 1·135 | 1·056 | 0·851 | 0·505 | 0 | −0·146 | −0·284 | −0·405 | −0·496 | −0·554 | −0·568 | −0·528 | −0·425 | −0·253 | 0 |
| (f) | 0 | 0·186 | 0·390 | 0·586 | 0·756 | 0·867 | 0·927 | 0·887 | 0·732 | 0·444 | 0 | 0·612 | 0·994 | 1·177 | 1·206 | 1·108 | 0·922 | 0·782 | 0·426 | 0·185 | 0 |

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to be either free or encastré. The V-values of such members are known, therefore, and it is necessary to determine constraint factors in other spans by working "inwards" from these known values.

Consider the structure shown in Fig. 1, herewith, in which a moment $M_A$ is applied to the end A of a beam A B, $\left(\frac{I}{L}\text{ ratio} = K\right)$, continuous with a beam B C of $\frac{I}{L}$ ratio $= K_{BC}$ and known constraint factor $V_{BC}$. Using the slope-deflection equations

$$M_{AB} = 2\,E\,K\,(2\,\theta_A + \theta_B) = 4\,E\,K\,V\,\theta_A \quad . \quad (1)$$

$$M_{BA} = 2\,E\,K\,(\theta_A + 2\,\theta_B) \quad . \quad . \quad . \quad . \quad (2)$$

$$M_{BC} = 2\,E\,K_{BC}\,(2\,\theta_B + \theta_C) = 4\,E\,K_{BC}\,V_{BC}\,\theta_B. \quad (3)$$

Since

$$M_{BA} + M_{BC} = 0,\ \theta_B = \frac{-K\,\theta_A}{2\,(K_{BC}\,V_{BC} + K)}$$

and by substitution in (1)

$$V = \frac{\frac{K_{BC}\,V_{BC}}{K} + \frac{3}{4}}{\frac{K_{BC}\,V_{BC}}{K} + 1} \quad . \quad . \quad . \quad (4)$$

The carry-over factor, $c$, say,

$$= \frac{M_{BA}}{M_{AB}} = \frac{\frac{2\,K_{BC}\,V_{BC}}{K}}{\frac{4\,K_{BC}\,V_{BC}}{K} + 3}$$

and from this it may be shown that

$$c = \frac{4\,V - 3}{2V} \quad . \quad . \quad . \quad (5)$$

These values may be readily calculated, but, for convenience, are plotted in Fig. 2, herewith, the values of V and $c$ being shown as ordinates against the ratio $\frac{K_{BC}\,V_{BC}}{K}$ as abscissa.

Müller-Beslau's theorem states that the influence line for any effect is the deflected shape of the structure produced by the appropriate unit distortion, e.g., the influence line for horizontal thrust in an arch may be obtained by moving one of the feet through a horizontal distance of unity. The influence line for bending moment at the support B, of the continuous beam A B C D (Fig. 3) may be produced, as shown thereon, by applying equal and opposite moments to the beams B A and B C, such that angle A'B C' is one radian. Using the previous notation

$$M_{BA} = 4\,E\,K_{BA}\,V_{BA}\,\theta_{BA},\ M_{BC} = 4\,E\,K_{BC}\,V_{BC}\,\theta_{BC}$$
$$\text{and } -\theta_{BA} + \theta_{BC} = 1.$$

The required rotations are thus given by

$$\theta_{BA} = \frac{K_{BC}\,V_{BC}}{K_{BC}\,V_{BC} + K_{BA}\,V_{BA}}$$

and

$$\theta_{BC} = \frac{K_{BA}\,V_{BC}}{K_{BC}\,V_{BC} + K_{BA}\,V_{BA}},$$

the required moment being

$$\frac{4\,E\,K_{BA}\,V_{BA}\,K_{BC}\,V_{BC}}{K_{BC}\,V_{BC} + K_{BA}\,V_{BA}}.$$

The carry-over factors for the various spans may be calculated from the formula given previously and the moments produced at each support may thus be obtained. The required deflected shape of the beams between supports may be best obtained by proportion from the diagram given in Fig. 4, which records the deflection ordinates of a beam produced by unit moment at the left-hand end. A mirror image of the same diagram shows the same effect for unit moment at the right-hand end and the resulting quantities may be added, since the principle of superposition here applies.

As an example of the method, Figs. 5 and 6, herewith, exhibit the successive steps in constructing the influence line for the moment at support D of the continuous beam A B C D E F. The meaning and method of computing the various sets of quantities may be summarised in the following manner.

(*a*) Constraint factors: calculated from equation (4) or Fig. 2 for known values in the end spans, working in the direction opposite to that of the arrows.

(*b*) Carry-over factors: obtained from equation (5) or Fig. 2, the arrows showing the direction of carry-over.

(*c*) Moment at D: derived from equation (6), appropriate carry-over factors being used to obtain the moments at the other supports.

In Fig. 6, the ordinates of the elastic line are calculated from the moments given by Fig. 5, where, for brevity of working, only the spans C D and D E are considered.

(*d*) Product of moment at the left-hand end of each span times the coefficient of the deflection at each point, taken in turn, times $\frac{L}{E\,K}$.

(*e*) Product of moment at the right-hand end of each span times the coefficient of the mirrored deflection at each point, taken in turn, times $\frac{L}{E\,K}$.

(*f*) The algebraic sum of (*d*) and (*e*) above, giving the true value of the ordinate of the influence line.

The influence line may be used directly when any one span is covered, using the principle of superposition. The area of the deflection curve due to unit moment at one end of a span is $\frac{L^2}{24\,E\,K}$ (see Fig. 4). The effect, then, on moment at D, produced by unit intensity distributed load on the span D E is given by:

area of unit-deflection curve × (algebraic sum of end moments),

$$= \frac{L^2}{24\,E\,K}\,(2{\cdot}66\,E - 0{\cdot}887\,E)$$

$$= \frac{L^2}{K}\ \frac{1{\cdot}773}{24} = 7{\cdot}4\text{ ft. units.}$$

# THE MEASUREMENT OF STRIP TENSION IN TANDEM MILLS.

By R. B. SIMS, B.Sc., A.M.I.Mech.E., A.Inst.P.

IT has become accepted practice to apply tension to strip metal during cold reduction in a rolling mill in order to improve the shape of the product. In mills fitted with small work rolls, heavy front tension is often essential to avoid skidding between the rolls and the strip. Apart from changes in shape which take place as tensions are increased, it has been shown that the load on the rolls and the thickness of the rolled strip are diminished.* When a mill is set up for a production run to a given schedule of strip gauges, there are obvious advantages, therefore, in maintaining the strip tensions at a constant value below the breaking load of the strip. While a rough estimate of tension may be obtained from the current in the armatures of the reel motors of single-stand mills, there is no simple means of determining the tension between the stands of a tandem mill from the characteristics of the electric drive. There is, therefore, a requirement for an instrument which will give a reliable indication of inter-stand tension.

An estimate of tension may be obtained from the force exerted on a roller axially parallel with the work rolls of a mill and arranged to deflect the strip from its normal pass-line. The arrangement is shown diagrammatically in Fig. 1, herewith, for mills in tandem, and is typical of the majority of inter-stand tensiometers in use at present.

An indication of strip tension may be obtained from the measurement of roll force or roll torque or forward slip, but the relationships between these variables and the strip tension are dependent in a complex way on the rolling conditions, so that any indication of a practical instrument based on the measurement of any one of these variables could have only qualitative significance.

The deflection-roller principle has been used in the present design of tensiometer. Before discussing its construction, the equations to the deformation occurring in the strip as it passes over the roller will be derived, and used to determine the dimensions of the apparatus.

### THE BENDING OF A STRIP UNDER TENSION.

In the simple theory of pure bending, the neutral plane is defined by the property $\sigma_\theta = 0$, where $\sigma_\theta$ is the longitudinal stress in the strip. If the strip is rectangular in section, and the origin of the co-ordinates is in its central plane with the $y$ axis normal to the surface, then, for horizontal equilibrium in an elastically deformed strip of thickness $h$,

$$\int_{-\frac{h}{2}}^{\frac{h}{2}} \sigma_\theta \, dy = 0.$$

When a strip is bent over a roller with tension T per unit width applied to it, the neutral plane is displaced from the origin by an amount $\frac{h\,m}{2}$, where $0 < m < 1$, and for equilibrium

$$\int_{-m\frac{h}{2}}^{\frac{h}{2}} \sigma_\theta \, dy - \int_{-\frac{h}{2}}^{-\frac{m\,h}{2}} \sigma_\theta \, dy = \mathrm{T}. \quad . \quad . \quad (1)$$

The solution of this equation depends on the mode of deformation of the strip; and the cases of purely elastic distortion, deformation of an ideally plastic material, and a material which strain hardens may be distinguished.

When the deformation of the strip is purely elastic, the longitudinal strain at any point distant $y'$ from the neutral plane is $e_\theta = \frac{y'}{\mathrm{R}_n}$, where $\mathrm{R}_n$ is the radius of curvature of the neutral plane. If E is the modulus of elasticity of the strip material, $\sigma_\theta = \frac{\mathrm{E}y'}{\mathrm{R}_n}$ and from equation (1)

$$\mathrm{T} = \frac{\mathrm{E}\,h^2 m}{2\mathrm{R}_n}, \quad . \quad . \quad . \quad . \quad (2)$$

and the maximum strain in the strip is

$$e_{\text{max.}} = \frac{h\,(1+m)}{2\,\mathrm{R}_n}. \quad . \quad . \quad . \quad (3)$$

If the material is a non-strain-hardening plastic-rigid material, the yield strength of which in plane strain is $k$, there is no elastic deformation and

$$\mathrm{T} = k\,h\,m \quad . \quad . \quad . \quad (4)$$

Since the deformation is plastic, the strip will elongate on the side distant from the roller as bending takes place, and, conversely, elongation will occur on the side adjacent to the roller as the strip is straightened after leaving the roller. No deformation occurs in the portion of the strip in contact with the roller.

When the strains in the strip are small, the strain at any point in the strip after the initial bending round the roller is, to a first approximation,

$$e_1 = \frac{1}{\mathrm{R}_n}\left(y + \frac{h\,m_1}{2}\right), \quad . \quad . \quad (5)$$

and the strain in the strip after straightening is complete is

$$e_2 = \frac{1}{\mathrm{R}_n}\left(y + \frac{h\,m_2}{2}\right), \quad . \quad . \quad (6)$$

where $\mathrm{R}_n$ is now the radius of curvature of the neutral plane when the strip is in contact with the roller, and tension stresses and strains are taken as positive.

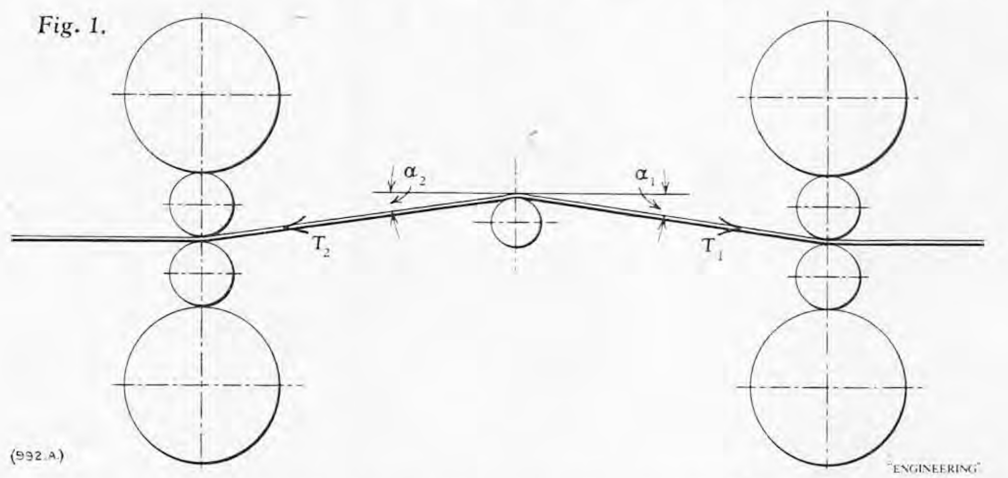



Fig. 1.

When the tensions applied to the strip on either side of the roller are equal, the total elongation per unit length of the strip, from equations (5) and (6), is

$$e_1 + e_2 = e \simeq \frac{h\,m}{\mathrm{R}_n}, \quad . \quad . \quad (7)$$

and is constant through the thickness of the strip.

On combining equations (7) and (4), the approximate relationship between the applied tension and the strain in the strip is

$$e = \frac{\mathrm{T}}{k\,\mathrm{R}_n} \quad . \quad . \quad . \quad (8)$$

an equation first derived by Swift.* The relationship between the applied tension and the elongation when the strip strain-hardens will not be given here. It has been derived in an approximate form by Swift and is compared below with the experimental results. The effect of strain-hardening may also be allowed for by assuming a mean value of the yield stress, $\bar{k}$, in equation (8).

The work $\delta w$ done in bending a small element of the plastic-rigid strip of unit length and width, and of thickness $\delta y$, is $\delta w = k\,e_1\,dy$, and the total work done on the first bend, per unit length, is

$$w_1 \simeq \frac{k\,h^2}{4\mathrm{R}_n}\left(1 + \frac{t_1^2}{k^2}\right),$$

where $t_1$ is the applied tensile stress in the strip approaching the roller.

If $t_2$ is the stress applied to the strip as it leaves the roller, and then for small strains, the work done in straightening per unit length is

$$w_2 \simeq \frac{kh^2}{4\mathrm{R}_n}\left(1 + \frac{t_2^2}{k^2}\right)$$

The total work done per unit volume in taking the strip over the roller is, to a first approximation,

$$\mathrm{W} \simeq \frac{k\,h}{2\,\mathrm{R}_n}\left(1 + \frac{\bar{t}^2}{k^2}\right) \quad . \quad . \quad (9)$$

where $\bar{t} = \frac{1}{2}(t_1 + t_2)$ the mean tension applied to the strip.

When the deformation occurs in plane strain, the work done on the strip per unit volume is

$$\mathrm{W} = t_1 - t_2 \quad . \quad . \quad . \quad . \quad . \quad (10)$$

when it is assumed that the roller over which the bending takes place rotates freely in its bearings. Combining equations (9) and (10),

$$t_1 - t_2 = \frac{kh}{2\mathrm{R}_n}\left(1 + \frac{\bar{t}^2}{k^2}\right) \quad . \quad (11)$$

for the ideal plastic-rigid material.

### EXPERIMENTAL DETAILS AND RESULTS.

The deformation due to bending under tension has been investigated using the apparatus shown in Figs. 2 and 3, opposite. It consists essentially of two guide rollers, 4 in. in diameter, which lead the strip through an 85-deg. bend over a roller (to be seen in the centre of Fig. 2) $\frac{3}{8}$ in. in diameter. The rollers were supported in ball bearings. The apparatus was attached to the housings of the experimental mill of the British Iron and Steel Research Association (B.I.S.R.A.). The strip was taken from the drag coiler, through the roller assembly and then to the wind coiler. The tensions, up to 4 tons, were applied to the strip at speeds ranging from 10 ft. to 100 ft. per minute. The strip used was annealed mild steel, initially 0·063 in. thick and $3\frac{1}{2}$ in. wide, in coils initially about 300 ft. long. The yield stress-strain characteristics of the material in plane compression are shown in Table I, herewith. These data were obtained by a method similar to that described by Ford.*

TABLE I.—*Yield Stress-Strain Characteristics of Metal in Plane Compression.*

| Reduction in thickness, per cent. | 0. | 10. | 20. | 30. | 40. | 50. | 60. |
|---|---|---|---|---|---|---|---|
| $k$ tons per sq. in. | 11·6 | 29·8 | 36·8 | 41·1 | 44·0 | 46·2 | 47·8 |

The experimental results are shown in Fig. 4, opposite, as reduction in thickness $r$ against the parameter $\frac{\bar{t}}{\bar{k}}$, where $\bar{k}$ is the mean yield strength in plane compression over the range of deformation of the strip. The theoretically-derived relationship between the deformation in the material and the applied tension, shown in this figure, has been calculated from the equation:

$$e = \frac{r}{1-r} = \frac{h}{\mathrm{R}_n}\left(\frac{\bar{t}}{\bar{k}}\right) \quad . \quad (12)$$

The agreement between the experimental results

* "The Principles of Continuous Gauge Control in Sheet and Strip Rolling," by W. C. F. Hessenberg and R. B. Sims, *Proc. I.Mech.E.*, vol. 166, page 75 (1952).

* "Plastic Bending under Tension," by Professor H. W. Swift. 7th International Congress of Applied Mathematics, Sept., 1948.

* "Researches into the Deformation of Metals by Cold Rolling," by Dr. H. Ford. *Proc. I.Mech.E.*, vol. 159 page 115 (1948).

# MEASUREMENT OF STRIP TENSION IN TANDEM MILLS.

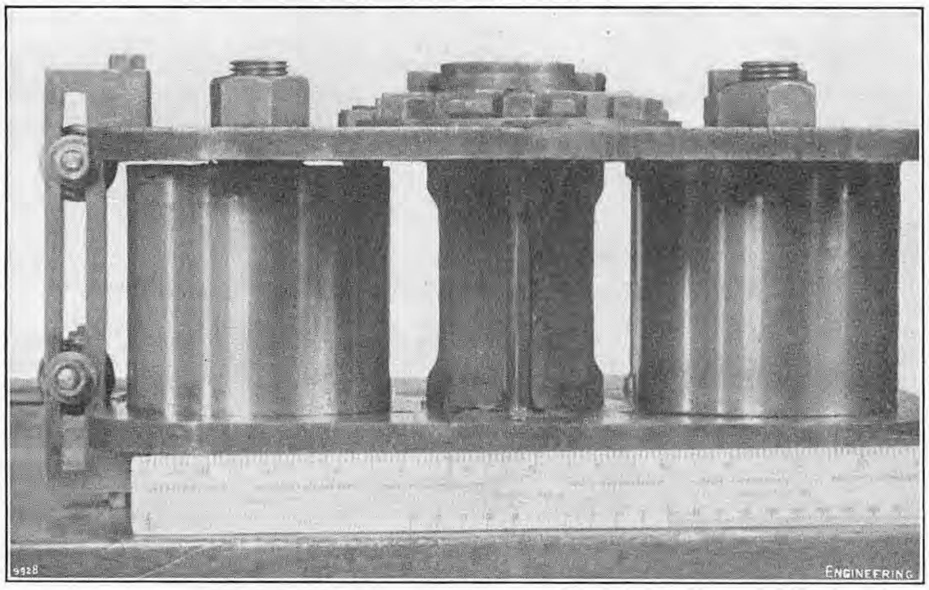


FIG. 2.

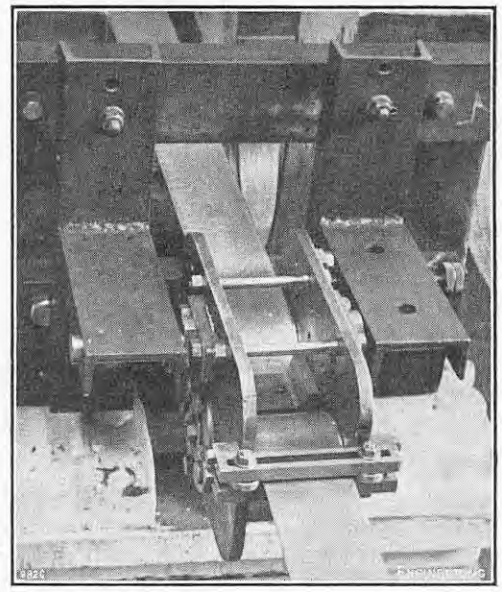


FIG. 3.

FIGS. 2 AND 3. APPARATUS FOR INVESTIGATING DEFORMATION DUE TO BENDING UNDER TENSION.

and calculation is considered satisfactory in view of the approximations made in deriving the theory.

In Table II, herewith, the calculated values of $t_1 - t_2$, from equation (11), are shown against the measured values; here also, there is reasonable agreement between experiment and theory.

TABLE II.—*Values of* $t_1 - t_2$.

| $\frac{\bar{t}}{k}$ | Calculated $t_1 - t_2$ from equation (11). | Measured $t_1 - t_2$. |
|---|---|---|
| | Tons in.$^{-2}$ | Tons in.$^{-2}$ |
| 0 | 1·9 | 1·7 |
| 0·2 | 3·2 | 3·2 |
| 0·4 | 4·5 | 4·8 |
| 0·6 | 5·8 | 5·4 |
| 0·8 | 7·2 | 6·4 |

### THE DESIGN OF A TENSIOMETER.

The load on the deflecting roller shown in Fig. 1 is

$$F = B\,(T_1 \sin \alpha_1 + T_2 \sin \alpha_2) \quad . \quad . \ (13)$$

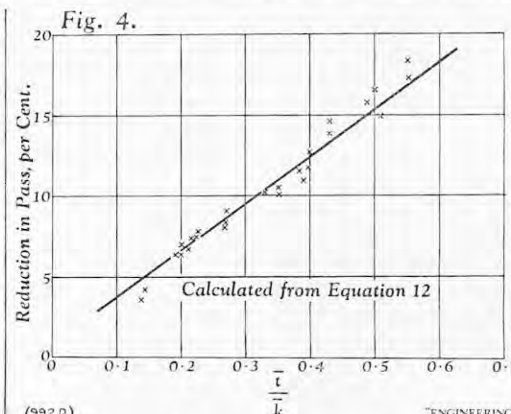
where $T_1$ and $T_2$ are the tension forces per unit width on either side of the roller, B is the strip width and $\alpha_1$ and $\alpha_2$ are the angles of contact with the strip. If it is assumed that the tensions applied to the strip on each side of the roller are equal, they may be calculated from a knowledge of the angles $\alpha_1$ and $\alpha_2$ and the force, F, on the roller.

From equation (11), it will be seen that the tension $T_1$ is equal to $T_2$ only when the deformation in the strip is elastic. If $t$ denotes the tensile stress in the strip before and after bending, and $k$ its yield stress in plane compression, then, from equations (2) and (3), for the deformation to be entirely elastic during bending,

$$\frac{h}{2R_n} \leqslant \frac{k}{E}\left(1 - \frac{t}{k}\right).$$

As an example, suppose that $\frac{t}{k} = 0{\cdot}75$ and $\frac{k}{E} = 0{\cdot}0025$—both values commonly found when cold-rolling steel—then, for strip 0·1 in. thick, the diameter of the measuring roller must be greater than 160 in. to ensure that only elastic deformation takes place; and, for strip 0·01 in. thick, the roller must be greater than 16 in. in diameter. These values would be increased considerably for annealed strip of similar dimensions.

It is not practicable to put rollers of this diameter in the pass-line of production mills, and if rollers of smaller diameter are used, plastic deformation will occur and there will be a difference in tension in the strip on either side of the measuring roller. The diameter of the measuring roller may be




calculated from the equations derived above, when the maximum allowable deformation in the strip and the errors in the measurement have been established.

When the difference in the tension stresses on either side of the measuring roller, $t_1 - t_2$, is denoted by $\Delta t$, equation (11) becomes

$$\frac{\Delta t}{\bar{t}} = \frac{1}{2}\,\frac{k\,h}{\bar{t}\,R_n}\left(1 + \frac{\bar{t}^2}{k^2}\right) \quad . \quad . \ (14)$$

If the tensiometer is designed so that $\alpha_1 = \alpha_2$, then, from equation (13), the load on the roll will be proportional to the mean stress, $\bar{t}$, applied to the strip. The stress $t_1$ will then be overestimated and the tension $t_2$ underestimated by the tensiometer, the fractional error being $\frac{1}{4}\,\frac{kh}{\bar{t}R_n}\left(1 + \frac{\bar{t}^2}{k^2}\right)$.

With $h = 0{\cdot}10$, $\frac{\bar{t}}{k} = 0{\cdot}75$, and a roller diameter of 8 in. the error in measurement due to the work of deformation will be 1·3 per cent., and the strip will be strained by 1·67 per cent., approximately, as it passes over the measuring roller. Both the error in measurement and the strain in the strip will decrease proportionately with the strip thickness.

(*To be continued.*)

SUSSEX INDUSTRIES EXHIBITION.—The 7th Sussex Industries Exhibition and Trade Fair will be held at the Corn Exchange, Church-street, Brighton, from Wednesday, September 17, to Saturday, September 27, both dates inclusive. A number of local firms manufacturing light engineering products will be among the exhibitors. The exhibition will be open daily, from 11 a.m. to 9 p.m., and is being promoted by the Federation of Sussex Industries, 32, Duke-street, Brighton, 1, from whom further information is obtainable.

# EXPANSION OF THE INTERNAL-COMBUSTION ENGINE INDUSTRY.

THE annual British output of internal-combustion engines, excluding engines for air and road transport, and marine engines of more than 1,500 brake horse-power, increased, between 1948 and 1951, from 2,500,000 to 4,500,000 brake horse-power. These figures give some idea of the large post-war expansion of the industry. How this has been achieved is described in a statement issued by the Anglo-American Council on Productivity, of which extracts are given below.

It is nearly two and a half years (according to the statement) since the Internal Combustion Engine Productivity Team went to the United States and almost two years since the publication of its report. The post-war period has seen great changes in the industry. Even more than in other industries, it is difficult to disentangle the influence of the Team's report from that of the general reorganisation of the industry and the expansion of certain individual companies which has been taking place, particularly in the last five years or so. This reorganisation is broadly on the lines of the report's recommendations and the report has been widely discussed throughout the industry, yet its suggestions have been too elementary for some manufacturers of smaller engines, who look rather to the methods of the British and American automobile industries than to those of the American internal-combustion engine industry. At the same time, the suggestions have been too radical for other manufacturers who prefer to continue the age-old British tradition of craft engineering, although even among such companies the report has caused reconsideration of lay-out and handling methods. As in other industries, the American visit and the report have led to a new freshness in approach to old problems.

The internal-combustion engine industry in Britain suffered severely in the world slump of 1929-31 because it has always been largely dependent on exports. During the last 20 years, however, it has grown steadily because of the expansion in the use of Diesel engines, the world-wide mechanisation of agriculture and the establishment of new factory power units in many industries. British direct exports of internal-combustion engines have increased in value from 3,400,000*l*. in 1938 to 25,000,000*l*. in 1951. When engine parts are included, this figure of direct exports in 1951 is increased to 33,000,000*l*. It is less easy to calculate the value of indirect exports, since these engines are incorporated in so many different items of equipment which are sent abroad but for which the value of the engine portion is not separately recorded in the *Trade and Navigation Accounts*. However, the total of indirect exports of internal-combustion engines is estimated to have increased in value from about 3,000,000*l*. in 1947 to about 8,500,000*l*. in 1951. The total value of direct and indirect exports for 1951 can be assessed at over 41,000,000*l*. The industry is still expanding rapidly and a bigger market is now available, for example, in providing engines for Diesel locomotives.

The report came in the middle of post-war rationalisation in the industry, which still continues. There is a trend towards larger manufacturing units and to amalgamation and association between companies, and this has led both to a reduction in the number of independent concerns and to increased simplification of the range of products in the individual factory. Most of what is now happening in the industry results from this trend; it is now stabilising itself after a period of rapid expansion. A notable event in the affairs of the industry since the war has been the rapid growth of the Brush Aboe group of companies, particularly in the number of units included in the group. The expansion of the Brush Aboe group was, of course, well under way when the team went to America, but the team visit has been of value in assisting the progress of the companies concerned. The same can be said of the Lister and Blackstone companies, as of many others.

Reorganisation, re-equipment and increases in output and productivity have taken place in a large number of companies in the industry. The report has clearly dotted the "i's" and crossed the "t's" of the plans of all the major producing units in the country. It has assisted development, although it has not initiated as much as, for example, the steelfounding or drop-forging reports. This is not because the team recorded or recommended less, but largely because, in the major part of the industry, the way ahead was already clear. There are sections of the industry where the report seems to have been presented to deaf ears, but these are the sections less likely to survive the present process of rationalisation and the increasing competition in foreign markets arising from renewed German and Japanese competition. American methods of flow-line production are more applicable to the makers of smaller and medium-sized engines than to makers of larger engines, which have to be erected rather than assembled. The team's report devoted comparatively little space to the manufacture of large engines in the United States, since its itinerary was not arranged to cover this field.

### Increases in Productivity.

Most of the firms in the industry have increased output, and a large number of companies have increased their productivity since the war, some greatly. As in many other industries, it is not an easy matter to arrive at proper and accurate comparisons of productivity between companies, nor frequently even within one company at different periods. Not only is the product not uniform in either size or type—that is, unless care is taken, oranges can be counted as apples—but also the labour force in one plant may include a wider range of classes of tradesmen than that in another, or may be different because one concern covers a more complete range of production operations than another. For example, in the internal-combustion engine industry some companies control what are basically assembling plants and buy a large proportion of parts from outside works; whereas others produce all components themselves, including even crankshafts and fuel-injection equipment. The figures given below only have meaning within the context of the company referred to; and even then they may not provide statistically accurate comparison. They certainly cannot be used for comparison between companies. It is difficult to find a unit of production which is completely unobjectionable. Value and quantity are often meaningless as measures of output; brake horse-power units, though sometimes misleading, are frequently taken as the units of output for this industry. All the figures given below, however, are quoted because they do give some indication of the size and import of the changes being made in the industry. They cannot, however, be considered as statistically sound measures of productivity; none has yet been devised.

British Polar Engines, Limited, have doubled production in the last five years, with little increase in the labour force, as a result of reorganisation and the installation of new machinery. Crossley Brothers, Limited, report that output has trebled since 1947 with a comparatively small increase in personnel. At Davey, Paxman and Company, Limited, output of connecting rods and big-end bearings has been quadrupled in the last few years by setting up a specialist department and tooling up a range of machines for machining these major engine components. The factories of R. A. Lister and Company, Limited, and Blackstone and Company, Limited, have been entirely re-planned and new plant has been installed which has considerably increased the entire production of these firms, including Diesel and petrol industrial and marine engines, and Diesel-electric generating plant. Mirrlees, Bickerton and Day, Limited, have expanded output to a very great extent since the war, and particularly since 1949. The output, measured in brake horse-power, has increased from 50,000 in 1946 to 210,000 in 1950, while total man-power, including indirect labour, in the same period, increased from some 625 to 1,200.

The National Gas and Oil Engine Company have increased their output, measured in brake horse-power, from 60,000 in 1947 to 200,000 in 1951, with an increase in total man-power from 1,600 to 2,500. This increase in output has been achieved by purchasing some parts, such as pistons, gudgeon pins, etc., outside. F. Perkins, Limited, have steadily increased output per man since 1932. From 1946 to 1951, this company increased its output, measured in brake horse-power, from 229,000 to 2,125,000. At Petters, Limited, the output was 300 cylinders a week before the war, 100 immediately after the war, 800 in 1948 and 2,000 now; engine output has expanded correspondingly with nothing like an equivalent increase in man-power. The average standard hours per engine produced have been decreased from 37 in 1949 to 31·2 in 1951. One of the main factories of Ruston and Hornsby, Limited, which produces oil engines, has more than doubled its output with a very small increase in personnel since the beginning of 1947. Four years ago this firm was producing 100 cylinders of one engine size a week, and is now producing some 300 to 400 with completely new layouts provided to reduce the labour on the assembly line.

### Action by B.I.C.E.M.A. and the Industry.

Two of the recommendations made by the team concerned issues on which this industry cannot itself take action: that on the need for simplification of the wage structure in the engineering industries and that on taxation. Other reports have referred to the wage structure in engineering, but its simplification is a matter of negotiation. Some progress has been made, particularly in the establishment of a consolidated rate for time workers, which is used also for the computation of overtime, night-shift and holiday premiums of both time workers and payment-by-result workers. Direct taxation of individuals was reduced in the recent Budget with the declared object of increasing incentives.

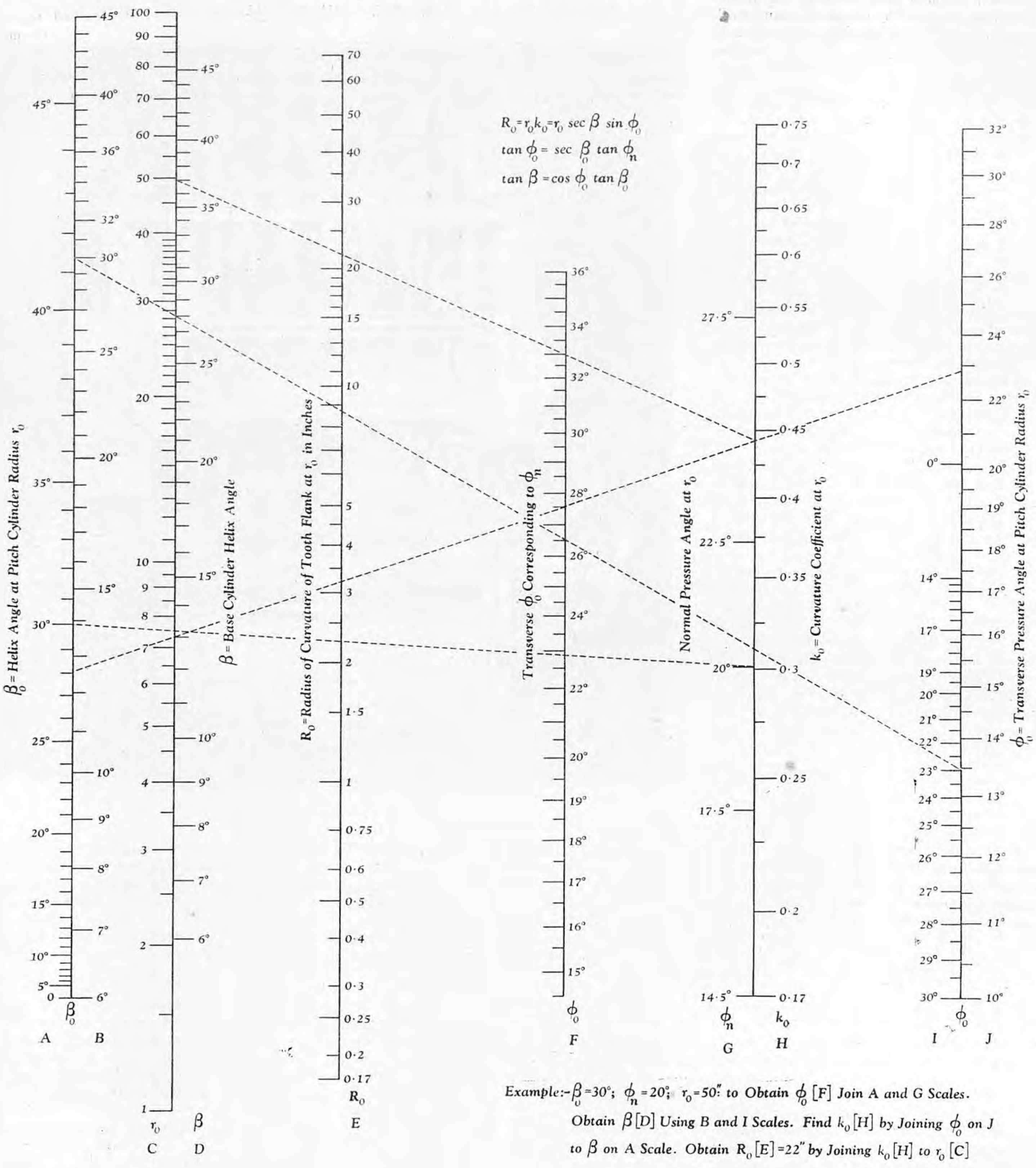
A number of other recommendations lent themselves to action by the trade association. B.I.C.E.M.A. produced a detailed report in 1950 for the Ministry of Supply on the inadequate supply of machine tools for the industry. The report was based on a factual investigation made by the special steering committee set up by B.I.C.E.M.A. Council. It emphasised the urgent need of increasing the number of machine tools available to firms in this country. Most internal-combustion engine manufacturers had then, and have since, suffered because of the difficulty in obtaining British machine tools, especially boring mills. One company has had to make bed-borers for horizontal engines in its own tool-room. Many have had to obtain secondhand machines or machines from Germany, Italy, France or Switzerland, at prices frequently twice the British prices. The supply of machine tools is vital for the industry and for the increase of productivity; indeed, much of the report was devoted to description of modern machine tools and tooling methods. The situation has not improved greatly since 1950, partly because of the shortage of steel and the demands of rearmament.

Another factual report was made for the Ministry of Supply by B.I.C.E.M.A. in 1951, on the important subject of crankshaft supply for internal-combustion engines. It was based on a questionnaire to members on their requirements of solid-forged, drop-forged and cast-iron crankshafts. The capacity in this country for forging and machining of crankshafts was inadequate for an expanding industry. The construction of a forging plant has been considered by B.I.C.E.M.A. but decided against; one of the larger companies has considered constructing its own forge. Details of requirements in the years 1952 and 1953 have been supplied to both the solid-forging and drop-forging industries.

The widespread reorganisation that is going on in many companies has been encouraged by the team's report and it is largely in line with the team's recommendations. The main changes that are being made in the industry are simplification in the range of production and alterations in the layout of machine and assembly shops or in the siting of departments in order to improve the flow-line of production. Simplification was in progress before the team's visit and has been accelerated since. For example, Blackstone and Company, Limited, have reduced the number of horizontal types produced from 22 to 6 since 1936; Davey, Paxman and Company, Limited, have cut down the number of models produced from 22 to 4 since 1948; the National Gas and Oil Engine Company have cut their range from 30 to 14 models of engines since the war; R. A. Lister and Company, Limited, have limited their range to three main types instead of 12, and one of their subsidiary companies is concentrating on one model only. Mirrlees, Bickerton and Day, Limited, are now concentrating on two main models which have been designed and brought into production since 1946; Petters, Limited, have, since 1948, concentrated on two main models of both Diesel and petrol engines. Ruston and Hornsby, Limited, plan to manufacture basically standard engines to which non-standard parts can be added as required; whereas some other companies, such as F. Perkins, Limited, and Stuart Turner, Limited, have always specialised within narrow limits. The statement then gives a number of instances of improved layout, etc., several of which have been described in ENGINEERING.*

* Blackstone & Co., Ltd., vol. 172, page 23 (1951); British Polar Engines, Ltd., vol. 171, page 98 (1951); R. A. Lister & Co., Ltd., vol. 169 page 10 (1950) and vol. 173, page 647 (1952); National Gas & Oil Engine Co., Ltd., vol. 173, page 584 (1952); F. Perkins, Ltd., vol. 169, page 699 (1950); and Petters, Ltd., vol. 172, page 747 (1951).

## MEAN RADIUS OF CURVATURE OF HELICAL TOOTH FLANKS.




# NOMOGRAM FOR MEAN RADIUS OF CURVATURE OF HELICAL TOOTH FLANKS.

By N. J. C. PERES.*

ONE of the curvatures of the involute helicoidal tooth surface at any point is called the first curvature of the surface and is constant along the helix through the given point. It is, in fact, the divergence of the unit surface normal at the point. The mean curvature for a helical gear tooth flank may be considered to be the first curvature of the surface along the pitch-cylinder helix. Its reciprocal is called the radius of mean curvature $R_0$, given by Professor W. A. Tuplin* as

$$R_0 = r_0 \sec\beta \sin\phi_0 = r_0 k_0. \quad (1)$$

where $\beta$ = base-cylinder helix angle; $\phi_0$ = transverse pressure angle at $r_0$; $k_0$ = curvature coefficient at $r_0$; and $r_0$ = pitch-cylinder radius.

The nomogram enables $R_0$ to be found with a reasonable degree of accuracy as well as the transverse pressure angle $\phi_0$ at $r_0$ corresponding to a given pitch-helix angle $\beta_0$ and normal pressure angle $\phi_n$ at $r_0$. This relation is given by

$$\tan\phi_0 = \sec\beta_0 \tan\phi_n. \quad (2)$$

As $\beta_0$ and $\phi_n$ are usually known rather than $\beta$ and $\phi_0$, obtain $\phi_0$ on scale F by joining $\phi_n$ on scale G to $\beta_0$ on scale A. The value of $\beta$ is found from the equation

$$\tan\beta = \cos\phi_0 \tan\beta_0 \quad (3)$$

Obtain $\beta$ on scale D by joining the value of $\phi_0$ (F) found above on scale I to $\beta_0$ on scale B.

The coefficient $k_0$ on H is found by joining the value of $\beta$ on A to $\phi_0$ on J, and $R_0$ is obtained by joining $k_0$ on H to $r_0$ on C.

The work described in this article was carried out as part of the research programme of the Division of Metrology, Commonwealth Scientific and Industrial Research Organisation, Australia.

* Division of Metrology, National Standards Laboratory, Commonwealth Scientific and Industrial Research Organisation, Australia.

* *Trans. Inst. Marine Engineers,* Vol. XL, page 113 (1948).

## CASE PACKER FOR BOTTLES.

The filling, capping and labelling of bottles can be done mechanically by a variety of automatic machines, but placing the bottles in the cases or crates in which they are dispatched from the bottling plant is an operation presenting a number of problems. The Lilleshall-Webster case packer, illustrated and described below, has been designed and built by the Lilleshall Company, Limited, St. George's, near Oakengates, Shropshire, to place bottles in cases automatically at a maximum rate of 900 cases an hour. It can be adapted to work in units of 10 or 12, and in certain multiples of these units; taking cases holding two dozen bottles, a size commonly encountered, the machine can deal with 1,800 dozen bottles per hour, or six per second.

The basic principle of the machine is unaltered, whether it is arranged to deal with decimal units or dozens, and whatever the size of the bottles that it is handling. For certain applications, it can be provided with interchangeable components which enable it to be worked for a period with bottles of one size, and then, after the appropriate components have been changed, to deal with a different size. Similarly, it can be arranged so that a change of components will enable it to work in dozens instead of tens, or vice versa.

The machine, which is approximately 11 ft. 4 in. long by 3 ft. 10 in. wide and 4 ft. 7 in. overall in height, has two main component assemblies, namely, a case feed and a bottle feed. The case feed is operated by compressed air, which is usually taken from a supply line on the site, though a small compressor can be built into the machine if required. It operates at 35 lb. per square inch and requires approximately 6 cub. ft. of free air per minute when operating continuously at its maximum speed. The bottle feed is operated by a 1-h.p. motor.

In operation, the machine takes its bottle feed from a power-driven conveyor which is brought in at the back. There can be more than one bottle conveyor if desired, in which case the conveyors can be independent, and unbalanced as regards rate of supply. Detector gear in the packing machine ensures that it will operate only if the correct number of bottles is in position. If there is any break in the continuity of bottle feed, the packing machine will pause and wait for the supply of bottles to correct itself. Overfeeding, likewise, is allowed for in the design of the machine. If the conveyors feed more bottles than the machine can dispose of, the reception area at the tail of the machine fills up, and the feed conveyor slips beneath the line of bottles, so bringing the feed to a standstill until the reception area is ready to accept more bottles. Provision is made to prevent damage to the machine or the bottles as a result of pressure building up in the reception area if there is overfeeding.

Empty cases are brought in on a power conveyor which leads to the head of the machine at right angles to the bottle feed. Filled cases are pushed off the machine by the empty cases on the infeed side, and pass to gravity rollers, or to another power conveyor on the same centre line as that for the empties. Detector gear ensures that the filling cycle will be halted if the case feed should fail.

Fig. 1, on this page, and Figs. 2 and 3, opposite, show the general appearance of the machine. Fig. 1 is a view from the front. The conveyors for the empty and full cases, which are not supplied with the machine, are not shown, but the points to which they have to be connected can be seen. In the centre is a case in process of being filled; on the right is an empty case waiting to move into the filling position, and on the left a filled case is leaving the machine. The main "stop-start" push-button control for the motor can be seen on the right in front of the empty case, and on the left is the main air stop-valve. These are the principal controls on the machine, and it can be stopped and started from the front by their use. Fig. 2 is a view from the left-hand side. The features already mentioned can be seen, and the illustration also shows the air filter and reducing valve to which the air supply is connected, the motor, and the main switch. In Fig. 3, the bottle feed is shown, and the point to which the bottle-feed conveyor is led is visible on the extreme right. The feed conveyor itself is not shown.

## CASE PACKER FOR BOTTLES.

THE LILLESHALL COMPANY, LIMITED, OAKENGATES, SHROPSHIRE.

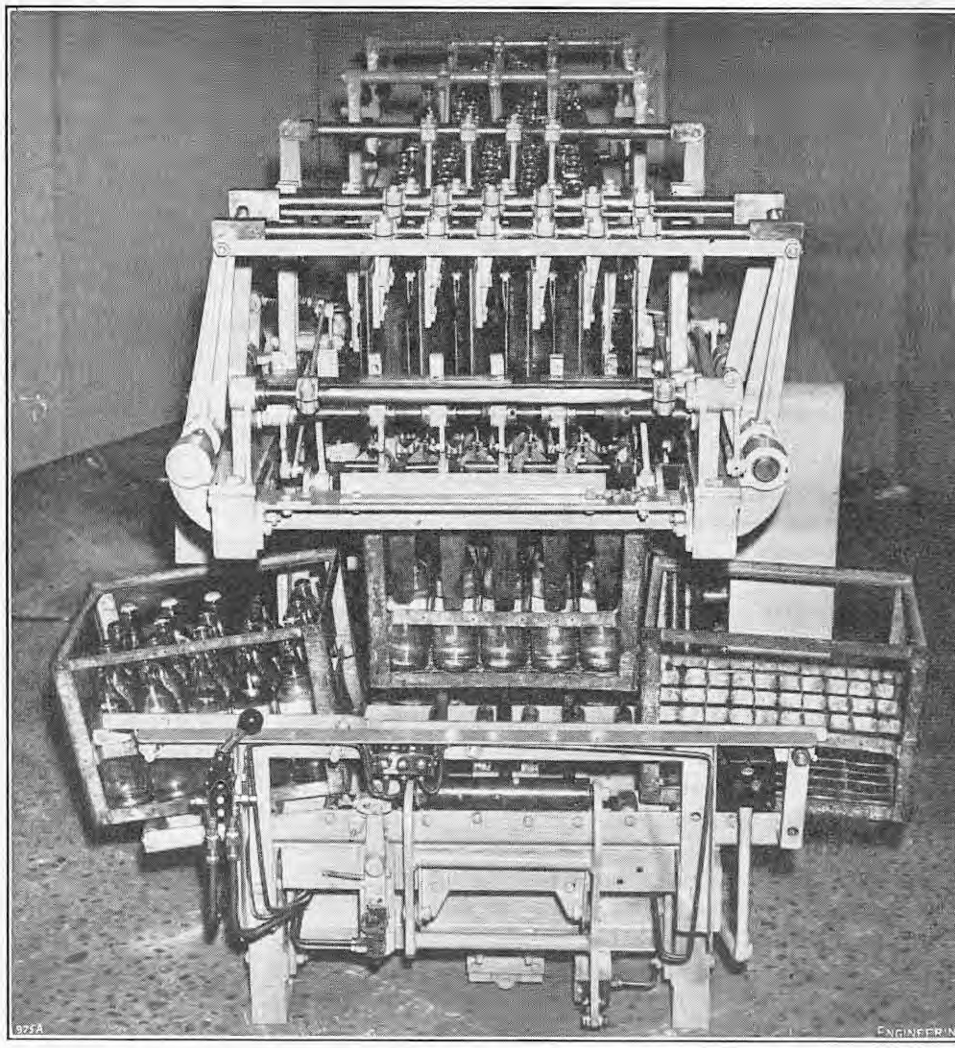


Fig. 1. Front of Machine.

By reference to Figs. 4 and 5, on Plate X, the operation of the machine can be followed in detail; these arrangement drawings, correspond, respectively, to the views of the machine reproduced in Figs. 2 and 3. The empty cases on the case-feed conveyor push the first case forward until it contacts the initiating trip *a*, Fig. 4. This sets in motion the case-centralising gear, to place the case in position, ready to receive bottles. The initiating trip causes the case-stop cylinder *b*, Fig. 5, to operate and arrest the second case in the feed line. At the same time, the horizontal roller arm *c*, which is controlled by the cylinder *d*, Fig. 5, comes into operation and pushes the case against fixed vertical rollers *e*. Vertical swinging rollers *f*, operated by air cylinders *g* then move in on each side of the case and complete its registration over the elevating table *h*. The case is now in position, and is registered in plan relatively to the bottle-feed mechanism. It is next elevated into a position where it can receive bottles from the mechanism above it. This is done by the vertical swinging roller *f* contacting a trip valve and so setting in motion the piston in the table-elevating cylinder *i*. At the same time, the vertical roller operates another trip valve which causes the vertical rollers to be returned to their "start" position.

While the empty case has been brought into position, centred and elevated, the bottle-feed mechanism has been marshalling bottles ready to be lowered into the case. At the tail end of the machine, the bottles are fed on to a stainless-steel slat conveyor *l*, extending over the whole width of the machine and from the tail end to the bottle-feed mechanism. It is driven by the motor through a variable-speed gear and reduction gearbox. A control handwheel, which can be seen in front of the motor in Fig. 2, enables the speed of the slat conveyor to be varied, and so changes the packing speed as required. At the intake end of the machine, the bottles enter two bottle lanes *m*, which are curved outwards to provide a brake on the flow of bottles, so relieving the pressure where marshalling into the final bottle lanes takes place.

To ensure uniform distribution into the final bottle lanes, a mechanical agitator is fitted. The side plates forming the bottle lanes are attached to vertical arms *n*, which are carried on an overhead spindle *p*. This spindle is given a continuous lateral movement by the face cams *q* and the connecting arms *r*. The gentle agitation causes the bottles to enter the bottle lanes smoothly and to travel in continuous lines to the packing mechanism. Here, each bottle is pushed off the conveyor by the one behind it, on to a bottle grid *s* over the waiting case. When they reach the end of the grid, the bottles in each lane operate detectors which free mechanical locks *t*, mounted on an escapement bar. When the grid is full, all these locks are lifted, and the escapement bar is free to move so far as the bottle-feed mechanism is concerned, but the bar still cannot move unless a case is in position for filling.

One more lock remains to be freed. This is similar to the others and is in the same line, but it is operated by a push rod and detector *u*, Fig. 5, which is moved when a case rises into the filling position. Only when all the detectors have freed the locks can the filling cycle continue. It is unimportant which of the locks is freed first. The bottle grid may be full before a case is in position, or a case may have to wait for a full complement of bottles. The interlocking is such that, until a case is in position and the grid holds the correct number of bottles, the filling cycle is arrested.

(To face page 236.)

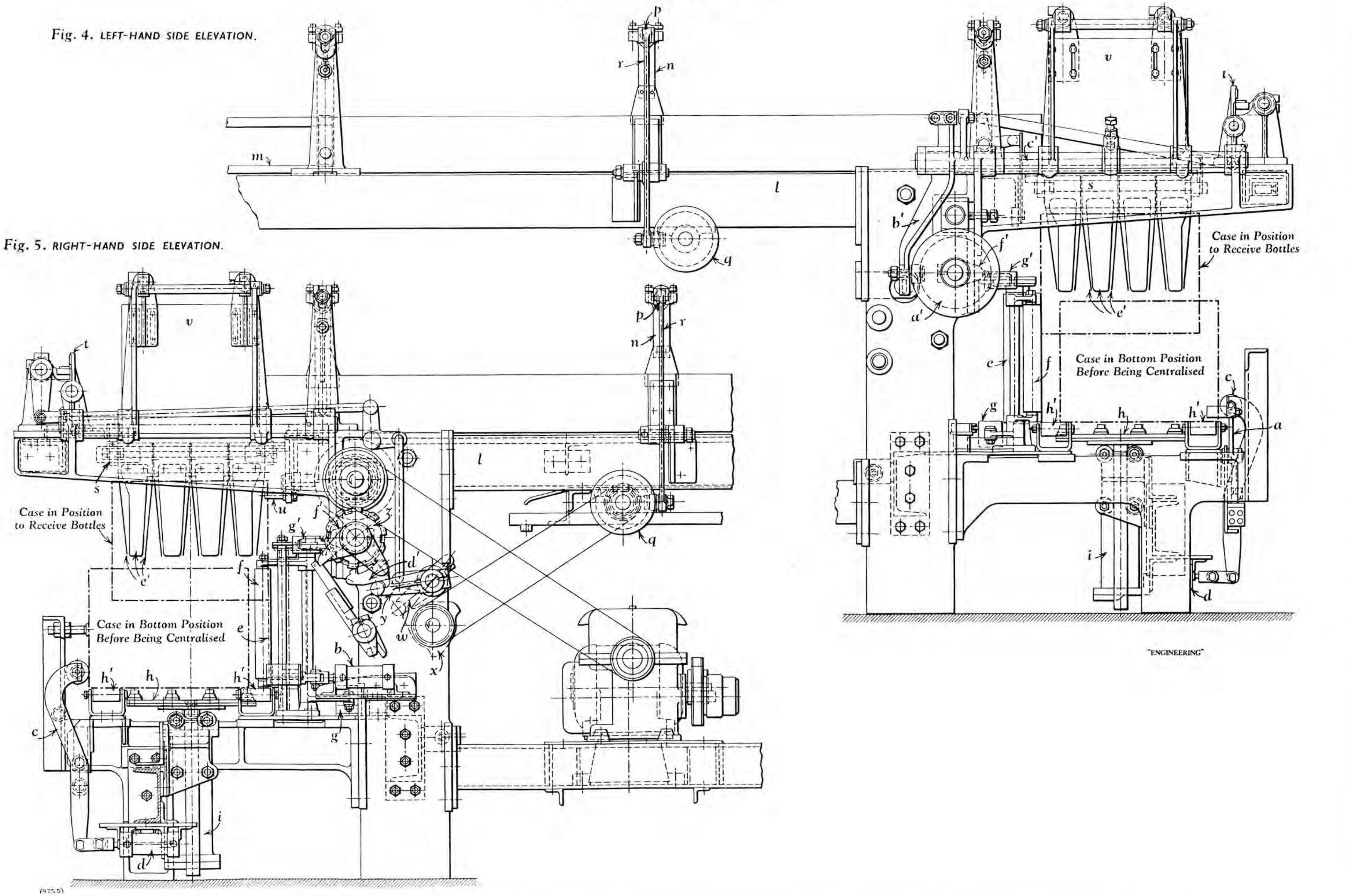
# CASE PACKER FOR BOTTLES.

THE LILLESHALL COMPANY, LIMITED, OAKENGATES, SHROPSHIRE.

(For Description, see Page 236.)

Fig. 4. LEFT-HAND SIDE ELEVATION.

Fig. 5. RIGHT-HAND SIDE ELEVATION.



# CASE PACKER FOR BOTTLES.

THE LILLESHALL COMPANY, LIMITED, OAKENGATES, SHROPSHIRE.

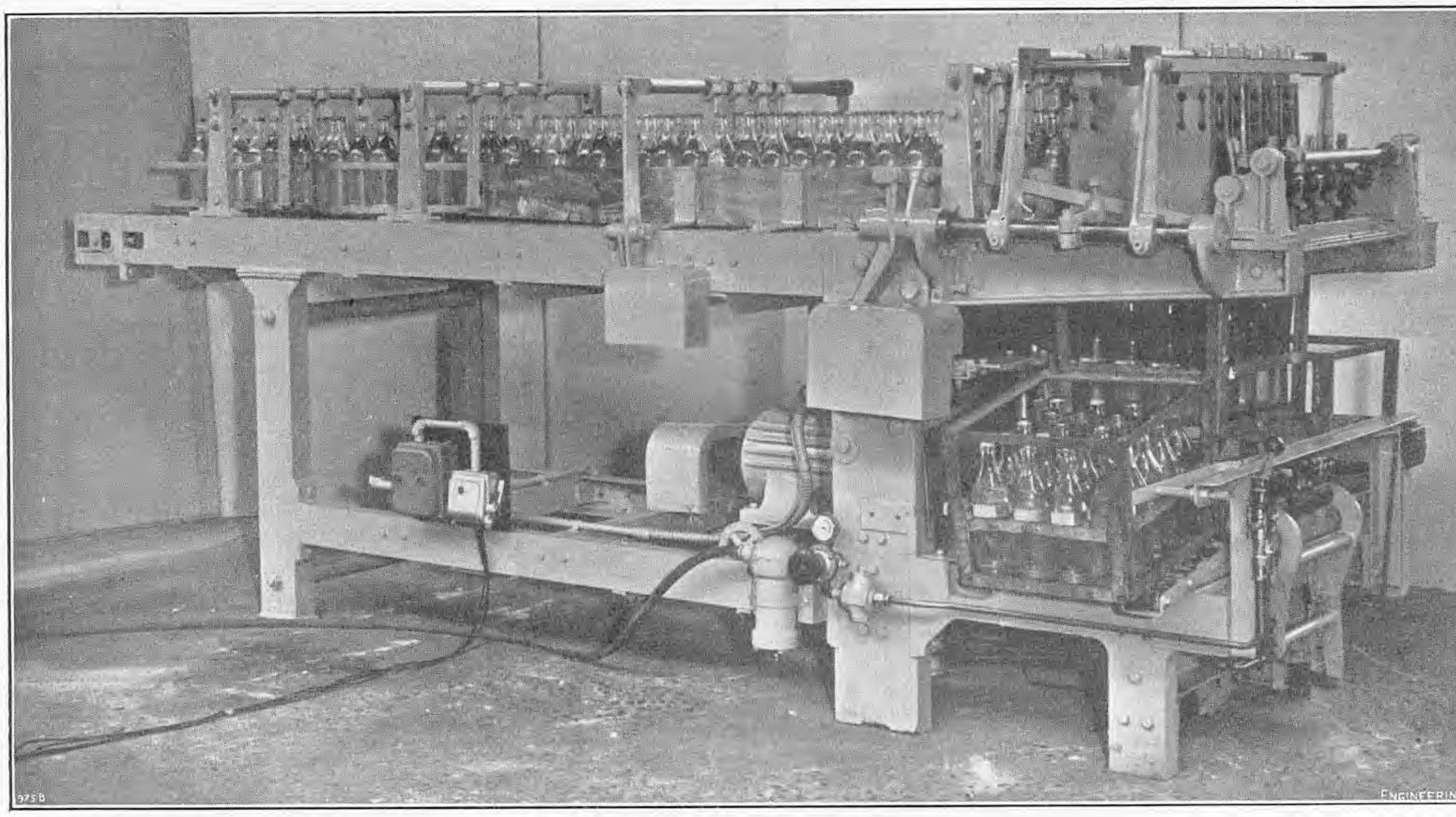


FIG. 2. LEFT-HAND SIDE OF MACHINE.

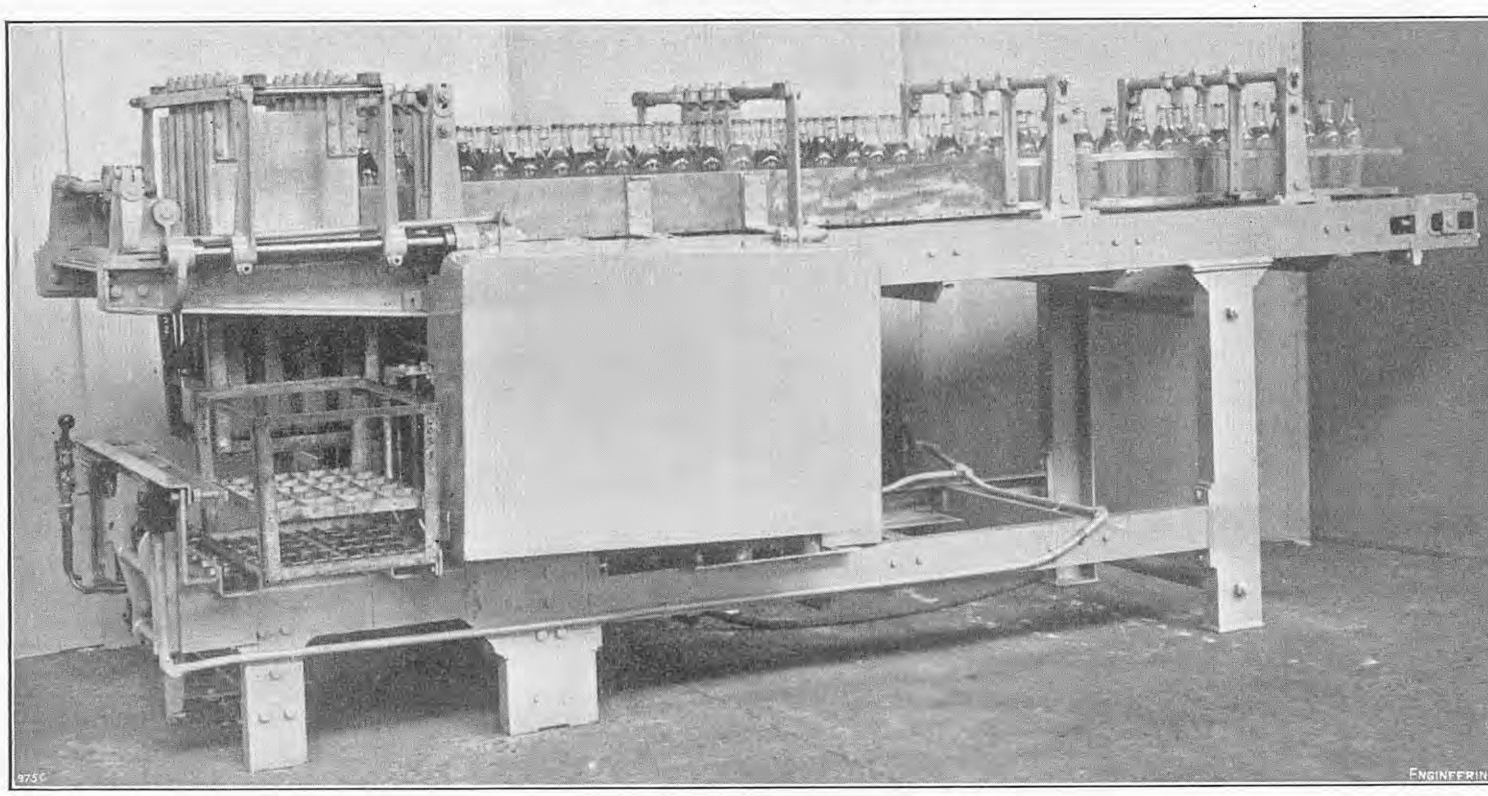


FIG. 3. RIGHT-HAND SIDE, SHOWING BOTTLE FEED.

As soon as all the detectors have responded to the correct conditions, the escapement bar rises and allows the transfer head *v* to move laterally, pushing the bottles off the grid supports. The movement of the transfer head is obtained from a cam, which is controlled as follows. The escapement bar is connected by rods and a bell-crank lever to a cam follower lever *w*, Fig. 5. As soon as the detectors open the locks, and so allow the escapement bar to rise, the lever *w*, which is spring-loaded, moves until the roller on its end makes contact with the agitator cam *x*, which is continually rotating. This provides a gentle agitation, and ensures that the levers and mechanism shall be "alive." At the same time, a lever *y*, on the same shaft as lever *w*, falls and releases a spring-loaded pawl which engages the continuously-rotating ratchet wheel *z*. This ratchet wheel normally rotates freely on its shaft, but when the pawl is engaged, the wheel gives motion to the shaft. On the opposite end of the shaft is a barrel cam *a'*, Fig. 4. This contacts a roller on a lever *b'* mounted on the shaft *c'*, which is connected to the transfer head. The head is thus moved sufficiently to push the bottles off the grid supports. At the completion of one revolution, the pawl *d'*, Fig. 5, strikes the lever *y* and is released from engagement with the ratchet wheel, which then continues to rotate freely. A non-return device prevents the ratchet wheel from moving in the wrong direction. The bottles, having been pushed off the grid, are now free to fall, which they do under the control of the guide springs *e'*, into the waiting case. As the bottles are falling through the springs, a cam *f'* opens a trip valve *g'*, which reverses the case-elevating cylinder and lowers the filled case to a position ready for discharge. As the case reaches its bottom position, a second cam (not shown on the drawing) engages another trip valve, which reverses the case stop cylinder *b*, and so frees the case which is on the conveyor, waiting to enter the machine. The empty cases then push the filled case off the machine over the rollers *h'*, and the cycle is complete.

# NOTES FROM THE INDUSTRIAL CENTRES.

## SCOTLAND.

THE LATE MR. J. D. MOIR.—We note with regret the death of Mr. James Drummond Moir, which occurred on August 10 at his home in Bo'ness, West Lothian. He was managing director of the Bo'ness Iron Company, Ltd., Dock Foundry, Bo'ness. Mr. Moir, who was 79, had been associated with the company as director and manager since its inception 52 years ago.

TELEVISION MOBILE UNIT.—A mobile unit for television outside broadcasts in Scotland was on view at Broadcasting House, Glasgow, on August 8. The technical equipment is installed in a six-wheeled vehicle which is designed to work with three cameras simultaneously. The cameras can be operated by remote control, and the picture signals from the control room are directed into the national television system by means of special G.P.O. land lines or mobile radio links, or a combination of both. The combined method was used in Scotland's first direct broadcast from a Glasgow theatre last week.

FIRE AT HILLINGTON WORKS.—The electro-plating shop of the Remington Rand factory at Hillington was destroyed by fire on August 11, and the roofs of three adjoining bays of the main building damaged. The fire is believed to have originated in a small laboratory at the side of the electro-plating shop.

MODEL OF FISHING BOAT.—A model of the Shetland smack-rigged, half-decked fishing boat Favourite, built 100 years ago, has been made by Mr. John Shewan, aged 87, of Lerwick, for the Royal Scottish Museum, Edinburgh. Mr. Shewan has made several models for the Liverpool Museum.

COURSES FOR WORKS AND PLANT ENGINEERS IN GLASGOW.—Following their practice in Bristol, Nottingham, and Birmingham, the Education Committee of the Incorporated Plant Engineers have arranged refresher courses for works and plant engineers in Glasgow, beginning in the autumn. The courses will consist of 20 lectures given at weekly intervals by specialists from industry. Each lecture will be followed by a discussion.

APPLICATION TO ERECT FACTORY.—An application by G. and J. Weir, Ltd., Cathcart, Glasgow, for permission to erect a factory on ground at Old Castle-road is under consideration by the Planning Committee of Glasgow Corporation.

## CLEVELAND AND THE NORTHERN COUNTIES.

PLANS TO DIMINISH LOAD SHEDDING IN NORTHERN REGION.—About 2,500 commercial and industrial undertakings in the Northern Region of the Ministry of Fuel and Power are being advised to reduce their electricity demands by 10 per cent. each day between 8 a.m. and 12 noon and 4 p.m. and 5.30 p.m. from November 17 to February 13. Last year, there were no severe electric-power cuts in the Northern Region, owing to the co-operation of firms in staggering their working hours so as to avoid the peak periods as much as possible. Sir Mark Hodgson, chairman of the Northern Regional Board for Industry, said that if there had not been staggered hours last winter, production would have been affected by electricity cuts. This winter, he added, the plant position was better and load-shedding, though necessary, would not be as severe as last winter.

COLLIERY MODERNISATION.—Mine cars for carrying colliers to their working places have been installed at the Bates Pit, Blyth, Northumberland, as part of a modernisation scheme. In addition, coal conveyors have been installed to carry coal to loading points. Recently, an 80,000*l*. railway was built connecting Bates Pit with the nearby Isabella and Crofton Mill collieries.

COAL PLOUGHS FOR THIN SEAMS.—In the course of an address given before a meeting of the North of England Institute of Mining and Mechanical Engineers, at Newcastle-on-Tyne, Mr. H. E. Collins, the production director of the Durham Coal Board, estimated that there were about 779 million tons of coal in thin seams in County Durham. He added that the economic winning of this coal was a problem which had to be solved if the coalfields in Durham were to continue in production. Coal ploughs appeared to be the solution, and several had been installed. It was proposed to install one each month until 1954, but his rate might be increased if the ploughs demonstrated heir efficiency for the work involved.

FULL-TIME RESUMED AT MIDDLESBROUGH WORKS.—On returning to work from holidays employees at the Cargo Fleet Ironworks, Middlesbrough, learned that the works were resuming full-time production for the first time for eleven months.

APPRENTICE SCHEME AT THORNABY-ON-TEES.—An apprentice recruiting and training scheme, established some years ago by Messrs. Head, Wrightson and Co., Ltd., Thornaby-on-Tees, has proved so successful that the firm have a waiting list of applicants for apprenticeships. Under the scheme, the heads of the various departments are asked periodically to estimate their apprentice needs for the ensuing 12 months. Applications are then invited through the local Press and candidates are interviewed by works managers and senior workmen. The most suitable are selected and, for the first year, are given two months' experience in each of the firm's six departments. Reports on the apprentices' progress are issued quarterly to their parents and, by the end of the year, it is generally possible to decide for what department the youths are most suited. About 80 apprentices are taken on annually.

CANCELLATION OF PRINTING-PRESS ORDERS.—It is understood, that, because of import restrictions by other countries, some orders for printing presses, placed with Vickers-Armstrongs Ltd., Newcastle-on-Tyne, have been cancelled. Some of the cancelled orders were for South Africa, New Zealand and Australia. As a result of the cancellation, some men normally engaged on making presses have been transferred to other work.

DEVELOPMENTS AT HOWDEN GASWORKS.—The Northern Gas Board are to inaugurate, on September 22, new plant costing 1,500,000*l*., erected at Howden-on-Tyne gasworks. The plant will increase the output of gas from Howden works from 3,000,000 to 12,000,000 cub. ft. a day.

LONGBENTON WORKS PROJECT.—Additional details are available of a new engineering works planned on a 100-acre site at Longbenton, Northumberland, for Vickers-Armstrongs Ltd. It may be some time before the works can be erected, because of the restrictions on capital expenditure. The plant is intended for the manufacture of tractors.

DESIGN OF WELDED STRUCTURES.—The courses of instruction on welding design organised by the Quasi-Arc Company, Ltd., in London and at their works in Bilston, Staffordshire, have proved so successful that they are now being extended to other industrial centres. A course has been arranged in Newcastle-on-Tyne, where lectures will be given on Tuesday and Wednesday evenings, over six weeks commencing October 14, 1952, at King's College. The instruction is designed especially to meet the needs of draughtsmen, particular emphasis being placed on the practical factors involved in designing welded structures and the efficient detailing of all types of welded structural components. Further details of the course, together with enrolment forms, can be obtained on application to the Constructional Design Department, The Quasi-Arc Company, Limited, Bilston, Staffordshire.

## LANCASHIRE AND SOUTH YORKSHIRE.

LARGE STEEL CASTING FOR CANADA.—From the Grimesthorpe Works, Sheffield, of the English Steel Corporation, Ltd., a large steel casting for a forging press has been dispatched by road to Manchester for shipment to Canada. It weighs 80 tons and is part of an order for twelve castings, worth 65,000 dollars, obtained by the English Steel Corporation. The eleven smaller castings are being made in the Corporation's subsidiary works at Darlington.

TRADE RECESSION AT DONCASTER.—At the Wheatley works, Doncaster, dismissal notices, to take effect to-day (August 22) have been handed to about 110 men and women employed there by Crompton Parkinson, Ltd., electrical manufacturers. The factory produces fractional horse-power electric motors, electric lamps and tubes, and motor-car batteries. An official statement says that the dismissals are due to the present trade position, although it is intended to continue building for stock. The management, however, are confident that the position will improve and will then be prepared to re-engage those dismissed.

MEASURES TO STOP RESERVOIR LEAK.—Sheffield Water Department has been troubled for 70 years by an intermittent leak in the Agden reservoir. Recently it became worse, necessitating immediate action. Under the supervision of Mr. J. Noel Wood, general manager and engineer of the water undertaking, three boreholes have been drilled in the bottom of the reservoir and cement pumped in. The reservoir will be filled to capacity this winter and it is believed that the measures adopted will prove efficacious.

## THE MIDLANDS.

EXCHANGE OF IDEAS ON PRODUCTION.—A group of Birmingham factory managers has been co-operating in the exchange of ideas on production methods. The scheme has worked so well that it is to be described in detail at the forthcoming national conference of the Institution of Works Managers in Birmingham, on October 16, 17 and 18. All the works managers who are co-operating—there are 35 at present—are members of the Institution. The principal speaker at the conference will be Mr. W. R. P. King, works manager of the Birmingham Mint.

FOREIGN COMPETITION IN BALL BEARINGS.—Part of a report issued by the National Union of Manufacturers has been challenged by a Midland company. The report said that ball and roller bearings from Japan, Italy and Switzerland have flooded the British market in the past six months, and that they are cheaper than the British-made article. As a result, orders placed with British firms have been cancelled. The Tipton firm of ball-bearing manufacturers, W. E. Cramp & Son (Tipton), Ltd., say, however, that foreign bearings have only been imported into this country because the British makers could not cope with the demand. The joint managing director of the firm, Mr. B. E. Cramp, stated that, after the duty had been paid, the foreign bearings were 25 per cent. dearer than the British. In overseas markets, British and foreign bearings are meeting on equal terms, and the British product is selling on its quality. British manufacturers are now in a better position to meet the demand, and it is becoming increasingly difficult to sell foreign bearings in this country.

COLLIERY FIRE.—Fire broke out underground at Bentinck Colliery, Kirkby-in-Ashfield, near Mansfield, on August 8. More than 250 miners were underground at the time, but all were brought out safely, though three were injured. The fire was brought under control in three hours, and normal working was resumed on August 11. Bentinck Colliery employs more than 1,200 men underground, and produces coking, gas, steam and household coal.

LANDSLIDE UNDER VILLAGE.—About half the houses in the small Shropshire village of Jackfield, near Broseley, have now been evacuated, and the people concerned re-housed elsewhere. It is expected that the remainder of the houses will be vacated shortly. The slow landslide which has been in progress since last January is gradually destroying the village, and some of the houses have already been damaged so badly that it has been necessary to demolish them. Engineers and geologists have examined the ground in the neighbourhood, and their preliminary report says that the landslide is not likely to develop further.

OPENCAST MINING DENIAL.—The Ministry of Fuel and Power has issued a denial that opencast coal mining is to be started at Mamble, near Bewdley, Worcestershire. Coal is known to exist over a considerable area in the Mamble district, both near the surface and at greater depths. Small-scale underground mining has been carried on there for a century or more. The last colliery to work in the area was Bayton Colliery, which closed down in 1950, soon after it had been taken over by the National Coal Board from its licensees. A promise was made by the previous Minister of Fuel and Power that Worcestershire County Council would be consulted before any opencast mining took place at Mamble, and the Ministry have given an assurance that this promise still holds good.

PROPOSED VISITS TO GERMAN FACTORIES.—The National Union of Manufacturers suggested some time ago that Germany should be approached with a view to arranging visits of industrialists and workmen to German factories. Some doubt has been expressed about German co-operation, but Mr. K. B. Hopfinger, a consulting engineer from Hampton-in-Arden, near Birmingham, has offered to organise team visits on the lines suggested, as he felt sure that, if German manufacturers were approached in the right way, they would be quite open about their methods.

AMERICAN COLLIERY SHUTTLE CARS.—Collieries in the East Midlands are to try out American shuttle cars as a means of facilitating the handling of materials and cutting costs. The cars can transport four tons of coal or other materials and are self-unloading. There have been battery-driven shuttle cars in the Division since 1943. The new type, however, is a rubber-tyred "runabout" vehicle which draws its power from the main electricity supply. It carries the cable on a reel, pays it out as it travels away from the power point and draws it in again on the return journey. The vehicle has a seat at each end, can turn in its own length, and move backwards or forwards.

## SOUTH-WEST ENGLAND AND SOUTH WALES.

THE COAL SITUATION.—Holidays at the mines and the attraction of the National Eisteddfod resulted in the lowest output at the South Wales mines, during Bank Holiday week, since the nationalisation of the mines. Production for the entire South-Western Division, during the week, totalled only 186,294 tons, compared with 345,606 tons in the previous week. In view of the heavy orders held by operators for the best qualities, it is expected that it will take some little while before the supply position returns to normal.

REDUNDANCY AT WHITFORD AND CWMFELIN WORKS.—As a result of a change of programme on the part of the Government, necessitating the suspension of an important contract for defence material, it was announced during the week that the Whitford fabricating works of Richard Thomas and Baldwins, Ltd., at Briton Ferry, were likely to be closed down shortly. In addition, it was stated that there would probably be considerable redundancy of labour at the company's Cwmfelin press and fabricating works at Swansea. An official of the company has stated that at the Whitford works, which employ about 150 persons, there appeared to be no alternative but to close down. About 200 out of a total of 850 employees would be affected at Cwmfelin.

ORDER FOR PADDLE FERRY STEAMER.—Pembrokeshire County Council, at a special meeting, decided to give an order for a new paddle steamer for the Neyland-Hobbs Point ferry to R. S. Hayes (Pembroke Dock) Ltd. This will be the first ship built at Pembroke Dock for many years. The firm of R. S. Hayes Ltd. went to Pembroke Dock five years ago to carry ou ship-repairing.

IDLE SHIPS IN SOUTH WALES PORTS.—There are now about 20 ships laid up at the South Wales ports. Ten of these are small vessels and the remainder fall into the 3,000 to 5,000-ton class. South Wales shipowners are viewing the prospect with some concern and it is reported that further inquiries have been received by the dock authorities and that a further four ships are likely to be idle shortly. So far, only a few Cardiff-owned ships are affected. The reason for the decision to lay-up tonnage has been the heavy falls in freight rates during recent months owing to the restrictions placed on imports by several countries. In some cases, rates have dropped by from 50 to 75 per cent.

## NOTICES OF MEETINGS.

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

HELICOPTER ASSOCIATION OF GREAT BRITAIN.—Friday, September 5, 5.30 p.m., Institution of Civil Engineers, Great George-street, S.W.1. "Helicopter Operating Experiences," by Mr. A. V. J. Vernieuwe.

INCORPORATED PLANT ENGINEERS.—*East Lancashire Branch:* Tuesday, September 9, 7.15 p.m., Engineers' Club, Albert-square, Manchester. Open Discussion Meeting. *Newcastle-upon-Tyne Branch:* Thursday, September 11, 7.30 p.m., Roadway House, Oxford-street, Newcastle-upon-Tyne. "Liquid-Fuel Firing," by Mr. Alan Moore. *Liverpool and North Wales Branch:* Monday, September 15, 7.15 p.m., Radiant House, Bold-street, Liverpool. "Amenities in Industry," by Mr. H. S. Crump.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*Midlands Centre:* Tuesday, September 9, 7.30 p.m., Crown Inn, Broad-street, Birmingham. "Some Factors Influencing the Choice of a Crankcase Lubricating Oil," by Mr. A. Towle. *North-West Centre:* Wednesday, September 17, 7.30 p.m., Adelphi Hotel, Liverpool. "Heavy Haulage," by Mr. E. Skelton.

INSTITUTE OF METALS.—Monday, September 15, to Friday, September 19, 44th Annual Autumn Meeting. Monday, September 15, 8.30 p.m., Sheldonian Theatre, Broad-street, Oxford, Autumn Lecture: "On the Foothills of the Plastic Range," by Professor H. W. Swift. Tuesday, September 16, and Wednesday, September 17, 9.30 a.m., Clarendon Laboratory, Parks-road, Oxford, various papers for discussion. Thursday, September 18, 9.30 a.m., Clarendon Laboratory, informal discussion on "Grain Boundaries." Various visits and excursions will take place on the afternoons of Tuesday, Wednesday and Thursday, and all day on Friday. For further particulars, see page 223, *ante*.

## ANNUALS AND REFERENCE BOOKS.

*Handbook of Dangerous Materials.*

By N. IRVING SAX, assisted by M. J. O'HERIN and W. W. SCHULTZ. Reinhold Publishing Corporation, 330, West 42nd-street, New York 18, U.S.A. [Price 15 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 120s. net.].

"DANGEROUS materials," in this context, relates to general chemicals, explosives, fungus diseases and fungicides, and radiation and radiation hazards. The general-chemicals section lists 5,000 dangerous materials for which the following information is given: hazardous properties (flammability and toxicity); treatment, antidotes and extinguishers; storage and handling advice; personnel safety precautions; physical properties (flash point, auto-ignition point, etc.); a description of the material; and shipping regulations and labelling instructions. The explosives section deals with high and low explosives, surface storage and destruction, and also contains a chapter, taken from the *Ordnance Safety Manual* of the U.S. Army, on chemical ammunition and miscellaneous explosives. A section on fungus diseases and fungicides is divided into two parts, one a general discussion of fungus diseases and the other relating to the toxicity of fungicides. A fourth section of the book, on radiation and radiation hazards, includes a chart of the nuclides, information on interaction and safety, units of measurement, and radiation measurement for health protection, and a guide to radiation protection. The last section gives the complete text of the Interstate Commerce Commission shipping "tariff" (i.e., regulations) as issued by the Bureau of Explosives. The information throughout the book is presented in non-technical language as far as possible, though, of course, the extent to which the author has been able to achieve this worthy aim is limited by the technicalities of the subject-matter. Nevertheless, he has gone a long way towards making his book acceptable, as he intended, not only to industrial physicists and safety inspectors, but also to plant managers and workers in research and development laboratories. The book contains over 800 pages, very well arranged and printed, and will probably prove to be an invaluable source of reference for the many and various professions and trades interested.

*Directory of Railway Officials and Year Book*, 1952-1953.

TOTHILL PRESS, LTD., 33 Tothill-street, London, S.W.1. [Price 40s.]

THE new material in the 58th year of publication of this useful reference book relates to the two Government railways in Nepal, the Pan American Railway Congress Association, the world's standardisation societies, and railways in Germany. There are also new maps of the Divisional Waterways organisation and of the Road Haulage Divisions, though the future of the latter is now uncertain in view of the Government's intention to denationalise road haulage. In general, the book gives the principal facts and statistics of railways and associated organisations throughout the world, though reliable information on countries behind the "Iron Curtain" is not available. The book has been tested often enough, and seldom found wanting.

## CONTRACTS.

DORMAN, LONG & CO., LTD., Middlesbrough, have received a contract, placed by the Crown Agents for the Colonies on behalf of the Nigerian Government, for a suspension bridge over the River Cross, Nigeria, at a point about 120 miles from the West-African coast. The overall length of the bridge will be 590 ft., and the main span over the gorge through which the River Cross flows will be 350 ft. The deck will be 90 ft. above the normal low-water level and the value of the contract, which will require 500 tons of steel, is 315,000*l*.

THE GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2, have obtained an order from the Electricity Supply Commission of South Africa for a 60-MW, 11·8-kV turbo-alternator to be installed at Wilge power station, which is 5,100 ft. above sea level. The turbines are being made at the Fraser and Chalmers Works and the alternators at the Witton works of the company.

THE NATIONAL GAS AND OIL ENGINE CO. LTD., Ashton-under-Lyne, have received an order for 24 of their M4AA7-type engines, each rated at 210 b.h.p. at 1,100 r.p.m., for Simon Handling (Engineers) Ltd., Cheadle Heath. The engines are for driving mobile grain-handling equipment destined for Turkey. Other orders are from British Oilfield Equipment Co. Ltd., Leeds, and include four R4AA4-type engines, each rated at 216 b.h.p. at 650 r.p.m., for driving mud pumps for drilling equipment, and four R4AAU7-type engines of 610 b.h.p., at 720 r.p.m., for incorporation in drilling rigs.

## PERSONAL.

VISCOUNT FALMOUTH, M.I.Mech.E., has been re-elected President of the British Internal Combustion Engine Research Association, 111-112, Buckingham-avenue, Slough, Buckinghamshire. AIR COMMODORE F. R. BANKS, C.B., O.B.E., DR. S. F. DOREY, C.B.E., M.I.C.E., M.I.Mech.E., F.R.S., SIR LYNDEN MACASSEY, K.B.E., Q.C., VICE-ADMIRAL (E) THE HON. SIR DENIS MAXWELL, K.C.B., C.B.E., MAJOR-GENERAL H. E. PYMAN, C.B., C.B.E., D.S.O., M.A., and LIEUT.-GENERAL SIR FREDERICK WRISBERG, K.B.E., C.B., have been re-elected vice-presidents.

AIR COMMODORE G. S. SHAW, C.B., R.A.F. (retd.), has been appointed group liaison officer to the Hunting Group of Companies, and will operate from the chairman's office, at 26, Ryder-street, London, S.W.1.

MR. T. E. GOLDUP, M.I.E.E., a director of Mullard Ltd., Century House, Shaftesbury-avenue, London, W.C.2, has been appointed chairman of the board of governors of the Ministry of Supply School of Electronics, Malvern, in succession to Professor Willis Jackson, D.Sc., M.I.E.E., professor of electrical engineering, City and Guilds College, London.

MR. STEWART SALMOND, F.R.I.C.S., Assoc.I.C.E., and MR. L. G. BOOEN, B.Sc., M.I.C.E., both of whom have been members of the staff of Sir Alexander Gibb and Partners, consulting engineers, Queen Anne's Lodge, London, S.W.1, for many years, have been made partners in the firm. Mr. Salmond will be resident partner at the Edinburgh office and Mr. Booen will normally be in London.

MR. RONALD KENDALL, who has been editor of *The Shipping World* since 1945, is to relinquish that position at the end of August to become managing director of BURNESS, KENDALL & PARTNERS, marine consultants and naval architects, 15, St. Helen's-place, London, E.C.3, and a director of the BURNESS SHIPPING CO., Ltd. He will retain his present directorship of SHIPPING WORLD, LTD.

MR. P. BUTLER, B.Sc., M.I.E.E., and MR. W. B. LAING, Assoc. Heriot-Watt College, M.I.E.E., have been appointed directors of Bruce Peebles & Co., Ltd., Edinburgh, 5, while retaining their status as joint general managers.

MR. D. R. BROOKS, manager of the No. 4, South-West Durham area, of the Durham Division of the National Coal Board, is to retire shortly. MR. W. WELSH, manager of No. 6 area will succeed Mr. Brooks and MR. J. A. NIMMO, deputy production director, will become manager of No. 6 area.

MR. G. B. HARPER has been appointed transformer engineer in the transmission design branch of the British Electricity Authority at headquarters, Great Portland-street, London, W.1.

MR. JAMES SMITH retired last week from the position of district traffic superintendent, British Railways, Ayr, after 51 years in the railway service. He is a director of two Ayrshire road-haulage firms, J. H. Livingstone Ltd., Kilmarnock, and Andrew Smith Ltd., Darvel.

MR. GLYN M. JONES, personnel superintendent of the steel division, Steel Company of Wales Ltd., has relinquished this position for health reasons but is continuing in the service of the company in an advisory capacity. His successor is MR. CAMPBELL ADAMSON, M.A. (Cantab.).

CONVEYANCER FORK TRUCKS LTD., Liverpool-road, Warrington, announce the departure of MR. C. E. MONTAGUE for Australia to assist in the formation of an associate company, CONVEYANCER FORK TRUCKS (AUSTRALIA) PTY. LTD. The resident Australian directors will comprise MR. J. N. KIRBY, MR. W. GWINNETT and Mr. Montague.

MR. C. T. M. BAGNALL has been appointed publicity manager of the English Electric Co. Ltd., in succession to MR. PETER SCOTT, as from September 1. MR. M. B. SCHROEDER has been appointed assistant publicity manager, while MR. A. E. L. JERVIS joined the department in London as trade and technical press officer on July 1. The publicity department has now been moved to Marconi House, Strand, W.C.2. (TEMple Bar 1577.)

A new Canadian Company, BRITISH AND DOMINION PROCESS ENGINEERING LTD., has been formed by the BALFOUR GROUP OF COMPANIES and W. S. BARRON & SON, LTD., Gloucester, in association with a branch of CANADA IRONFOUNDRIES, LTD., and DOMINION WHEEL AND FOUNDRIES LTD. Under the aegis of the new company, HENRY BALFOUR & CO. LTD., GEORGE SCOTT AND SON (LONDON) LTD., and ERNEST SCOTT & CO., LTD., which three firms comprise the Balfour Group of Companies, and W. S. BARRON & SON, LTD., will extend their operations in Canada and the United States.

JOHNSON AND PHILLIPS, LTD., Charlton, London, S.E.7, have appointed the China Engineers Ltd., 41, Chartered Bank Chambers, P.O. Box 565, Singapore, to be their sole agents in Singapore and Malaya.

# "BRITANNIA" PROPELLER-TURBINE AIR-LINER.

BRISTOL AEROPLANE COMPANY, LIMITED, FILTON, BRISTOL.

(*For Description, see Page* 245.)

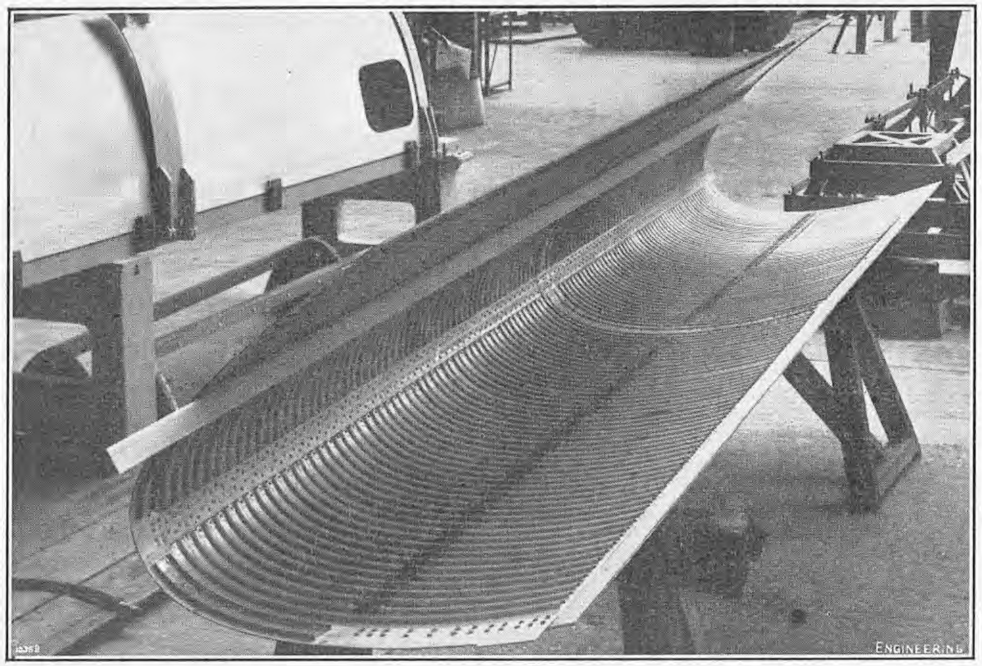



Fig. 1 Wing Leading Edge, Showing Bonded Corrugations.

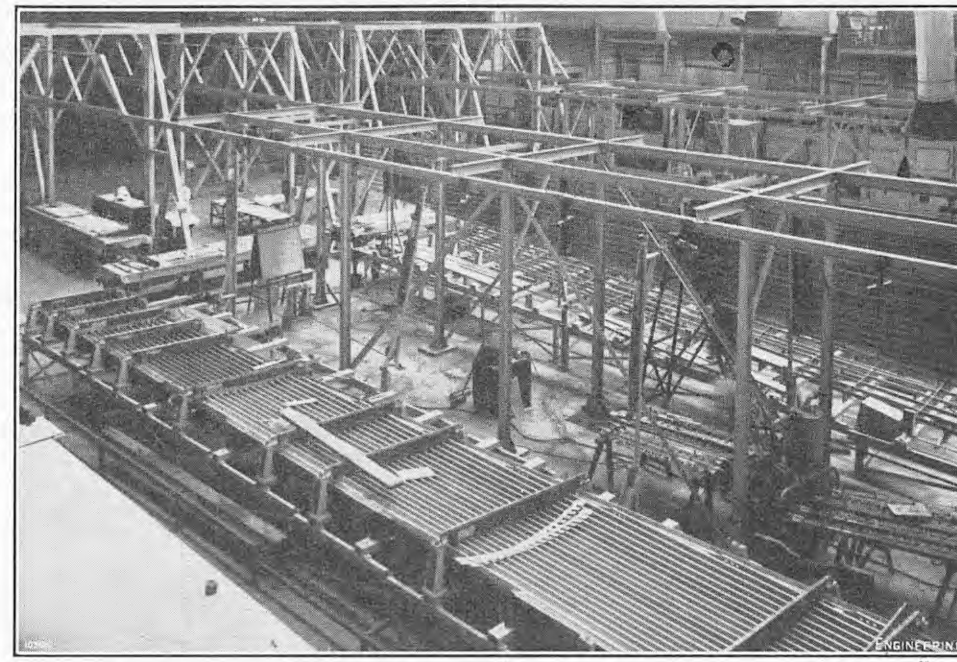



Fig. 2. Wing-Panel Assembly Jig.

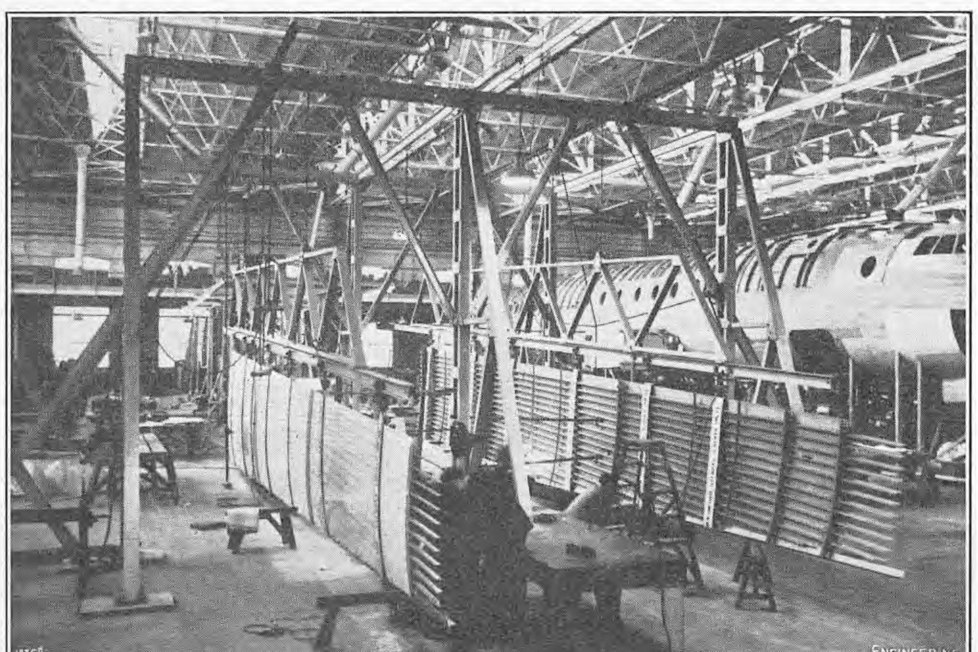



Fig. 3. Wing Riveting Bay.

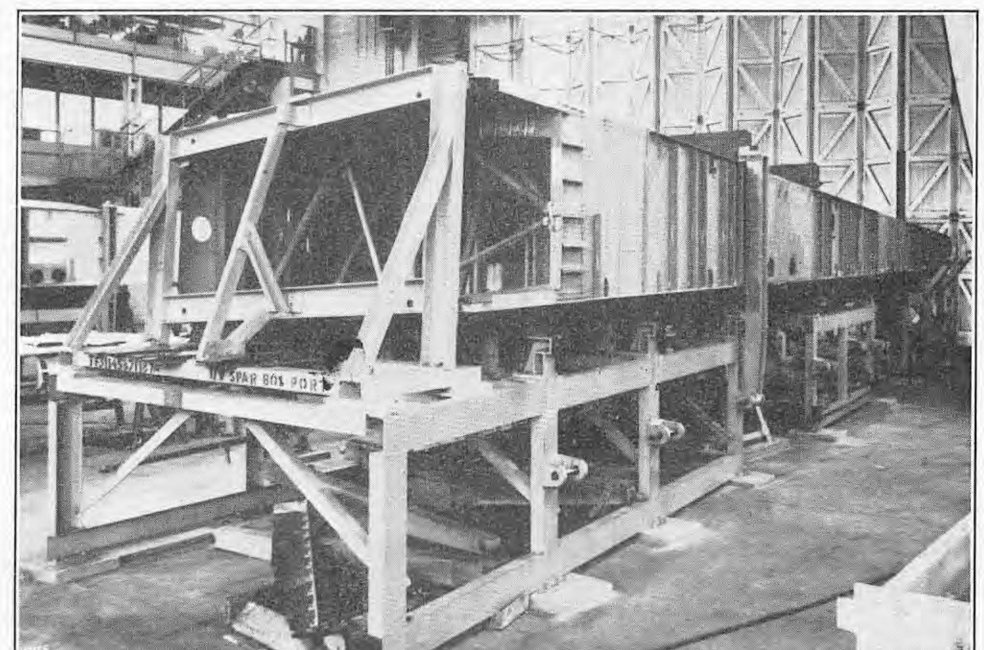


Fig. 4. Wing "Boxing-Up" Jig.

# ENGINEERING

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

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### 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.**

## CONTENTS.




# ENGINEERING

*FRIDAY, AUGUST 22, 1952.*

VOL. 174. No. 4517.


## THE IRON AND STEEL CORPORATION OF GREAT BRITAIN.

WHATEVER personal views might be held by the thoughtful public regarding nationalisation of the British iron and steel industry, it was generally recognised that the task of co-ordinating its hundreds of firms and wide variety of products was one of extraordinary magnitude and complication, comparable only with that of nationalising the coal-mining industry; and that the first report of the Iron and Steel Corporation of Great Britain—the holding and policy-making organisation set up under the terms and authority of the Iron and Steel Act, 1949—would probably be concerned mainly with the details and progress of that task. The report is now available* and it may be said at once that it records a remarkable amount of fundamental work, accomplished in a comparatively short time. The transfer of the companies' securities to the Corporation took effect on February 15, 1951, so that the report covers only seven and a half months of trading. It relates to the affairs of 298 companies, employing nearly 300,000 persons and having an annual turnover of about 500*l*. millions. During 1951, the publicly-owned companies—which retained their individual identities, as a matter of policy—produced more than 98 per cent. of the total output of ingot steel. To go into rather more detail, they were responsible for 97·4 per cent. of the total production of iron ore, 97·1 per cent. of the pig iron, 98·7 per cent. of the carbon steel ingots, and 90·6 per cent. of the heavy steel sections and rails. The consolidated profit for the period of $7\frac{1}{2}$ months was 34,496,452*l*.

Of the 298 undertakings of which the Corporation acquired control on February 15, 1951, 215 were publicly-owned companies, in that the Corporation had the beneficial interest in all the securities concerned; 54 were controlled subsidiaries, the Corporation holding a majority of the securities; 25 were wholly owned, without being companies as defined in the Act; and four were partnerships. Not all of these holdings were acquired directly, of course; in fact, the direct ownerships transferred to the Corporation on the vesting date covered the whole of the securities of only 58 companies and some of those of a further 22 firms. The previous owners of the shares received in exchange British Iron and Steel $3\frac{1}{2}$ per cent. Guaranteed Stock 1979-81. At the date of the transfer, the number of accounts was about 185,000; by the end of March, 1952, these had been reduced to 127,000.

From the technical point of view, some of the most interesting sections of the report are those dealing with materials and production. The total production of steel in 1951 was 15,638,000 tons—about 4 per cent. less than in 1950, the reduction being due to deficiency in the supply of materials, especially scrap, the available quantity of which fell by 1,114,000 tons. This was counterbalanced in part by an increase of 345,000 tons in the quantity of pig iron used in making steel, and in part by drawing on stocks. On the basis of iron content, about half of the ore used was imported, the total for 1951 being the highest ever reached in one year. Stocks of imported ore increased during the year by 175,000 tons, but the cost rose considerably, largely as a result of higher freight charges, which reached a level about double that of the previous year. The ore is imported and distributed by B.I.S.C.(Ore), Limited, the organisation set up and maintained by the British Iron and Steel Federation and, therefore, not under the direct control of the Corporation. The cost of the ore to the consuming firms was not increased, in spite of the heavier expense; thus there was "a substantial loss" to be made good out of the Industry Fund of the Federation. This fund is maintained by levies on all the steel produced.

The consumption of home-produced ore in 1951 was about 14 million tons, supplied by 28 publicly-owned companies and having an average iron content, before treatment, of about 30 per cent.; this compares with an average of about 55 per cent. for imported ore. The principal sources of imported ore, in order of their importance, were Sweden, Algeria, Spain, Newfoundland, and Sierra Leone, the quantity imported being 8,645,000 tons. The dependence of the industry on imported ore leads the Corporation to express the view that it will be necessary to safeguard future supplies by an increased participation in the ownership and control of overseas ore-fields. The endeavour is being made to reduce the dependence of the industry on imported ore by providing concentrating plant to treat the home ores, thus lessening the load on the blast-furnaces and, presumably, to some extent, reducing transport and handling costs.

Considerable attention is given in the report to the scrap position. Imports from Germany were nearly $1\frac{1}{2}$ million tons less than in 1950; an appreciable proportion of the 13·1 million tons of ferrous scrap used in the United Kingdom during 1951. Of the latter total, 70 per cent. was used in steel production, 21 per cent. in the production of iron castings, 6 per cent. went into pig iron, and the remainder reappears as wrought iron, refined iron, etc. A table in the report shows the sources of

* *Iron and Steel Corporation of Great Britain: Report and Statement of Account for the period ended 30th September*, 1951. H.M. Stationery Office. [Price 3s. net.]

supply of steel-making scrap for the years 1938, 1949, 1950 and 1951, during which years the consumptions were 6,126, 9,775, 10,254 and 9,140 thousand tons, respectively. "Arisings" in steelworks constituted the largest item in 1938, 1950 and 1951, and yielded an extra 325,000 tons in response to the national campaign for scrap recovery. Apart from this source within the industry, the campaign was only partly successful, and in 1951 the scrap stocks, which had fallen by 195,000 tons in the previous year, were reduced by a further 350,000 tons in the effort to maintain steel production in spite of diminishing imports of scrap. On the face of things, there would seem to be a case for a further increase in the controlled price of scrap, to encourage the recovery of much that is obviously available, though sometimes widely scattered and at present, therefore, presumably uneconomic to collect. The controlled price, as regulated by the Ministry of Supply, was 85*s*. a ton until August, 1951, when it was increased to 125*s*. a ton; yet imported scrap is 20*l*. a ton or even more, representing a heavy loss, which has to be made good out of the Industry Fund.

The section of the report which deals with coke shows that, in 1951, 10,685,000 tons of coke were delivered to the blast furnaces, the actual consumption (after screening) being 10,281,000 tons. These figures compare with receipts of 10,231,000 tons and a consumption of 9,896,000 tons in the previous year. About 70 per cent. of the coke consumed was produced in ovens operated by the steel industry and 25 per cent. was obtained from plants owned by the National Coal Board. The steel industry's ovens carbonised some 11,600,000 tons of coal to produce 7,745,000 tons of metallurgical coke, representing about 48 per cent. of all the hard coke produced in Great Britain in 1951. Particular attention is being devoted by the Corporation to ensuring that, as new blast furnaces come into operation, adequate supplies of coke will be available to meet their requirements. It is expected that, by the end of 1952, the blast furnaces will be needing about 240,000 tons of coke a week. A Joint Carbonisation Committee has been set up, on which the Corporation, the National Coal Board and the Gas Council are represented, to co-ordinate activities in this direction.

All the foregoing topics, and various others, are discussed in Part I of the report. Part II consists of the Accounts, included in which is a summary of the sales of steel during the period from February 15 to September 30, 1951. This summary shows that the total sales of steel products brought in 286,496,393*l*., and that "other products" (including ores, pig iron, iron castings, wrought iron, etc.) added a further 85,703,510*l*., making a grand total of 372,199,903*l*. A summary is also given of the trading results of 80 companies, showing an aggregate profit, before taxation, of 49,515,034*l*.; but the periods covered in the case of individual companies vary widely, so that direct comparisons involve some calculation. The detailed accounts of the Corporation and of the publicly-owned companies are presented in a separate and bulky volume, published by the Corporation; a reference to this volume appears on page 256, under our heading of "Books Received." A number of steel plants have been closed by the Corporation, to enable fuller supplies of raw materials to be assured to the newer plants, with lower operating costs, which otherwise would have been working at less than their designed capacity. This is a policy, of course, which would normally be adopted in any case, and followed recommendations of a committee of the British Iron and Steel Federation. It is expected that capital investment on modernisation and extensions of plant, which has been at the rate of about 50*l*. millions per annum, will continue at 60*l*. millions annually for some years to come.

## FIRE PREVENTION AND CONTROL.

JUDGING by comments in the daily Press, and by the B.B.C. it appears to be considered that the most important sections of the reports of the Fire Research Board are those giving figures of the total number of fires and their causes. In particular, the fact that, in 1950, 7,282 fires were caused by children playing with matches appears to be taken as the high light of the report for the year 1951.* The statistical tables from which this particular piece of information has been extracted are based on the returns of fire brigades and insurance companies; the collection of figures of this kind is not the business of the Fire Research Board and it has no machinery for such collection. Its concern is the development of methods for preventing the initiation of fires and for controlling and extinguishing those which have started.

The report does not give any information about the serious nature, or otherwise, of the fires caused by children playing with matches but it is a reasonable assumption that the majority of these were of a domestic nature. Some, or many, may have resulted in individual distress or loss but, in total, they do not constitute an important item in the fire problem. A large part of the whole loss caused by fires, estimated at some 22*l*. million per annum, results from large industrial fires little likely to be caused by children. The numbers of this latter class of fires can only be reduced by better parental supervision, but as it is to be feared that in many cases the parents have no more sense of responsibility than the children the possibility of any considerable reduction is not promising. It is rather surprising that the number of fires in buildings caused by children playing with matches has been fairly constant in every year from 1946 to 1950.

The way to deal with this particular matter is the way in which the Fire Research Station is dealing with it. Children will continue to play with matches but the damage that their activities may lead to, as also the damage due to "smoking materials," which were responsible for more fires in buildings than were the children, may be reduced by improved structural materials and more careful lay-outs. The rate of incidence of fires in post-war temporary dwellings, which was 9·5 damaged dwellings per 10,000 in 1946, was 13·7 per 10,000 in 1950. It is stated that the increase was due to "fires starting in the contents of the houses." This appears to suggest that sufficient attention had not been given to the fire risk in planning the arrangement of the contents. No doubt, restricted space complicates the problem, but a contribution towards preventing the spread of fires or perhaps their initiation, has been made by the study of methods of treatment designed to reduce the ignitability of fibre building board. Work on the inflammability of paints also constitutes a contribution towards the same end. An investigation which may help to prevent the spread of fires in dwelling houses will, it is hoped, be made by the use of models in studying the growth of fires. It is pointed out in the report that scale techniques of the kind available to the designers of ships or aircraft do not exist in connection with the spread of fires but a start towards their establishment has been made by tests with one-twentieth to one-fifth scale models. The results have so far been promising.

The more important parts of the report are those bearing on large-scale industrial and building fires. There are so many ways in which a fire may be started that no procedure can possibly be worked out that is likely to control them all. Many fires are rendered more serious by the collapse of the building or portion of a building, in which they start, hampering the application of fire-fighting procedure, and the investigations which are in progress on the fire resistance of prestressed concrete should form a useful contribution towards the solution of the problem of restricting the area of fires. What Sir George Burt, the chairman of the Board, in his introductory section of the report, refers to as the "most striking" of the conclusions which have so far been reached is that "plaster applied in normal thicknesses has a marked protective value." He adds that "it is, of course, important that the bond between the concrete and tensile wires should remain good." In one test, a defect in construction led to the failure of a main beam after less than 20 minutes exposure to fire, whereas a well-constructed one endured for two hours without collapse. The report gives particulars of tests on floors with various protective coverings and states that well-keyed plaster on a prestressed concrete floor should give protection of from one to two hours.

This time interval is of great importance in dealing with many types of industrial fires, affording a reasonable opportunity of preventing them from spreading. A table given in the report shows that the greatest average loss in factory and works fires occurs with the "manufacture of electrical installations, cables and apparatus" followed by "cotton manufacture." With commercial premises, warehouses containing mixed commodities head the list. The tabulation is in terms of value, but in all these cases it is a reasonable assumption that the nature of the contents encourages the spread of fire and accentuates the point that, in as far as a building can be constructed so that sections can be isolated, fire control will be facilitated. Lay-outs of this kind are hardly possible in many manufacturing plants but should be applicable in warehouses. The absence of this possibility in factories accentuates the importance of the development of methods of construction of such type that a building is not likely readily to collapse even if its contents take fire.

The second line of defence is the extinction of fires when they have started. The report gives detailed information about the flame-suppression qualities of methyl bromide and other compounds and adds that recent work by the U.S. Army and Air Force has shown that by suitable selection of hydrocarbons containing both fluorine and bromine it is possible to obtain compounds of high stability and low toxicity but with an efficiency at least as good as methyl bromide. Water sprays, however, are, and are likely to remain, the chief fire-extinguishing agent. In earlier reports of the Board it was pointed out that the practical advantages of very high-pressure sprays was likely to prove limited and it is now stated that a "well-constructed" spray using a pressure of the order of 100 lb. per square inch should be satisfactory for most fires. In semi-confined spaces the steam produced by the evaporating water makes a great contribution to the extinguishing effect and this is of striking significance in the case of low-pressure sprays.

A point of considerable interest has arisen in connection with fires caused by sparks from locomotives. Analysis covering four years has shown that the number of fires attended on one day was very much higher than the number which occurred on the previous day. The effect is apparently related to rainfall, relative humidity, maximum temperature and sunshine. Data for the London area have shown that when a relative humidity at 3 p.m. of 48 per cent. or less occurs between mid-May and mid-September a peak period is imminent and the peak cannot be said to have ended until at least 6 mm. of rain have fallen in three, or less, consecutive days.

* *Report of the Fire Research Board with the Report of the Director of Fire Research for the Year* 1951. H.M. Stationery Office. [Price 2*s*. net.]

# NOTES.

LAUNCH OF THE "PRINCESS" FLYING BOAT.

ON Tuesday, August 19, the 140-ton Princess flying boat, designed and constructed by Messrs. Saunders-Roe, Limited, East Cowes, Isle of Wight, was launched from the slipway on the river Medina. The Princess is the largest aircraft ever built in this country; it was designed to be powered by ten Bristol Proteus III propeller turbines, but, on account of delays in the production of these engines, in the prototype aircraft which has just been launched Proteus II engines, of lower power, have been fitted to enable flight trials to be commenced. Originally intended as a commercial air liner for the North Atlantic route, the Princess, with Proteus III engines, is estimated to have a still-air range of 5,500 statute miles, at an average cruising speed of 380 m.p.h., with a payload of 40,000 lb. As a military transport, the Princess would be capable of carrying 200 troops over a stage distance of 3,550 miles. The prototype aircraft, however, will be used for experimental flying. Construction of the two other Princess aircraft, already well advanced, is in abeyance, pending the availability of Proteus III engines. The prototype Princess was launched, by means of a winch and cable, on a beaching chassis which can float. The chassis comprises two four-wheeled main units, which are attached to the wing structure on each side of the hull, and a two-wheeled bow unit engaging with the nose hull structure.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

The centenary of the formation of the North of England Institute of Mining and Mechanical Engineers is to be marked by a special meeting, to be held at the headquarters, Neville Hall, Newcastle-on-Tyne, on September 22 and 23. Concurrently, there will be an Exhibition of Mining in the Durham University School of Mines, at King's College. The formation of the Institute, which was incorporated by Royal Charter in November, 1876, arose out of a series of inquiries into colliery explosions on the North-East Coast, the immediate outcome of which was the passing, in 1850, of the first Act governing the inspection of coal mines. A meeting of mine-owners, viewers and others interested was held in the Coal Trade Office at Newcastle, on July 3, 1852, when it was decided to form a society to "discuss the means for the ventilation of coal mines, for the prevention of accidents, and for general purposes connected with the winning and working of collieries." Thus was constituted the North of England Institute of Mining Engineers, with Nicholas Wood, the friend and associate of George Stephenson, as first President; the addition of "and Mechanical" to the title was made some 14 or 15 years later. The present occupant of the presidential chair is Professor Granville Poole, who is the 48th holder of that office. In connection with the centenary, an appeal is being made for money to establish a capital fund to maintain the Institute's activities in the future.

ELECTRIC POWER AND THE SOUTH KENSINGTON SCIENCE MUSEUM.

The current issue of the *Journal* of the Institution of Electrical Engineers contains an announcement which will be of interest to all those who recognise the historical and educational value of museums, as well as that the displays should tell a coherent and accurate story. It is stated that the re-building programme of the Science Museum at South Kensington is to include provision for a site in a commanding position for an Electrical Power Collection. This will enable the existing exhibits to be re-staged and others added, while at the same time effective use will be made of modern display techniques. Although the Museum authorities will supply and maintain the necessary exhibition space, they have very limited funds with which to purchase the necessary exhibits. The cost of providing these must therefore fall on the industry and we are glad to learn that an appeal for 75,000*l*., which has been made for this purpose, has already received substantial support. It is intended that the Collection shall be accommodated on the ground floor of the new block of the Museum which was first used last year to house the Exhibition of Science, held in connection with the Festival of Britain. It will include an historical exhibit, covering the period 1825 to 1890 and illustrating the work of the early inventors and pioneers. The period from 1880 to the present day will be represented by sections illustrating the generation and distribution of electricity, its conversion to mechanical power and its measurement. It is hoped that the Collection will be ready for public inspection by the autumn of 1953 or soon afterwards, although this will depend on the rate at which the expenditure of the Government's contribution is authorised. The Committee on Electrical Exhibitions are proposing to turn their attention next to the modernisation and expansion of the other electrical displays at South Kensington, especially those concerned with electric traction, telecommunications and electricity and magnetism. The aim of all this work is to stage the electrical exhibits as an integrated whole and in a manner worthy of the importance to the public welfare of electrical science and engineering.

CHEMISTRY OF CEMENT: INTERNATIONAL SYMPOSIUM.

An international symposium on the chemistry of cement is to be held in London from September 15 to 20, 1952; the programme, which has been organised jointly by the Cement and Concrete Association and the Building Research Station, is to be held, on the first day, at the Royal Institution, 21, Albemarle-street, W.1, and thereafter at the Royal Society of Arts, John Adam-street, Adelphi, W.C.2. The official language will be English. Registration will take place on Monday morning, September 15, at the Royal Society of Arts, and on Monday afternoon at the Royal Institution. The first session held at the Royal Institution will be opened with addresses of welcome by the President, Sir Ben Lockspeiser, F.R.S., Secretary of the D.S.I.R., and Sir Francis Meynell, R.D.I., Director of the Cement and Concrete Association and vice-president of the Symposium. They will be followed by the introductory addresses, which are to be given by Dr. A. Alan Bates, vice-president of the Portland Cement Association, U.S.A., and by Professor H. Lafuma, Director, Centre d'Etudes et de Recherches de l'Industrie des Liants Hydrauliques, France. The first session will be completed by a paper and discussion on "The Early History of Portland Cement in England," by Mr. P. Gooding, A.M.I.Struct.E., and Dr. P. E. Halstead. A Government reception will be held in the evening. The remaining sessions will be held at the Royal Society of Arts, when the following groups of papers will be given and discussed. The second session, on Tuesday, will be devoted to "The Constitution of Portland Cement," which will be followed in the third session on the Wednesday by papers under the heading of "The Setting and Hardening of Portland Cement." "Special Cements" forms the subject of the fourth session (Thursday morning), and the fifth and final session, on Friday morning, will be concerned with "Applications of Research," and the closing address will be given on "Cement Research and the Future," by Dr. F. M. Lea, C.B.E., Director of the Building Research Station. On the evening of Wednesday, September 17, the Cement and Concrete Association will be giving a banquet; attendance will be by invitation only. Arrangements have also been made for visits during the week to the Building Research Station, Garston, Hertfordshire; the laboratories at Birkbeck College, University of London, 21, Torrington-square, London, W.C.1; the research laboratories of the Associated Portland Cement Manufacturers, Limited, Stone, Greenhithe, Kent; a cement works and the Cement and Concrete Association's Research Laboratory, Wexham Springs, Stoke Poges, Buckinghamshire. The symposium will be closed by a conversazione on the Friday evening. Further details may be obtained from the organising secretary, at the offices of the Cement and Concrete. Association, 52, Grosvenor-gardens, London, S.W.1.

# OBITUARY.

## COLONEL T. M. HUTCHINSON, D.S.O., O.B.E.

WE note with regret the death, on August 16, of Colonel T. M. Hutchinson, D.S.O., O.B.E., M.I.Mech.E., who, though he commenced a Service career in the infantry and served in the Boer War, afterwards transferred to the Army Service Corps, studied the theory and practice of motor transport, and took a prominent part in mechanising the supply lines of the Army.

Thomas Massie Hutchinson was born at Harpurhey, Lancashire, on February 14, 1877, the son of the Rev. T. W. Hutchinson, and was educated privately, at Great Yarmouth Grammar School, and at Cambridge, where he studied higher mathematics, applied mechanics, chemistry and physics. He was commissioned in the Militia in 1898 and granted a regular commission in the East Surrey Regiment in 1899. From that year until 1902, he served in Natal, Zululand, Pongola Bush, Transvaal, Orange Free State and Cape Colony, and was present at the relief of Ladysmith. He won the Queen's Medal with four clasps and the King's Medal with two clasps. His chief interest, however, was in motor transport—he had been a motorist even before he went to South Africa and his work at the University was on engineering subjects. In 1903, therefore, he transferred to the Army Service Corps. He gained his first practical experience at the Chatham workshops of the Royal Engineers, on fitting and erecting, steam-engine repairs and driving. Then for three years he was in charge of the Corps' transport in Ireland.

Between 1907 and 1914, during which time he was a motor-transport instructor at the A.S.C. Aldershot training establishment, he applied himself to study at the City and Guilds Institute, South Kensington, gaining a first-class and a bronze medal in motor-car engineering in 1909, and first-class honours in 1910. Towards the end of his period as instructor he was appointed a member of the War Office committee on mechanical transport and in 1914 was made secretary of the committee. In that year, too, he was promoted to field rank, having been made a captain in 1905. With the outbreak of war, he quickly rose to the position which his experience and qualifications—probably almost unique at that time—had earned him: he became Chief Inspector of Mechanical Transport to the British Expeditionary Forces in France and Flanders, with the rank of Lieut.-Colonel, and held this post from May, 1915, to 1919. For his services, he was mentioned four times in dispatches, awarded the D.S.O. in 1917 and made an O.B.E. in 1919.

After the war, Colonel Hutchinson was War Office Inspector of Mechanical Transport from 1920 to 1924, and from 1926 to 1930 he was an advisor on mechanical transport to the India Office. He retired from the Army in 1933, and until his death he was a director of the Hammond Engineering Company, Limited, Enfield, Middlesex, makers of rotary compressors, exhausters and pumps. In his later years he was a member of a number of committees, including a War Office tank technical sub-committee, automobile committees of the British Engineering Standards Association (now the British Standards Institution), the Engineering Board of the Department of Scientific and Industrial Research, and others which advised the General Staff on matters relating to mechanical transport and fighting vehicles. He was elected a member of the Institution of Mechanical Engineers in 1920.

SMALL RESETTING COUNTERS.—English Numbering Machines, Limited, 25, Queensway, Enfield, Middlesex, have introduced improved versions of their four and five figure small resetting counters. They are available with either a ratchet or universal drive, the former providing a count for each shaft oscillation of 45 to 50 deg., the latter for each full revolution of the shaft (it can also be used as a rachet-operated unit for oscillations greater than 130 deg.). Performance rating is up to 1,000 counts per minute. The figure design provides for clear reading at 9 to 10 ft. distance. Re-set is by a single turn of a knob, although a modification to a lock and Yale-key reset is being planned.

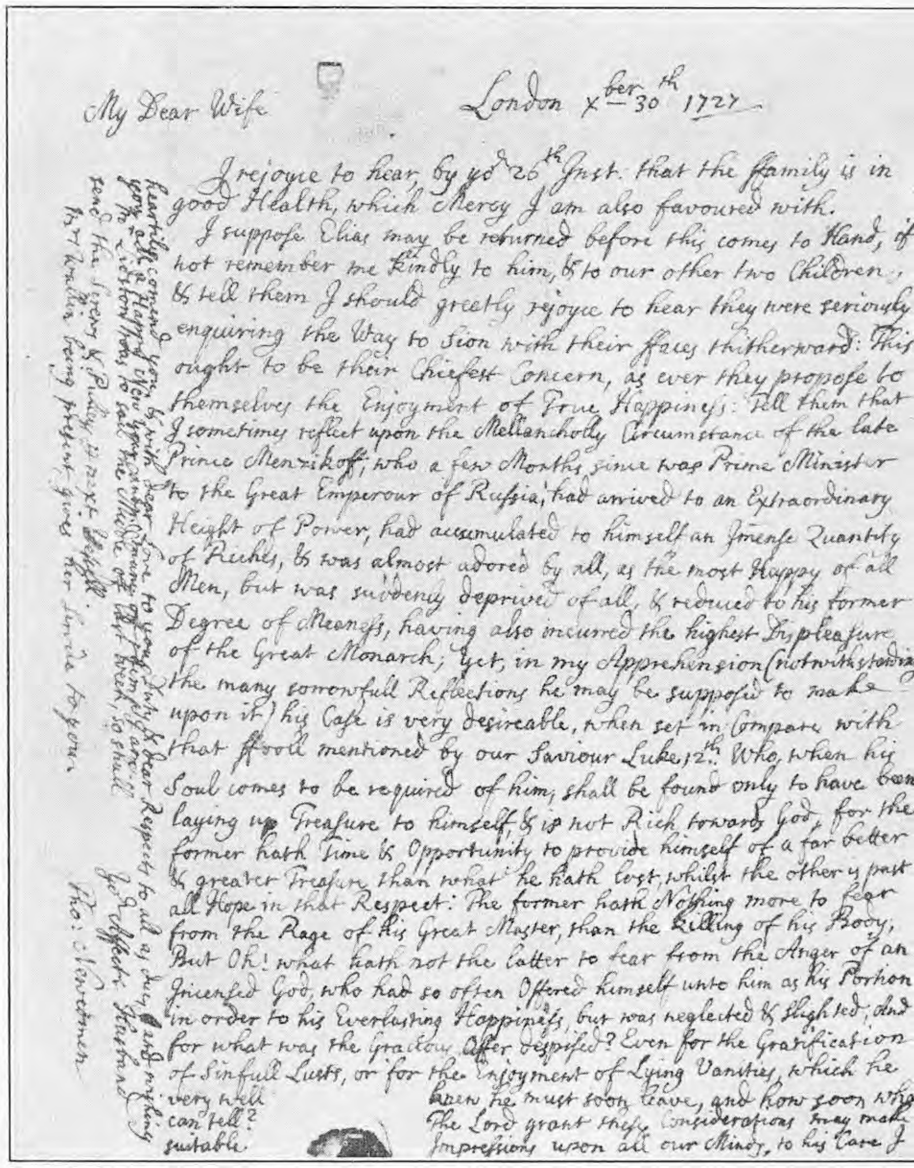
# HOLOGRAPH LETTER OF THOMAS NEWCOMEN.

To Mrs Hannah Newcomen

4

in

Dartmouth.



My Dear Wife London Xber 30th 1727

I rejoyce to hear, by yrs 26th Inst. that the ffamily is in good Health, which Mercy I am also favoured with.

I suppose Elias may be returned before this comes to Hand, if not remember me kindly to him, & to our other two Children, & tell them I should greatly rejoyce to hear they were seriously enquiring the Way to Sion with their ffaces thitherward: This ought to be their Chiefest Concern, as ever they propose to themselves the Enjoyment of True Happiness: Tell them that I sometimes reflect upon the Mellancholly Circumstance of the late Prince Menzikoff, who a few Months since was Prime Minister to the Great Emperour of Russia, had arrived to an Extraordinary Height of Power, had accumulated to himself an Imense Quantity of Riches, & was almost adored by all, as the most Happy of all Men, but was suddenly deprived of all, & reduced to his former Degree of Meaness, having also incurred the highest Displeasure of the Great Monarch; Yet, in my Apprehension (notwithstanding the many sorrowfull Reflections he may be supposed to make upon it) his Case is very desireable, when set in Compare with that ffool mentioned by our Saviour Luke 12th Who, when his Soul comes to be required of him, shall be found only to have been laying up Treasure to himself & is not Rich towards God, for the former hath Time & Opportunity to provide himself of a far better & greater Treasure than what he hath lost, whilst the other is past all Hope in that Respect: The former hath Nothing more to fear from the Rage of his Great Master, than the killing of his Body, But Oh! what hath not the latter to fear from the Anger of an Incensed God, who had so often Offered himself unto him as his Portion in order to his Everlasting Happiness, but was neglected & slighted; and for what was the gracious Offer despised? Even for the Gratification of Sinfull Lusts, or for the Enjoyment of Lying Vanities, which he very well knew he must soon leave, and how soon who can tell? The Lord grant these Considerations may make suitable Impressions upon all our Minds, to his Care I

Yr Affect: Husband

Tho: Newcomen

## COMMEMORATION OF THOMAS NEWCOMEN.

A YEAR ago, we recorded the efforts that were being made in the town of Dartmouth, at the instigation of Mr. Percy Russell, F.S.A., to establish as an annual event a ceremony to commemorate the birth of Thomas Newcomen (1663-1729), inventor of the first successful steam engine, who was born in the town and spent there the greater part of his life. It had been the custom for a number of years to deposit on his monument, on or near August 5—the actual date of his birth—a chaplet of laurel, the ceremony usually being carried out by the Mayor, on behalf of the Newcomen Society for the Study of the History of Engineering and Technology. In 1951, with the collaboration of the Dartmouth Rotary Club, a luncheon was held and an address was given by Dr. W. G. Hoskins, reader in economic history at the University of Oxford; but this year, though there was no address corresponding to that of Dr. Hoskins, the occasion was invested with a more extensive ceremonial and Mr. Russell—again the organiser of the function—was able to secure the co-operation of a number of societies, British and American, in support of the recently constituted Dartmouth Newcomen Association, which was formed for the purpose of fostering the memory of Thomas Newcomen. Of still greater historical significance, he was able to produce for the inspection of the company which assembled on August 16 in the Dartmouth Guildhall the holograph letter of Thomas Newcomen which we reproduce on this page, the existence of which came to light as a result of the publicity given to last year's function. Only one other letter is known, in the Staatsbibliothek at Berlin; and two signatures on deeds in the Dartmouth archives. The authenticity of the Berlin letter was in some doubt, but comparison with the present letter proves that the Berlin letter also is genuine.

The societies participating in this year's commemoration, in addition to the Dartmouth Newcomen Association and the Newcomen Society, were the North American Newcomen Society (originally a branch of the British parent society), which was represented by Dr. Charles Penrose, senior vice-president in North America; the American Society of Mechanical Engineers, whose secretary, Colonel C. E. Davies, is a past President of the parent society; and the South Devon branch of the English Speaking Union, represented by the President, Sir Reginald Leeds, Bt. The parent Newcomen Society was represented by its President, Mr. J. Foster Petree, and its honorary secretary, Mr. A. S. Crosley. Dr. Penrose was supported by Major F. J. Ney, M.C., LL.D., a member of the Canadian Committee of the North American Newcomen Society; Mr. Bryant Baker, of New York; Mr. Hollis Baker, of Grand Rapids, Michigan; Captain E. H. Thiele, U.S. Coast Guard; and Lieut.-Commr. V. E. M. May, R.N.

The proceedings opened with a reception in the Guildhall by the Mayor of Dartmouth (Alderman A. M. W. Chapman) and the Mayoress, at which were displayed the Corporation regalia, etc., and the letter of Thomas Newcomen. The company then walked in procession to the Royal Avenue Garden on the water front, where a wreath and four chaplets were placed on the Newcomen memorial; the wreath by the Mayor, on behalf of the Dartmouth Newcomen Association, and the chaplets by Mr. Petree, for the Newcomen Society, by Dr. Penrose for the North American Newcomen Society, by Mr. Bryant Baker for the American Society of Mechanical Engineers, and Major Ney for the Canadian Newcomen Committee. Another chaplet, in memory of the late Dr. H. W. Dickinson, founder secretary of the Newcomen Society, who died on February 21, 1952, was laid by Mr. A. S. Crosley.

At the subsequent luncheon, held in the Raleigh Hotel, the chair was taken by Councillor F. C. B. Kirk, chairman of the Dartmouth Newcomen Association. The toast, "The Memory of Thomas Newcomen," was proposed by Dr. Penrose, who coupled with it that of Dr. Dickinson, to whose enthusiasm for the study of engineering history the growth of the Newcomen Society, in England and America, owed so much. The toast of "The Newcomen Society" was proposed by Councillor H. G. White, M.A., of the Royal Naval College, and was acknowledged by Mr. J. Foster Petree; and that of "The Borough of Clifton-Dartmouth-Hardness," by Mr. Hollis Baker, the Mayor responding. In the afternoon, by the kindness of Mrs. Hine-Haycock, the English Speaking Union gave a garden party in the grounds of her house, Kittery Court, Kingswear—a singularly appropriate venue, the summer headquarters of the North American Newcomen Society being at Kittery Point, Maine, which owes its name to members of a Dartmouth family who settled there in the Eighteenth Century.

APPRENTICESHIP IN THE GAS INDUSTRY.—A booklet entitled "Pathways to Opportunity," giving particulars of the trade-apprenticeship schemes organised by the Gas Council and the Area Gas Boards, has been issued recently by the Gas Council, 1, Grosvenor-place, London, S.W.1. Boys between 15 and 17 years old are eligible for apprenticeship. They require a report from the headmaster of their school, and they may be asked to undergo general knowledge and aptitude tests.

# "BRITANNIA" PROPELLER-TURBINE AIR-LINER.

BRISTOL AEROPLANE COMPANY, LIMITED, FILTON, BRISTOL.

FIG. 5. THE "BRITANNIA" IN FLIGHT.

Fig. 6.

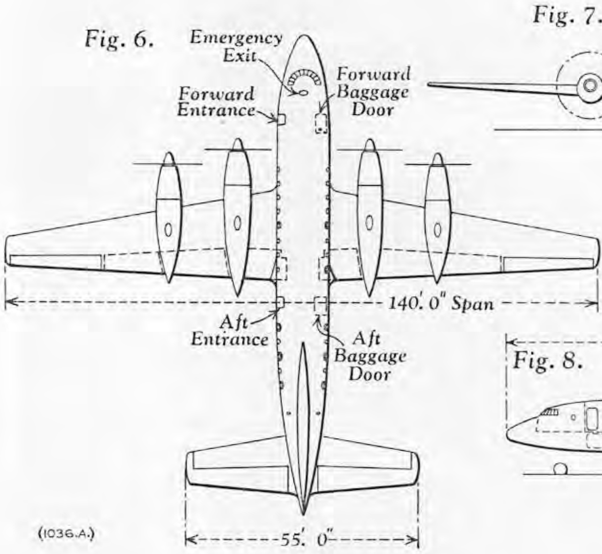



Fig. 7.

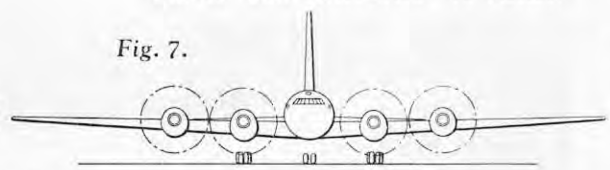
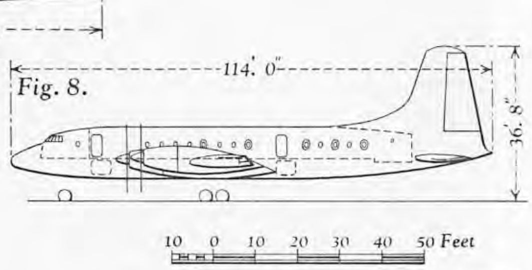


Fig. 8.




## BRISTOL "BRITANNIA" PROPELLER-TURBINE AIR-LINER.

LAST Saturday (August 16), the 140,000-lb. Bristol 175 air-liner, known by the builders as the Britannia, successfully completed her maiden flight. The development of the Britannia has been followed with considerable interest by the air-transport industry, because it is believed that, as a result of its propeller-turbine power plants and its structural efficiency, it sets a new standard in economy, flexibility of operation, and load-carrying capacity, at a cruising speed of about 360 m.p.h., which is high in comparison with existing air-liners other than the jet-propelled Comet. The "revenue index" of the Britannia is estimated to be 4,000 ton-miles per hour, an exceptionally high figure. The Britannia was conceived as a result of a preliminary specification for a medium-range air-liner issued by British Overseas Airways Corporation in 1946. The Bristol company's tender, in competition with other entries, was selected, and since then the aircraft has been developed into a long-range air liner, in close collaboration with B.O.A.C. Orders for 26 aircraft have been placed by the Corporation, and deliveries are expected to commence in 1954.

A photograph of the prototype Britannia on her first flight is reproduced in Fig. 5, above. The conventional low-wing monoplane layout of the aircraft, which has a tricycle undercarriage with four-wheel bogie main units, can be seen in Figs. 6, 7 and 8. The fuselage, which is cylindrical over most of the cabin portion, has a maximum diameter of 12 ft., and the overall length is 114 ft. The height of the aircraft is 36 ft. 8 in., and the track is 31 ft. The wing span is 140 ft., the gross wing area is 2,055 sq. ft., and the aspect ratio is 9·55. Fuel is carried in flexible bag tanks in the wings, with a capacity of 6,800 Imperial gallons. Power is provided by four Bristol Proteus propeller turbine engines driving 16 ft. diameter four-bladed de Havilland Hydromatic propellers of the hollow-steel reversible-pitch type. The whole of the fuselage interior forward of the front fin-attachment frame, which forms an airtight bulkhead, is pressurised and air conditioned, with the exception of a nose compartment below the flight-deck floor, housing the nose-wheel unit, and a small servicing compartment below the cabin floor immediately forward of the wing, which is carried across the fuselage. Thermal de-icing is provided for the wing, the tail-surface leading edges, the propeller blades, and the pilot's windscreen.

### PERFORMANCE AND ROLE.

B.O.A.C. are proposing, at present, to operate two versions of the Britannia, the first with seating for 60 passengers, and, later, a tourist version for 90 passengers. They will fly on fast trunk-route services. Up to 104 passengers can, in fact, be carried in the Britannia, and in addition there are two large freight holds, with a total cubic capacity of 668 cub. ft., below the cabin floor. At an average cruising speed of about 360 m.p.h., a maximum payload of 25,000 lb. can be carried, it is estimated, over a still-air range of 4,000 statute miles. After allowing for fuel reserves to cater for diversions, adverse winds, etc. (according to the standards agreed by the Society of British Aircraft Constructors), this corresponds to a stage distance of about 3,150 miles. With full fuel tanks (6,800 Imperial gallons), the aircraft has an estimated maximum still-air range of 5,600 statute miles with the pay load, under these conditions, limited to 12,000 lb. Thus, over the east-to-west crossing of the North Atlantic, where exceptionally severe head-winds are encountered throughout the year, flying directly between London and New York, 50 passengers and their baggage can be carried on 80 per cent. of occasions; the New York to London crossing, with 50 passengers, can be carried out with 100 per cent. regularity. On routes where severe head-winds are not encountered normally and therefore lower fuel reserves can be allowed, the Britannia should be able to operate over a stage distance of about 4,600 miles with full fuel tanks and 12,000 lb. payload. Calculations of the direct operating costs (again, according to the standard method of the Society of British Aircraft Constructors) indicate that, for stage lengths ranging from 1,000 to 3,000 miles, there is little variation from the optimum operating cost. Reasonably economical operation should be possible even over stages as short as 500 miles.

It should be made clear that the range and performance figures quoted above relate to the production aircraft, which will have four Proteus 705 propeller-turbine engines, each developing 3,320 shaft horse-power plus 1,200 lb. thrust under static sea-level conditions. A description of the Proteus 705 power plant was given on page 792 of our 173rd volume (1952). In the prototype aeroplane now flying, Proteus 625 engines of lower power are fitted, but ultimately they will be replaced by Proteus 705 engines. With the latter type of engine, it is estimated that, at the maximum take-off weight of 140,000 lb. and standard atmospheric conditions, the aircraft will take off against a 5-m.p.h. wind at sea-level and will clear a 50-ft. obstacle in a distance of 3,700 ft. This distance increases to 6,400 ft. at an ambient temperature of 27 deg. C. and a pressure altitude of 5,500 ft. The Britannia can land over a 50-ft. obstacle, in a 5-m.p.h. wind, within a distance of 2,800 ft.

To allow for rapid changes of role, an ingenious floor structure has been adopted in the Britannia. As may be seen in Fig. 9, which shows the interior of the fuselage structure, there are eight longitudinal seat bearers, four on each side of the cabin, with holes drilled at 1-in. pitch to receive the quick-release hooks which anchor the seats. With this arrangement, it is possible to fit individual seats for four abreast (two on each side of the aisle), or multiple two-seat or three-seat units to accommodate five or six passengers abreast. The 60-passenger layout to be adopted initially by B.O.A.C. will seat four abreast, with a galley and single toilet for men and crew members forward; the men's and women's wash rooms, and three toilets, will be at the aft end of the cabin. Electrically-operated flushing closets are provided in the toilets. Water supplies for the galley, toilets, and the cabin humidifier are carried in insulated stainless-steel tanks, with a total capacity of 100 Imperial gallons, installed in the roof. In the high-density version, to be adopted later, the passengers will be seated in two columns of three seats abreast.

### STRUCTURAL DESIGN.

As may be seen from the weight-breakdown summary, given in Table I, the high load-carrying capacity of the Britannia is a result partly of the lightweight propeller-turbine power plants, but principally of the structural efficiency.

TABLE I.—*Summary of Britannia Weight Breakdown.*

| | Weight, lb. | Percentage of All-up Weight. |
|---|---|---|
| Structure .. .. .. .. .. | 32,599 | 23·3 |
| Power plant .. .. .. .. | 19,199 | 13·7 |
| Fuel and oil systems .. .. .. | 2,370 | 1·7 |
| Air frame services, comprising flying controls, hydraulic and electrical systems, engine-driven accessories .. | 4,051 | 2·9 |
| Air-frame equipment, comprising radio, instruments, automatic pilot, anti-icing systems, fire protection, etc. .. | 3,019 | 2·2 |
| Cabin furnishings (for 90-passenger version) .. .. .. .. .. | 8,187 | 5·8 |
| Operator's service items .. .. .. | 3,408 | 2·4 |
| Basic operational weight .. .. | 72,833 | 52·0 |
| Crew and baggage (4 flight, 2 stewards, 1 stewardess) .. .. .. .. | 1,495 | 1·1 |
| Payload .. .. .. .. .. | 25,000 | 17·8 |
| Fuel and oil .. .. .. .. | 40,672 | 29·1 |
| All-up weight .. .. .. .. | 140,000 | 100·0 |

The low structure weight of the Britannia has been attained, to a large extent, as a result of the comprehensive structural-design investigations undertaken for the Brabazon project. (A summary of some of the Bristol studies on riveted structures was given on page 467 of our 170th volume (1950).) Great attention has been paid to detail design and to comprehensive testing. Redux-bonded reinforcement has been widely adopted, although not in the primary load-carrying structure; the methods developed for the bonding process were described on page 144 of our 171st volume (1951). In general, the loads are distributed over the structure, and heavy structural sections are avoided. The wing is continuous through the fuselage, and the wing skin is unbroken by the nacelles and engine tail-pipes. Although setting the tail-pipes above the wing surface has caused some additional body drag, it is amply compensated by the resulting weight saving.

## "BRITANNIA" PROPELLER-TURBINE AIR-LINER.

BRISTOL AEROPLANE COMPANY, LIMITED, FILTON, BRISTOL.

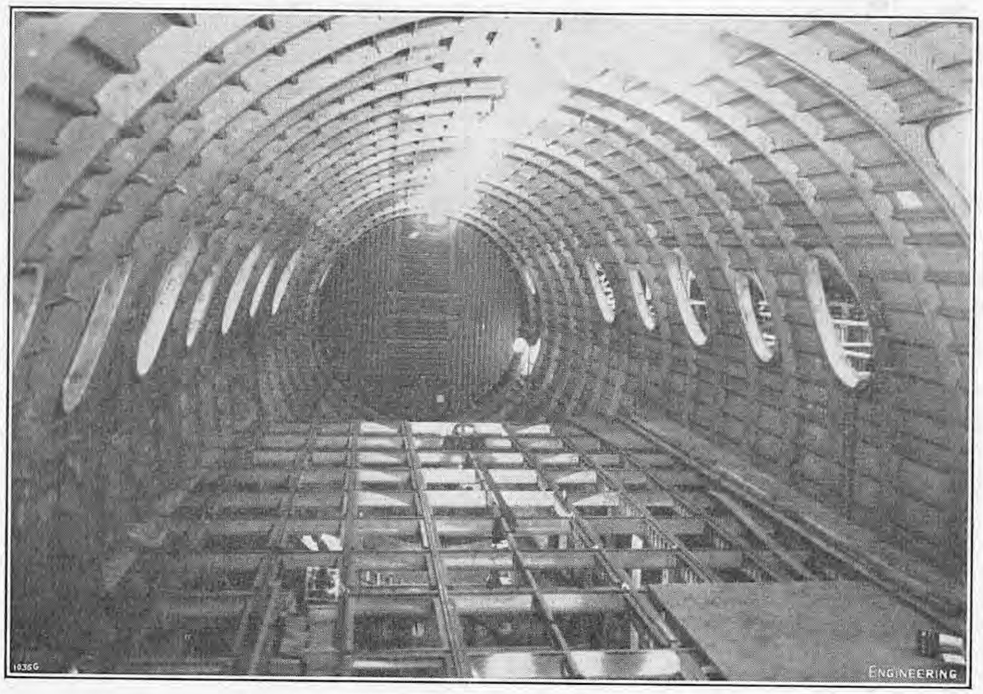



FIG. 9. FUSELAGE STRUCTURE, LOOKING AFT.

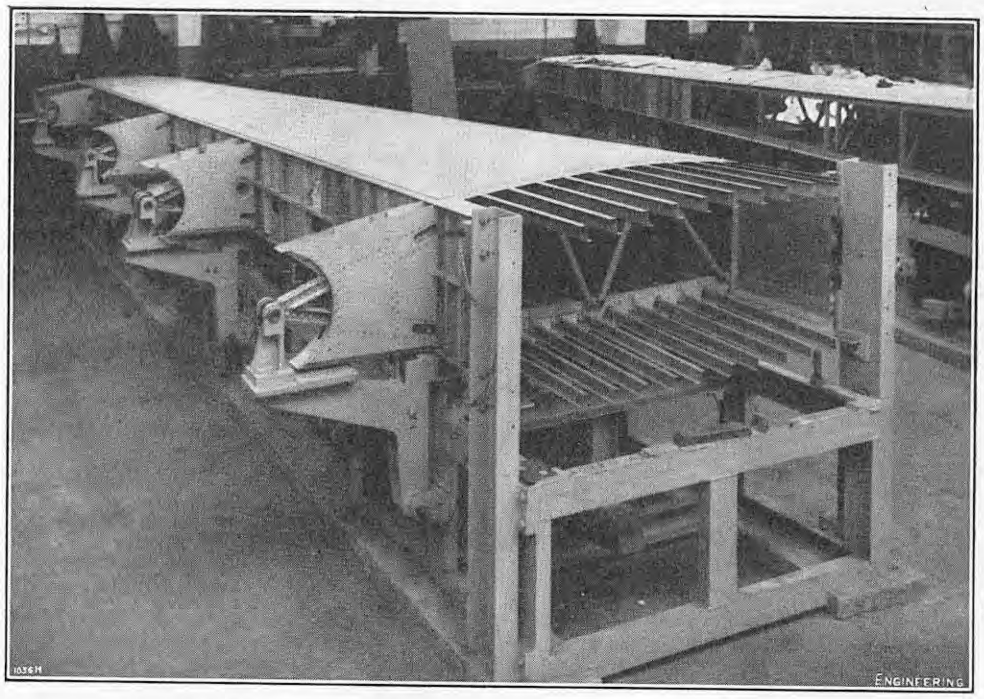



FIG. 10. WING DURING ASSEMBLY, SHOWING STRUCTURAL FEATURES.

In constructing the Britannia, a departure has been made from the conventional practice of building up the aircraft outwards from frames located in fixed jigs, as in the construction of the Brabazon (described on page 261 of our 168th volume (1949)). Instead, a form of panel construction has been used, building inwards from the skin panels and assembling the stiffened skin panels in final-assembly jigs. By this means a close control of profile can be obtained, and "squeeze riveting," one of the manufacturing processes developed by the Bristol company for reducing distortion introduced by riveting, can be employed. Where Redux-bonded reinforcement is used, moreover, the panel method of construction is essential.

### WINGS AND TAIL SURFACES.

Considering first the wing structure, a fairly heavy gauge skin is employed, with a constant thickness of 10 s.w.g. over the inboard portion. Outboard of the outer nacelle, the skin is tapered, to 18 s.w.g. at the wing tip. The primary structure comprises a torsion box formed by the upper and lower wing-skins, which are strongly reinforced by closely-spaced parallel spanwise stringers of extruded Z section, and carry about 98 per cent. of the bending loads; and by two shear webs, at 15 per cent. and 50 per cent. of the chord. The structure is shown clearly in Fig. 10. The upper and lower boundary angles of the shear webs serve for attaching the shear webs to the skin, and do not function as

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BRISTOL AEROPLANE COMPANY, LIMITED, FILTON, BRISTOL.

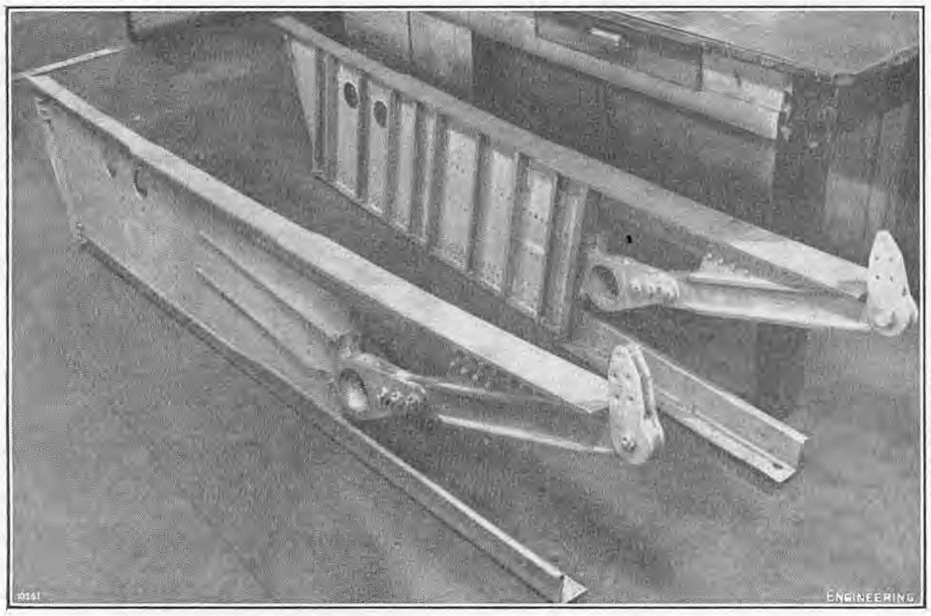


FIG. 11. "EXTERNAL" RIBS OF INBOARD NACELLE.

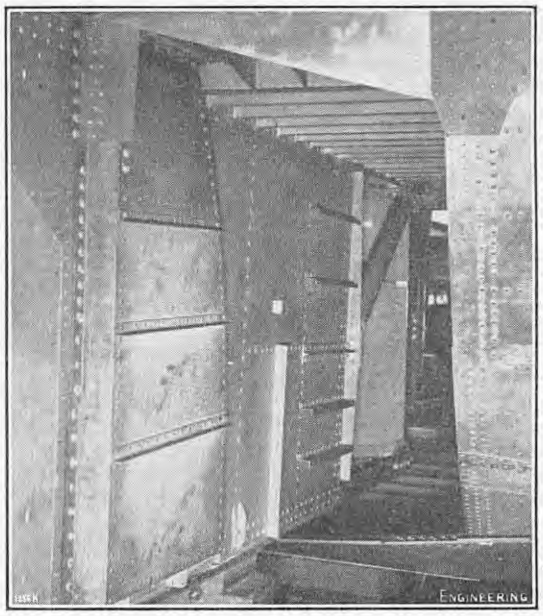


FIG. 12. CENTRE-LINE JOINT OF WING IN FUSELAGE.

spar booms. By using closely-spaced stringers, it has been possible to adopt a wide rib spacing, so that nine large flexible-bag fuel tanks can be installed in each wing, from the side of the fuselage out to the aileron rib. Enclosing each bag tank are double-skinned diaphragm-type ribs with a Redux-bonded corrugated-skin reinforcement. Intermediate "portal" ribs are used in the tank bays, to allow for inserting the tanks during assembly. Outboard of the fuel-tank bays, the ribs are of Warren girder construction. Additional ribs at the nacelles would normally have been required to take the engine and undercarriage loads, but it was found possible to avoid interfering with the tank space by building up "external ribs" to stabilise the wing skin. The upper external ribs form a housing for the engine tail-pipes. At the inner nacelle, the lower external ribs, illustrated in Fig. 11, above, also carry the trunnions for the under-carriage front radius rods. The port and starboard wings are joined on the centre-line of the aircraft through a heavy diaphragm rib, with Redux-bonded corrugated web reinforcement, and tubular "pyramid" bracing, which, as can be seen in Fig. 12, allows access to components and bag tanks installed in the wing.

The wing leading edge is used as a duct for the hot-air de-icing system. As shown in Fig. 1, on page 240, the outer skin is reinforced by an inner skin, Redux-bonded to it with chord-wise corrugations, which form guide channels for the hot air. At 6 per cent. chord, a spanwise diaphragm separates the hot-air supply and return ducts. The leading edge is supported from spigots on the front shear web of the primary wing structure (Fig. 10), which engage in bushes on the nose diaphragm. The trailing-edge structure comprises a series of box-section ribs carrying the aileron hinges and tracks for the double-slotted flaps, which extend over 32 per cent. of the chord. The skin panels of the trailing edge, flaps, and ailerous are reinforced with Redux-bonded Z-section stringers.

The structure of the tailplane, which is also carried across the fuselage, and of the fin, is similar to that of the wing. The tailplane and fin can, however, be readily detached from the fuselage for ease of replacement, whereas the wing cannot. Electrothermal leading-edge de-icers have been adopted for the tail surfaces instead of hot-air de-icing. The tailplane and fin leading edges are detachable to allow for replacement of the de-icer elements. The tip of the fin, which is insulated from the main structure, houses an aerial.

### BUILDING THE WINGS.

The primary wing structure is constructed in two sections, an inner section extending from the centre-line to the aileron boundary rib, and an outer section corresponding to the aileron span. In each case, the top and bottom skin panels are first formed and are placed horizontally in separate panel jigs. On each panel, the stringers are located in position, and guide rivet holes are drilled in the skin. The panel is then hoisted by winch arms to a vertical position, and the rivet holes in the skin are cut-countersunk to a controlled depth for flush riveting. The panel is attached by slings to a roller carriage running on an overhead runway, and is traversed to the riveting bay. The panel jig and adjacent handling gear can be seen in Fig. 2, on page 240; and Fig. 3 shows the inner-wing panels in the riveting bay. Here the panel is slung on a Warren girder, which can be raised or lowered by a winch between the jaws of a hydraulically-operated automatic squeeze-riveting machine. The latter has been developed by Bristol Aeroplane Company in conjunction with the Ratcliffe Tool Company, Limited, North Acton, London, N.W.10. The machine can be traversed longitudinally along tracks in the floor formed to the shape of the wing, and has an adjustable head which can be pivoted so that the rivets are always set normal to the skin profile; these motions are automatically brought about by a "feeler" mechanism.

After one side of the panel has been riveted it is reversed, and then the other side is completed. The stiffened panel is then removed, on a bogie trolley, to a "boxing up" jig; in this fixture, the lower skin panel is laid on a cradle, the ribs are assembled, the top skin is lowered and located, the shear webs are added to complete the torsion box, and the whole assembly is reaction-riveted by hand. Fig. 4, on page 240, shows the port wing in the boxing-up jig, the wing-root structure being clearly visible in the foreground. The nacelles and trailing edges are also attached to the inner wing on this jig. The outer wings are constructed similarly. The completed wing sections are transferred, on mobile jig trolleys, from the experimental shop where sub-assembly work has been carried out to the assembly hall. The jig trolleys are provided with V-wheels which engage in locating V-blocks set in the floor of the assembly hall. The trolley fixture is universally mounted to facilitate the mating of components. Hinged arms which are set in the floor provide means for locating the main undercarriage and engine-mounting attachment points.

*(To be continued.)*

## THE IRON AND STEEL INSTITUTE.

A SPECIAL meeting of the Iron and Steel Institute will be held in Swansea from Tuesday, October 7, to Thursday, October 9.

On October 7, an all-day visit to the Trostre Works of the Tin-plate Division of the Steel Company of Wales Limited, has been arranged. At this visit the chief guest will be Mr. Duncan Sandys, P.C., M.P., the Minister of Supply. In the evening a reception, given by the Mayor of Swansea, will be held in the Brangwyn Hall, Swansea.

On Wednesday, October 8, a morning visit will be paid to the Margam Works of the Steel Company of Wales Limited, where coke-ovens, blast furnaces and steelworks will be inspected. After luncheon at Margam, the afternoon will be devoted to a visit to the new steelworks and strip mills of the Abbey Works of the Steel Company of Wales Limited. In the evening a banquet and dance will be held at the Brangwyn Hall, Swansea.

On Thursday, October 9, several excursions and a number of visits have been arranged. These include day trips to Llanwrtyd Wells and to Tenby; morning visits to the Aluminium Wire and Cable Company, Limited, Port Tennant, Swansea; the British Iron and Steel Research Association, Sketty Hall, Swansea; Imperial Chemical Industries, Limited, Waunarlwydd, Swansea; the University College of Swansea; the Metal Box Company, Limited, Neath, Glamorgan; the Mond Nickel Company, Limited, Clydach, Swansea; National Oil Refineries Ltd., Llandarcy Works, Skewen, Neath; the National Smelting Company, Limited, Llansamlet, Swansea; and the Steel Company of Wales Limited, King's Dock, Swansea. Afternoon excursions will be made to Gower and district, and to the Vale of Glamorgan and Ogmore-by-the-Sea. The meeting will terminate with informal social evening gatherings, to be held at Swansea and Porthcawl.

## THE FUTURE OF THE BLAST FURNACE.

The possibility of changes in the design and operation of blast furnaces, in the admittedly somewhat distant future in so far as this country at all events, is concerned, is foreshadowed in an article in the current issue of *Steel News*, which is published by the British Iron and Steel Federation, Steel House, Tothill-street, London, S.W.1. After pointing out the high thermal efficiency attained by the normal tall blast furnace, which, however, requires hard and strong metallurgical coke, ore in lump form, and sintered ore fines to withstand the high stack pressure within the furnace, it is stated that there are indications that existing supplies of coking coal may not be sufficient to keep pace with increased demands for blast-furnace coke and that more finely-divided, soft and low-grade iron ores are gradually replacing the better-quality ores as the latter are becoming worked out. Consequently, it is felt that, in time, furnaces will be designed to enable smelting to be carried out with fuels such as non-coking coals and lignite. A blast-furnace with a normal tall shaft cannot use such materials and the solution to the problem is to adopt "low-shaft" furnaces, of which there are three types. The first type, the electric low-shaft furnace is a well-established piece of plant in Scandinavia, Switzerland and Northern Italy, but the other two, namely, the oxygen-enriched blast low-shaft furnace, and the low-shaft furnace, utilising briquetted charges, which may or may not employ enriched blast, are still in the experimental stage. The briquetted charge consists of ore, fuel and flux powdered, mixed and pressed into shape with a binder.

Trials at a low-shaft furnace, financed by international contributions through the Organisation for European Economic Cooperation (O.E.E.C.) are soon to be carried out at a works in Liége, Belgium. The furnace, which should come into production before the end of 1952, has an elongated oval hearth measuring 9 ft. 9 in. by 4 ft., and eight tuyeres. The vertical side walls are 16 ft. 6 in. in height from the tuyeres to the stockline, giving a ratio of height to average hearth diameter of about $3\frac{1}{2}$ : 1, or about half the normal for blast furnaces. The unit will produce about 60 tons of iron a day with normal blast and greater quantities if blast enriched with 30 per cent., or more of oxygen is employed. The experiments to be carried out will include high top-pressure operation, and the use of low-grade ores and poor-quality cokes and lignites. Similar work is in progress at Oberhausen, in the Rhineland, while a briquetted charge low-shaft furnace is in experimental operation at Cologne. These trials are being watched with interest in all European iron-making countries because of the benefits that are expected to accrue.

Third National Packaging Exhibition.—The next national packaging exhibition to take place under the auspices of the Institute of Packaging will be held at Olympia, London, W.14, from Tuesday, January 20, to Friday, January 30, 1953, both dates inclusive. For the present, these exhibitions will take place biennially, as shortages of many packaging materials, among other reasons, render annual exhibitions impracticable. The organisers are Provincial Exhibitions, Ltd., of City Hall, Deansgate, Manchester, and 167, Oakhill-road, London, S.W.15.

Corrosion and Temporary Protectives.—The Shell Petroleum Co. Ltd., have now issued the fifth in a series of technical publications dealing with specially prepared oils and their application. The first part of the publication, which is entitled "Corrosion and Temporary Protectives" is devoted to a consideration of the mechanism of corrosion and the atmospheric corrosion of engineering metals. The second part of the book deals with petroleum-base protectives and their application to external and internal surfaces, and the final section describes the "Shell Ensis" protectives. These, it is stated, vary from thin, oily films, giving protection for short periods indoors, to thick, comparatively hard films able to withstand lengthy weathering. Copies of the publication are obtainable on application to Shell-Mex and B.P. Ltd., Shell-Mex House, Strand, London, W.C.2, or from any of the firm's divisional offices.

## LABOUR NOTES.

Representatives of the Engineering and Allied Employers' National Federation agreed last week to meet the leaders of the Confederation of Shipbuilding and Engineering Unions to-day. This meeting was asked for by the Confederation's executive council after the delegates to the annual conference of the Confederation at Southsea had unanimously approved a resolution declaring their profound dissatisfaction with the rejection of their recent wage claims. The annual conference authorised the council to seek immediate meetings with the Engineering and Allied Employers' National Federation, the Shipbuilding Employers' Federation and the Railway Executive, to inform them of the serious situation which existed. The resolution also asked that the council should summon a special conference of the executive committees of the 38 unions affiliated to the Confederation at York on September 10 to receive a report on the council's meetings with the employers' organisations.

The conference's resolution was approved, however, only after considerable differences of opinion had been expressed regarding the resolution and its implications. The President of the Confederation, Mr. H. G. Brotherton, who moved its adoption, described the existing situation, arising from the rejection of the wage claims as volcanic. He said that there were people who thought in terms of a direct strike as a possible outcome, but anyone with a real understanding of the inner working of workpeople's minds knew that direct strikes were not the only way in which resentment could be shown. The resolution was seconded by a delegate from the Electrical Trades Union, who declared that it had to be made quite clear that neither the Confederation nor its affiliated members were in any mood to temporise, or in any way to surrender their wage claims.

A representative of the National Union of General and Municipal Workers, Mr. J. Cooper, laid much stress on the importance of collective bargaining and emphasised that members of the organisation he represented expected results from their leaders, not a situation which could be solved only by the almost obsolete strike weapon. He deplored a statement attributed to the secretary of the United Society of Boilermakers, that he would not restrain members of that union from any action which they might take in protest. Mr. Cooper suggested that the Confederation council should not merely press for the acceptance of the original claim of 40*s*. a week for all adult male manual employees, but be given power to negotiate. Mr. J. H. Wigglesworth, secretary of the Iron, Steel and Metal Dressers' Trade Society, criticised the council for deciding to demand an increase of 40*s*. and suggested that, if the movement was not justified in asking for such an increase, the council should not have lacked the courage and enterprise to tell them. One delegate, among the other speakers on the resolution, expressed the view that an increase of 11*s*. a week might be acceptable.

Further substantial demands to be made on the engineering employers, were referred to at the annual conference on the following day, August 14, after the date of the meeting with the Engineering and Allied Employers' National Federation had been announced. A resolution condemning the Government's economy measures and declaring that it was the responsibility of trade unions to demand wage increases, in order to effect improvements in the real wages of workpeople, was moved by Mr. J. Gardner, general secretary of the Amalgamated Union of Foundry Workers, and carried unanimously. Mr. Gardner said that by the time consultations with the employers were resumed it would require quite the 40*s*. a week increase merely to restore the wages of engineering employees to their 1939 value, and there would be no improvement.

Mr. Gardner's resolution proposed that, when the existing wage claim had been settled, the engineering employers should be requested to consolidate existing basic rates of wages and bonuses, and to provide a new minimum rate for piecework employees such as would ensure for these men earnings of one-third above the new minimum basic rate. Higher wages for apprentices and juvenile employees, increases in payments for holidays, and equal pay for women operatives were also called for in the same resolution. The consolidation of the present basic rate and bonuses would mean increases in the payment for overtime throughout the industry and it is considered that many classes of piecework employees would gain at least 20*s*. a week, should the employers agree to these demands. With respect to holiday rates, the suggestion was that payments should be based on the average earnings of the individual concerned and not on the bare time rate. Railway shopmen also would benefit from these concessions.

Warnings on the dangers of inflation were given by Mr. Hugh Gaitskell, Chancellor of the Exchequer in the previous Government, in a speech to Labour Party student organisations at South Woodford, Essex, on Monday last. He emphasised the need for recognising that claims for increases in wages could not always be met out of profits. There were some industries where that could be done, but one of the difficulties was that, while certain individual firms might be able to meet wage claims in that way, there would always be, in each industry, a number of firms which could not. This position did not arise where there were nationalised industries.

There were two dangers to be faced in respect to demands for higher wages. On the one hand, there was the steady inflation of incomes, accompanied by advances in costs and prices, and, on the other, a process that made it very difficult for the planning of the correct distribution of labour in the community to be effective. These were the crucial problems in the country's national economy. Unless they could be solved, it was difficult to see how full employment could be maintained without rising costs and prices. Trade-union leaders were well aware of the position and had given much thought to it.

Comments on the wage position in the engineering industry, written shortly after the rejection of the 40*s*. a week claim, are contained in the *Monthly Report* of the United Patternmakers' Association for August. Mr. W. B. Beard, the Association's general secretary, makes it clear that the statement by Sir Alexander Ramsay, the director of the engineering employers' Federation, when rejecting the claim, was a long one and that it dealt with almost every aspect of the subject. One point put forward, Mr. Beard states, was that earnings, as distinct from basic rates, were as high in the engineering industry as in any other, if not higher. The earnings for most trades were quoted and Mr. Beard re-quotes those for patternmakers, covering about 94 per cent. of the Federation's employing power. Employees on time work in June, 1951, received 9*l*. 3*s*. $8\frac{1}{4}$*d*. for 47·2 hours, and, in May, 1952, obtained 10*l*. 5*s*. $3\frac{3}{4}$*d*. for the same number of hours. Other pattern makers received 9*l*. 8*s*. $7\frac{1}{2}$*d*. in June, 1951, for 47·2 hours, against 10*l*. 7*s*. 3*d*. in May, 1952, for 47 hours.

Sir Alexander stated, Mr. Beard writes, that a weekly increase of 2*l*. in the engineering industry would lead to a spate of applications from other industries and that they would destroy the country's economy. The best service to the country and the workpeople themselves was to refuse the application. Mr. Beard comments that it is, of course, true that the country is in a very difficult position and that large wage claims might have a boomerang effect on workpeople generally if they are granted, or if strikes of any magnitude resulted from them. Stoppages of work would increase balance of payments difficulties and the pound would be worth much less than it is now, both at home and abroad. A similar situation could arise if large wage increases obtained by all classes of workpeople were not related to national productivity. The country had to live by its exports and a change of Government would not alter that position.

# WENVOE TELEVISION TRANSMITTING STATION.


FIG. 1. MAIN BUILDING AND AERIAL SYSTEM.


FIG. 2. CONTROL ROOM WITH MEDIUM-POWER TRANSMITTERS.

## TELEVISION TRANSMITTER AT WENVOE, GLAMORGANSHIRE.

WITH the start of regular television transmissions from Wenvoe, near Cardiff, on August 15, the British Broadcasting Corporation virtually completed the first stage of their plan to bring television programmes within the reach of the whole country. The Wenvoe transmitter is the last of the five high-power stations which were envisaged in the plan. For the present, and until its high-power transmitters are completed, the station is operating on a medium power of 5 kW for vision and 2 kW for sound. Even so, a large region of South Wales and South-West England has been added to the guaranteed television service area, which is now estimated to include 78 per cent. of the population of the United Kingdom. This is the largest national television coverage in the world.

The new station, which is illustrated in Fig. 1, on this page, is situated on a commanding site, of approximately 30 acres extent, close to the Cardiff-Swansea road and some five miles to the west of Cardiff. The buildings are 400 ft. above sea level, and as the main transmitting aerials are fixed on a 750-ft. mast, their total height exceeds 1,100 ft. This is an important feature, since much of the country within the service area is hilly. The vision transmitter operates on a frequency of 66·75 megacycles per second and the sound transmitter on 63·25 megacycles per second. These correspond to wavelengths of 4·495 and 4·745 m., which are the shortest of those employed by the B.B.C. in their television service. The folded-dipole aerials at Wenvoe, therefore, are somewhat smaller than those at the other four transmitters.

The medium-power vision and sound transmitters now in use at Wenvoe were built to specification by Marconi's Wireless Telegraph Company, Limited, Electra House, Victoria Embankment, London, W.C.2, and are similar in design to those supplied by this company to other television stations of the B.B.C. They are housed in a building separate from but close to the main building in which the high-power transmitters and their associated equipment are now being installed. When the latter are brought into service, the medium-power transmitters will be retained as a stand-by.

The medium-power vision transmitter is of the low-level modulated type and has a peak white output of 5 kW. Modulation is carried out at the 500-watt level and the signals are subsequently amplified by two class-B wide-band linear radio-frequency amplifiers, each of which is fitted with two BR 191 air-cooled triode valves supplied by the English Electric Company, Limited, Queen's House, Kingsway, London, W.C.2. The appropriate shaping of the vestigial side-bands is accomplished within the transmitter circuits and not in a separate filter, as in the case of the high-power transmitter now under construction. The valve filaments, with the exception of those in the modulated amplifier and the linear amplifiers, which derive their supplies from metal rectifiers, are heated by alternating current. The high-voltage supplies are obtained from hot-cathode mercury-vapour rectifiers, which provide a maximum of 3,000 volts for the anodes of the linear class-B amplifiers.

The sound transmitter has an output power of 2 kW and is of the conventional class-B modulated type. All the valve filaments are heated by alternating current and, as in the case of the vision transmitter, the crystal-controlled drive and the power-conversion equipment are an integral part of the transmitter. Both transmitters are housed in steel cubicles mounted in line, which present a continuous front in the control room, as illustrated in Fig. 2. The air-blast cooling equipment, supplied by Messrs. Rosser and Russell, Limited, 30, Conduit-street, London, W.1, and the vision and sound combining-filter are mounted behind the transmitter cubicles, which are built into a soundproof partition-wall, so as to isolate the noise of the air blowers from the control desk. The latter, seen in the foreground in Fig. 2, is fitted with a waveform monitor and two picture monitors in addition to the conventional controls and meters.

The controls of each transmitter are interlocked to ensure that the various power supplies are applied in the correct order and, where this is appropriate, after the correct intervals of time. Adjacent to the control desk, and visible in the background of Fig. 2, are the vision and sound input-equipment and the test-waveform generating equipment. The latter provides a variety of signals for testing, lining up, and maintaining the characteristics and performance of the vision transmitter.

The Wenvoe station will ultimately receive its vision programmes over a coaxial cable from London by way of Bristol and Cardiff. This cable is the property of the General Post Office and is part of its national distribution system for television. In the meantime, programmes from London travel by cable to Dollis Hill. Thence they are transmitted over an experimental radio linkage to Cardiff, whence they complete the journey to Wenvoe by cable. The accompanying sound transmission travels to Wenvoe over special telephone circuits similar to those used by the General Post Office for other broadcast transmissions.

The main mast which, as already mentioned, is 750 ft. high, was constructed according to specification by British Insulated Callender's Construction Company, Limited, Bloomsbury-street, London, W.C.1. Both the mast and aerial system—the latter supplied by Marconi's Wireless Telegraph Company, Limited—are generally similar to those used at Sutton Coldfield, Holme Moss and Kirk o' Shotts. The installation at the last of these was illustrated on page 205, *ante*. A separate 150-ft. mast, also constructed by British Insulated Callender's Construction Company, Limited, and visible in Fig. 1, carries emergency aerials. These have separate feeders, and switches are installed which permit a rapid change-over from the main to the stand-by system.

As at Holme Moss and Kirk o' Shotts, the outputs of the vision and sound transmitters are combined at ground level and conveyed to the main aerial over a single transmission line. The latter is similar to the one used at Kirk o' Shotts, which was described previously in ENGINEERING (vol. 173, page 361 (1952)). It was supplied by Electrical and Musical Industries, Limited, Blyth-road, Hayes, Middlesex, who are also supplying the high-power vision transmitter. The coaxial cable to the reserve aerials was supplied by the Telegraph Construction and Maintenance Company, Limited, 22, Old Broad-street, London, E.C.2.

The main building at the station contains the offices, canteen, quality-checking room, power-distribution switch-gear, control-room and hall for the high-power vision and sound transmitters. The latter, supplied by Standard Telephones and Cables, Limited, Connaught House, Aldwych, London, W.C.2, is already installed and the former is under construction.

## 204-H.P. DIESEL LOCOMOTIVE.

ANDREW BARCLAY, SONS AND COMPANY, LIMITED, KILMARNOCK.

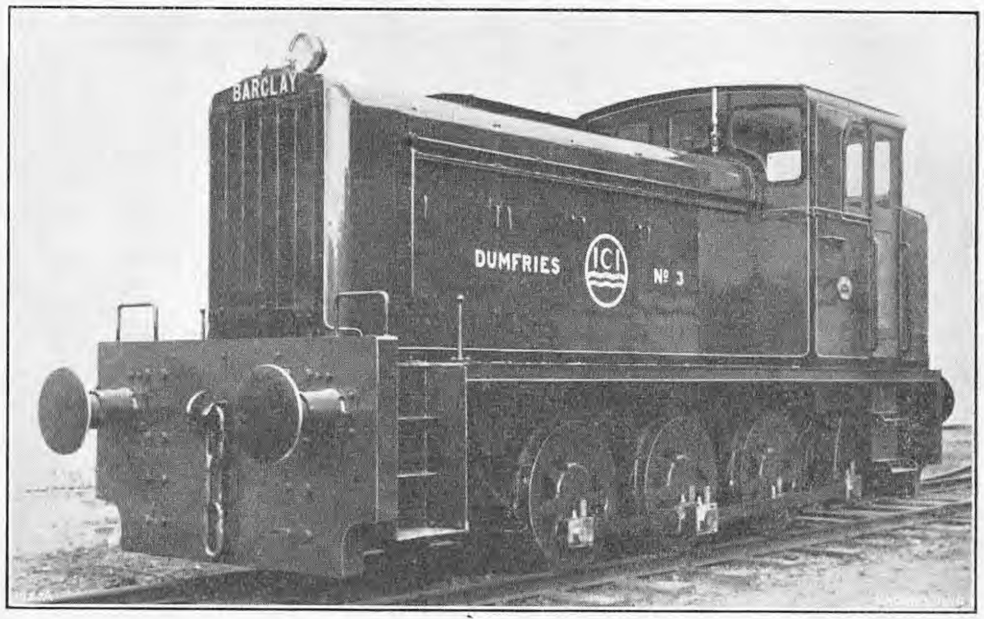



FIG. 1.

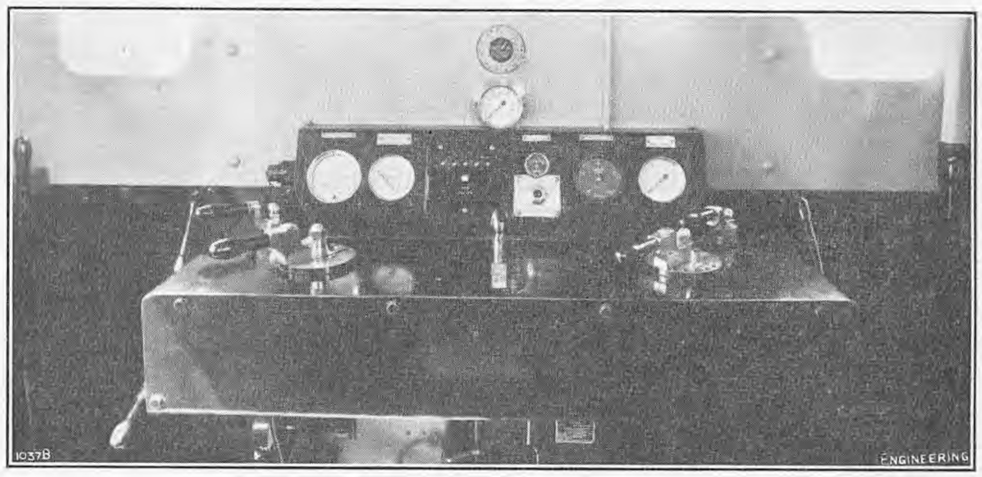



FIG. 2.

## DIESEL LOCOMOTIVE WITH OIL-OPERATED GEARBOX.

THE 204-h.p. Diesel locomotive shown in Fig. 1, above, has recently been built by Messrs. Andrew Barclay, Sons and Company, Limited, Caledonia Works, Kilmarnock, for the new Ardil factory, at Dumfries, of Imperial Chemical Industries, Limited. It is fitted with a Gardner engine and an S.L.M. oil-operated gearbox, and embodies the builders latest improvements in design and equipment. The six coupled wheels are driven by side rods from a jack-shaft; they are 3 ft. 2 in. in diameter and have a wheelbase of 8 ft. 6 in. The frames are exceptionally heavy, being 1½ in. thick, and buffer beams of steel plate 3 in. and 6 in. thick are fitted to give the weight necessary for adhesion. The engine is mounted on a sub-frame and the gearbox is bolted directly to the frames around the jack-shaft, which forms an additional frame stay and increases the rigidity of the frame structure. A six-feed Wakefield mechanical lubricator is coupled to the axleboxes.

The controls, with the exception of the reverse gear, are duplicated so that the locomotive may be driven from either side of the cab. The convenient arrangement of the controls is shown in Fig. 2; accessibility of all valves and connections to the instruments has received special attention. Teak doors and windows are fitted in the sides of the cab, the side windows being arranged to slide. All the windows are "glazed" with Perspex. The cab is fitted with a hot-water radiator supplied from the engine cooling system and, in addition, a special heater is fitted in which the exhaust gases are led through a coiled pipe so that it acts in the same way as a radiator. The flow of water through the radiator and of gases through the heater can be regulated. Messrs. Barclay's patent reversing control is fitted to prevent the reverse gear from being operated before the locomotive wheels have come to a standstill. Another interlock is provided so that the reverse gear cannot be operated unless the speed gear control is in neutral.

The engine is a Gardner 8L3 type, which has eight cylinders in line and is set to give an intermittent power output of 204 brake horse-power at 1,200 r.p.m. The Gardner engine and the reliability of its performance are well known, and it is therefore not necessary to give a detailed description of it here. The engine has the usual auxiliaries, consisting of twin electric starting motors, a 24-volt nickel-iron battery of 198 ampere-hour capacity, a centrifugal circulating pump and thermostatic by-pass control for the cooling water, oil-bath air filters, and filters for fuel and lubricating oils. A spark-arrestor silencer of Alexanders' vortex type is fitted. Cooling is provided by a Reliance sectional radiator. A refinement is the fitting of immersion heaters with thermostatic control in the water-cooling system and low-temperature tubular heaters under the crankcase to keep the engine warm in cold weather and to ensure easy starting. The wiring for these heaters is carried out in Pyrotenax cable and a plug and socket is supplied for connecting to the electricity supply in the engine-house. An additional plug and socket is fitted for the over-night recharging of the starter batteries, which can be carried out without removing the batteries from the cab. An electrical interlock is provided so that the engine cannot be started up as long as the flexible cables to the heaters or battery are connected.

The transmission is taken from a rigid traction-type hydraulic coupling mounted on the engine flywheel to a propeller shaft, with multi-disc flexible couplings, which connects to the gearbox. The gearbox is of the S.L.M. type, supplied by Modern Wheel Drive, Limited, Slough, Buckinghamshire, and gives four speeds in either direction. All gears are in constant mesh and the speed gears are engaged by friction clutches, one for each gear, which are operated by oil at a pressure of about 70 lb. per square inch, but a reduced oil pressure of 40 lb. per square inch is used to take up any "slack" on the train when starting. This is achieved by having a starting position for the control handle at

# TANGENTIAL PIPE-SCREWING MACHINE.

W. J. L. (MACHINERY), LIMITED, LONDON.

Fig. 1.

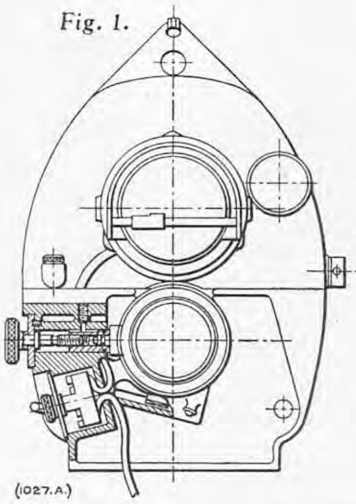


Fig. 2.

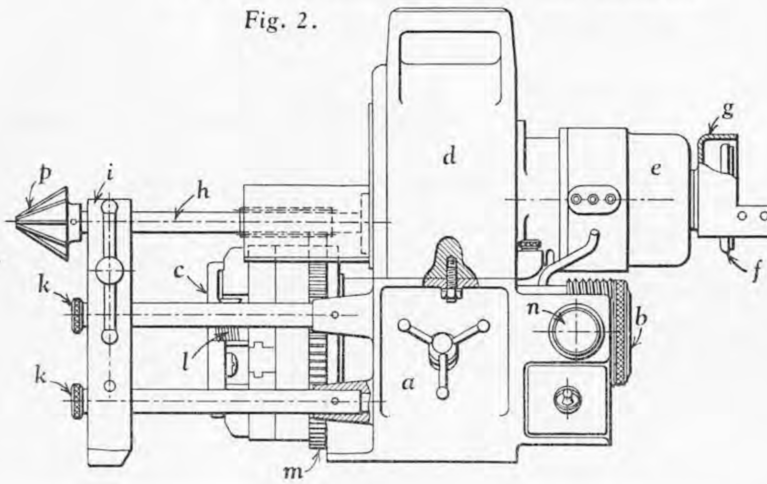
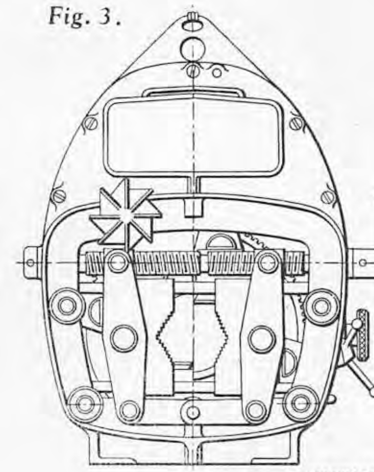



Fig. 3.



(1027.A) "ENGINEERING"

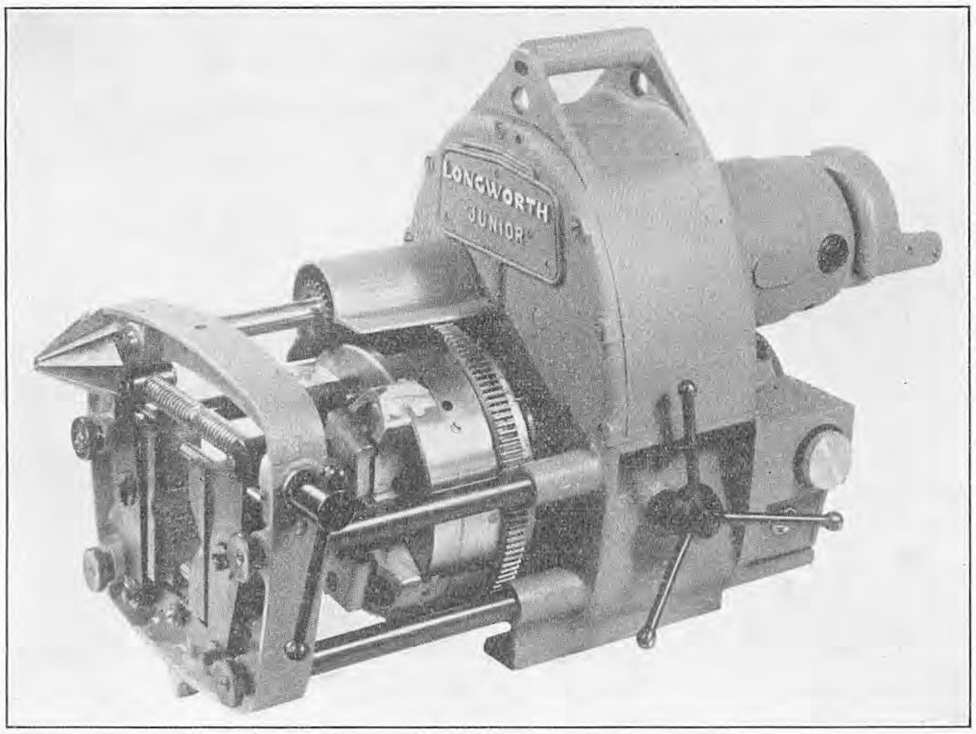



FIG. 4.

which compressed air is admitted to a relief valve, which regulates the oil pressure to 40 lb. per square inch. When the locomotive is on the move, the gear handle is put into the first-gear position and the full oil pressure is applied. The gear control levers are interconnected with the brake control, and when the compressed-air brakes are applied, the oil pressure for operating the gears is released and no power can be transmitted until the brakes are released and the oil pressure rises. The combination of the hydraulic coupling with the oil-operated friction clutches permits a very smooth "take-up" when the locomotive is starting a heavy train, and eliminates shocks when gear-changing. The reverse gear is of the bevel type, with two crown-wheels meshing with one pinion, and sliding dog-clutches which connect one or other of the crown-wheels to a cross shaft. These sliding clutches are operated by compressed air from the Westinghouse brake system. Following the reverse gear, a double-reduction spur gear takes the drive to the jack-shaft. The maximum speeds of the locomotive in each gear are 2·82, 4·64, 7·76 and 13·09 miles an hour, and the corresponding tractive efforts are 21,100, 12,850, 7,650 and 4,550 lb. The weight of the locomotive in working order is 37 tons, giving an adhesion ratio of 3·93 : 1. The brakes are operated by Westinghouse equipment, giving a brake force 65 per cent. of the weight of the locomotive. Electric lamps comprise head and tail lamps, a lamp under the engine casing, a cab lamp and portable lamp.

## TANGENTIAL PIPE-SCREWING MACHINE.

THE Longworth Junior pipe-screwing machine, illustrated in Figs. 1 to 4, herewith, is made by Messrs. W. J. L. (Machinery), Limited, Dacre House, Dean Farrar-street, London, S.W.1, and is designed to thread tubes from ½ in. to 2 in. B.S.P., or conduit from 1 in. to 2 in. in size. It weighs only 80 lb., and, as it can be used without being secured to a stand or bench, can be readily transported to, and employed on, any site where a suitable supply of electric current is available. The universal motor will operate on any single-phase or direct-current supply, and has a maximum current consumption of only 2 amperes at 250 watts. Any length of parallel thread can be cut, and taper threads up to the width of the die. The tangential dies used are about 2 in. long, and can be reground some hundreds of times, for which purpose a grinding wheel is mounted on the rear end of the motor shaft, and is provided with a permanent grinding fixture, formed to the correct angle. Thus the operator can regrind the dies on site, as often as may be necessary. Once the dies are set to give the correct cut, the machine can be operated by unskilled labour. Changing the dies takes about five minutes. Two sets of dies—B.S.P. parallel, with 14 and 11 threads per inch—are supplied with the machine, together with the appropriate lead-screws. Other forms of dies, with their lead-screws, can be obtained to order. The maximum rate of cutting is 11 threads per minute up to ¾ in. diameter, and 5 threads per minute from 1 in. to 2 in. diameter.

The machine consists of an aluminium-alloy base *a*, enclosing the lead-screw *b*, which advances or retracts the die-head *c*. Mounted on the base is a cast-iron gearcase *d*, also of aluminium alloy, with a handle on the top and the motor *e* attached by a flange to its rear side. The motor spindle is extended to the rear to carry the grinding wheel *f*, which is guarded by the shroud *g*. The shroud is extended to support the grinding fixture, which holds the dies at the correct angle against the wheel while they are being ground. The motor drives, through two-speed gearing, the output pinion shaft *h*, the outer end of which is supported in a bearing on the frame, *i*, of the pipe-vice, which is attached to the base of the machine by four horizontal steel bars, screwed into bosses on the base casting. The pipe-vice is secured to these bars by knurled nuts *k*, so that it can be readily detached to provide access to the die-head, for the purpose of changing the dies *l*.

The motor drives the die-head through the pinion on the shaft *h*, which engages with a toothed ring *m* on the periphery of the die-head, so that, as the die-head is moved axially by the lead-screw, the drive is constantly in mesh. The master lead-screw, which is changed as necessary to suit the thread that is being cut, feeds the die-head forward over the end of the tube, held in the vice. The knob *n*, to be seen to the right of Fig. 4, puts the lead-screw into or out of engagement with the drive. The three-armed capstan handle on the side of the machine actuates the die-head for purposes of adjustment when the follower, which drives the die-head forward when a thread is being cut, has been disengaged from the lead-screw; for example, when the lead-screw has to be removed and replaced by another. The die-head opens automatically when the required length of thread has been cut. On the end of the shaft *h*, which projects to the front of the pipe-vice, can be mounted a cutter *p*, which is used to remove burrs from the inside of tubes which have been sawn to length before screwing. The gear ratio is changed by means of a knob at the rear of the gearbox; pushing the knob in engages the high gear, used in screwing small tubes, and pulling it out changes the drive to the low gear, which is used for all pipe diameters of 1 in. or larger. The gears run in oil. Merely to lift the machine about, the handle is sufficient; but, for convenience in carrying it for any distance, holes are provided below the handle, through which a ¾-in. round bar can be passed to enable the machine to be carried by two men.

LIGHT-METAL PRODUCTION IN THE UNITED KINGDOM.—Statistics issued recently by the Ministry of Supply show that the production of virgin aluminium in the United Kingdom totalled 12,902 tons during the first five months of the present year. In addition, the recovery of aluminium by the re-melting of scrap during this period totalled 41,381 tons, and 88,265 tons of the metal were imported.

# PLOTTING TRAJECTORIES OF PRINCIPAL STRESS.

Fig. 1.

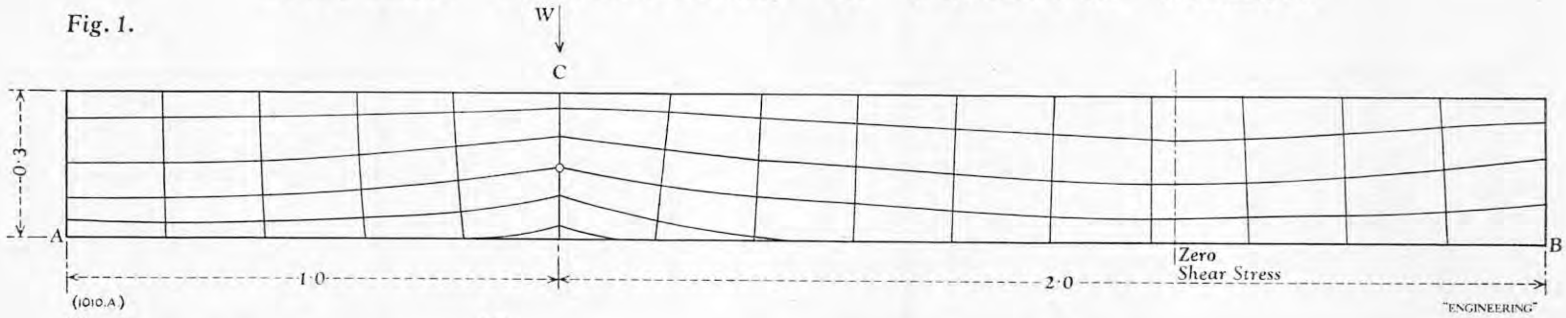



Fig. 2.

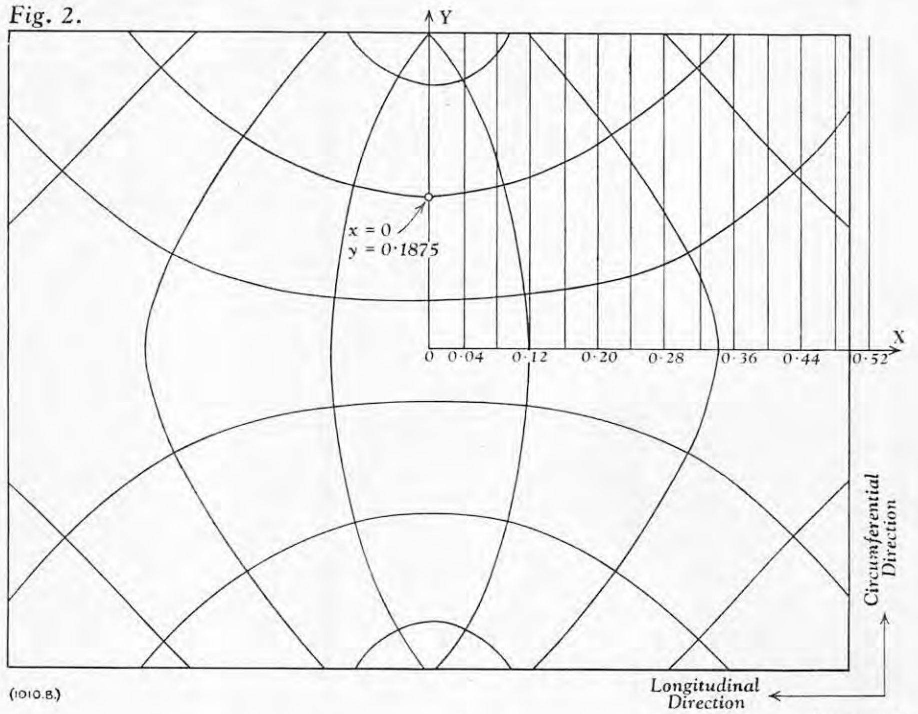
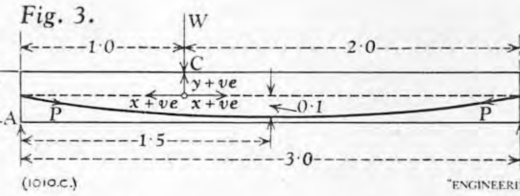



Fig. 3.




## PLOTTING TRAJECTORIES OF PRINCIPAL STRESS IN PLANE STRESS PROBLEMS.

By P. B. MORICE, B.Sc., Ph.D.

WHEN a stress analysis of a structure is carried out it is often desirable to determine the trajectories of principal stress. An example of this is the reinforced-concrete shell roof, where it is frequently required to make the reinforcement lie in the direction of the principal tension. Usually, it is not possible to obtain the equation of the trajectories in explicit form, and a process of "sketching in" has generally to be adopted. The solution of the principal stress trajectories involves integration of a first-order differential equation of the type

$$y' = f(x, y), \quad . \quad . \quad . \quad (1)$$

the form of the function $f(x, y)$ being such that an analytical solution to (1) is not available, and this suggests the use of the method of forward integration by finite differences.

The Newton interpolation formula enables the value of the function $y$ of $x$ to be determined for an arbitrary value of $x$:

$$x = x_k + rh, \quad . \quad . \quad . \quad (2)$$

where $h$ is an interval in $x$, $r$ a variable and $k$ an integer. When $y$ is known for discrete values of $x$, $x = x_k$, $(k = 0, 1, 2 \ldots)$, at equal intervals $h$, $h = x_1 - x_0 = x_2 - x_1 = \ldots . = x_n - x_{n-1}$. The particular form of the Newton formula to be used is

$$y = y_k + r\,\Delta\, y_{k-1} + \frac{r(r+1)}{2\,!}\,\Delta^2\, y_{k-2} + \ldots, \quad (3)$$

in which $\Delta$, $\Delta^2$, etc., have their usual meanings of first, second, etc., difference, respectively.

Since the formula (3) is independent of the form of the function $y$, it may equally well be written in terms of differentials $y'$, $y'_k$ and their differences $\Delta y'_{k-1}$, $\Delta^2 y'_{k-2}$, etc.

$$y' = y'_k + r\Delta y'_{k-1} + \frac{r(r+1)}{2\,!}\,\Delta^2\, y'_{k-2} + . \quad (4)$$

Now, we may write

$$y_{k+1} - y_k = \int_{x_k}^{x_{k+1}} y'\,dx, \quad . \quad (5)$$

while from (2) it is seen that $dx = h dr$, so that

$$y_{k+1} - y_k = h\int_0^1 y'\,dr. \quad . \quad . \quad (6)$$

We may therefore substitute (4) into (6), when we have

$$y_{k+1} - y_k = h\,[y'_k + \tfrac{1}{2}\,\Delta y'_{k-1} + \tfrac{5}{12}\,\Delta^2\, y'_{k-2} + \tfrac{3}{8}\,\Delta^3\, y'_{k-3} + \tfrac{251}{720}\,\Delta^4\, y'_{k-4} + \ldots .] \quad . \quad (7)$$

The principal stress values in a plane-stress problem are given by the well-known quadratic solution

$$\begin{matrix}\tau_{\eta\eta}\\ \tau_{\xi\xi}\end{matrix} = \tfrac{1}{2}\,(\tau_{xx} + \tau_{yy}) \pm [\tau_{xy}{}^2 + \tfrac{1}{4}\,(\tau_{xx} - \tau_{yy})^2]^{\frac{1}{2}}, \quad (8)$$

and the orientation of the principal axes is given by

$$\tan 2\,\theta = \frac{2\,\tau_{xy}}{\tau_{xx} - \tau_{yy}}. \quad . \quad (9)$$

But the slope of the trajectory is a function of the orientation

$$\begin{aligned} y' &= \tan\theta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)\\ &= \frac{1}{2\,\tau_{xy}}\Big\{-(\tau_{xx} - \tau_{yy}) \\ &\qquad \pm \sqrt{(4\tau_{xy})^2 + (\tau_{xx} - \tau_{yy})^2}\Big\} \end{aligned}$$

Therefore, we can write

$$\left.\begin{aligned} [y']_\eta &= -\,U + [1 + U^2]^{\frac{1}{2}} \\ [y']_\xi &= -\,U - [1 + U^2]^{\frac{1}{2}} \end{aligned}\right\} . \quad (11)$$

where

$$U = \cot 2\,\theta = \frac{\tau_{xx} - \tau_{yy}}{2\,\tau_{xy}}. \quad . \quad (12)$$

The equations (11) are of the type (1) and may therefore be solved by forward integration using the formula (7).

In order to demonstrate the use of the above results, we shall follow the initial calculations involved in plotting principal stress trajectories from the membrane theory of cylindrical shells. In a shell of semi-circular section of length L and radius R, supported at the ends, the membrane stresses, $\tau$, for the dead weight of the structure, $w$ per unit area, are given by

$$\left.\begin{aligned} \tau_{xx} &= \frac{w}{R}\left(x^2 - \frac{L^2}{4}\right)\cos\frac{y}{R} \\ \tau_{yy} &= -\,wR\cos\frac{y}{R} \\ \tau_{xy} &= -\,2\,wx\sin\frac{y}{R} \end{aligned}\right\} . \quad (13)$$

where $x$, $y$, are co-ordinates; $x$ is measured along the length of the shell with the origin at the centre, and $y$ is measured along the arc of the shell section.

Taking particular values for the dimensions of the shell of $L = 1{\cdot}00$ and $R = 0{\cdot}24$, then $0{\cdot}50 > x > -\,0{\cdot}50$ and $0{\cdot}375 > y > -\,0{\cdot}375$, since $y < \pm\,0{\cdot}24\,\frac{\pi}{2}$.

We have from (12)

$$\begin{aligned} U &= \frac{4{\cdot}19\,(0{\cdot}25 - x^2) - 0{\cdot}24}{4x}\cot 240{\cdot}069y \text{ deg.} \\ &= g(x)\cot Ky \text{ (say)} \end{aligned}$$

With intervals in $x$ of $h = 0{\cdot}04$ we may write out $g(x)$ values as shown in Table I.

TABLE I

| $k$ | $x$ | $g(x)$ | $k$ | $x$ | $g(x)$ |
|---|---|---|---|---|---|
| 0 | 0 | $\infty$ | 7 | 0·28 | 0·4277 |
| 1 | 0·04 | 5·0000 | 8 | 0·32 | 0·2956 |
| 2 | 0·08 | 2·4397 | 9 | 0·36 | 0·1837 |
| 3 | 0·12 | 1·5567 | 10 | 0·40 | 0·0857 |
| 4 | 0·16 | 1·0941 | 11 | 0·44 | −0·0021 |
| 5 | 0·20 | 0·7999 | 12 | 0·48 | −0·0822 |
| 6 | 0·24 | 0·5898 | 13 | 0·52 | |

In order to reduce error, it is advisable to start the calculation from a point at which the curvature is likely to be small. Thus, for the first set we choose $x = 0$, and for a particular line, $y = 0{\cdot}1875$.

By putting $x = 0$, $y = 0{\cdot}1875$ in equations (13), substituting in (12) to find $U_o$, and then in (11) to find $y'_o$ we have

$$y'_o = 0.$$

Therefore,

$$\begin{aligned} y_1 - y_o &= 0. \\ y_1 &= 0{\cdot}1875. \\ \cot Ky_1 &= 1{\cdot}0000 \text{ and } g_1(x) = 5{\cdot}0000. \\ U_1 &= 5{\cdot}0000. \end{aligned}$$

Thus, from (11) we may write

$$\begin{aligned} y'_1 &= -\,5{\cdot}0000 + \sqrt{1 + 25{\cdot}0000} \\ &= 0{\cdot}0990 \end{aligned}$$

Starting the table of differences, Table II below, we have from equation (7)

$$y_2 - y_1 = h\,[y'_1 + \tfrac{1}{2}\,\Delta y'_o]$$
$$= 0{\cdot}04\,[0{\cdot}1485]$$
$$= 0{\cdot}0059.$$

Therefore,

$$y_2 = 0{\cdot}1934$$
$$\cot \mathrm{K}y_2 = 0{\cdot}9520\ ;\ g_2 = 2{\cdot}4397$$
$$\mathrm{U}_2 = 2{\cdot}3206$$

and

$$y'_2 = 0{\cdot}2063$$
$$y_3 - y_2 = h[y'_2 + \tfrac{1}{2}\,\Delta y'_1 + \tfrac{5}{12}\,\Delta^2 y'_o]$$
$$= 0{\cdot}0105.$$

Therefore

$$y_3 = 0{\cdot}2039.$$

The computation is continued until the line crosses the boundary, i.e., $x = 0{\cdot}5$ or $y = 0{\cdot}375$. For the orthogonal trajectories the procedure is similar, except that the required slope is given by the second equation of (11)

$$[y']_\xi = -\,\mathrm{U} - \sqrt{1 + \mathrm{U}^2}$$

In calculating for these lines, we have taken our starting points on the boundary $y = 0{\cdot}375$, for we have here

$$[y']_\xi = -\,1.$$

The results for three pairs of orthogonal lines are shown in development in Fig. 2, opposite, where one quarter only has been calculated since the structure is bi-symmetric.

TABLE II

| $k$ | $x$ | $y$ | $y'$ | $\Delta y'$ | $\Delta^2 y'$ | $\Delta^3 y'$ |
|---|---|---|---|---|---|---|
| 0 | 0·00 | 0·1875 | | | | |
| | | | 0·0000 | | | |
| 1 | 0·04 | 0·1875 | | 0·0990 | | |
| | | | 0·0990 | | 0·0083 | |
| 2 | 0·08 | 0·1934 | | 0·1073 | | 0·0070 |
| | | | 0·2063 | | 0·0153 | |
| 3 | 0·12 | 0·2039 | | 0·1226 | | 0·0024 |
| | | | 0·3289 | | 0·0177 | |
| 4 | 0·16 | 0·2199 | | 0·1403 | | —·0085 |
| | | | 0·4692 | | 0·0092 | |
| 5 | 0·20 | 0·2418 | | 0·1495 | | —·1079 |
| | | | 0·6187 | | —·0087 | |
| 6 | 0·24 | 0·2696 | | 0·1408 | | —·0181 |
| | | | 0·7595 | | —·0268 | |
| 7 | 0·28 | 0·3024 | | 0·1140 | | —·0065 |
| | | | 0·8735 | | —·0333 | |
| 8 | 0·32 | 0·3373 | | 0·0807 | | |
| | | | 0·9542 | | | |
| 9 | 0·36 | 0·3764 | | | | |

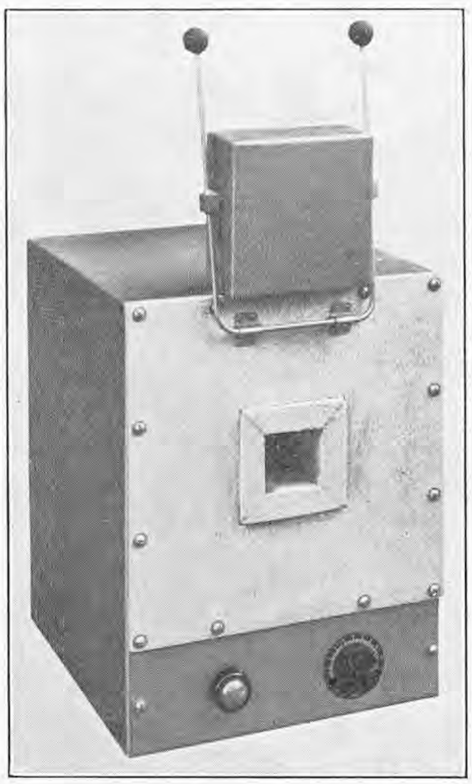
As a further example, Fig. 1 shows the lines of principal stress in a beam with a span-depth ratio of 10. The transverse load is one-fifth of the prestressing force (Fig. 3).

VACATION COURSE ON ELECTRICAL INSULATION.—A five-day vacation course on "The Insulation of Electrical Equipment" is to be held in the Electrical Engineering Department of Imperial College of Science and Technology, London University, South Kensington, S.W.7, from Monday to Friday, September 15 to 19. The object of the course is to consider the factors which are limiting insulation design in the main classes of electrical equipment and the general principles which should govern the approach to the solution of outstanding problems in this field. Lectures are to be given by Professor Willis Jackson, Dr. L. Hartshorn, Dr. S. Whitehead, Mr. C. G. Garton, Mr. R. Snadow, Dr. L. G. Brazier, Dr. R. S. Vincent, Dr. J. S. Forrest, and others. Further particulars may be obtained from the head of the Electrical Engineering Department at the College.

THE "MICROFILTER" DUST RESPIRATOR.—The Microfilter dust respirator owes its inception to the Committee for Industrial Health of the British Steel Founders' Association, who requested Messrs. Siebe, Gorman and Company, Limited, Neptune Works, Davis-road, Tolworth, Surrey, to design and manufacture a respirator capable of being worn for long periods, under the arduous conditions involved in finishing steel castings. These operations produce quantities of finely-divided silica, causing silicosis in workers not adequately protected. The respirator, which is approved by the Ministry of Labour and National Service, comprises a moulded plastic facepiece and filter holder fitted to a soft sponge-rubber face pad. The filter is of Merino wool impregnated with resin, and rests on a perforated metal and muslin carrier. An elastic harness holds the respirator in position on the face.

## ELECTRIC MUFFLE FURNACE.

SOME novel features have been incorporated in the design of a range of electrically-heated muffle furnaces built by Gradec, Limited, 96, Hackney-road, London, E.2, for temperatures up to 1,000 to 1,200 deg. C. The furnaces are intended for general laboratory use, and for heat-treating small components; they are marketed in three sizes and a photograph of the smallest size, No. 00, is reproduced below. The muffle of this furnace is 2¾ in. wide, 2¾ in. high and 8 in. deep, while the muffle size of furnace No. 0 is 7 in. wide, 4½ in. high and 14 in. deep, and that of furnace No. 1, 7 in. wide, 7 in. high and 11 in. deep. The casings of the furnaces are made of heavy-gauge steel sheet, reinforced with angle iron. The muffles are made of high-grade moulded refractory and are wound with Kanthal A wire. This is an iron-chromium-aluminium-cobalt alloy produced in Sweden, and it contains 23 per cent. of chromium, 5 per cent.



of aluminium, from 1 to 2·5 per cent. of cobalt, and the balance iron. It is claimed that heating elements of this alloy give a particularly long service life. The muffles are supported and insulated in the furnace casings by means of insulating bricks and powder, and the refractory materials employed are selected so that, under the worst conditions, they are used at temperatures 200 deg. C. below their maximum recommended working temperature.

The furnaces are fitted with the balanced rising door shown in the illustration and, as will be noted, the operator is not presented with two hot faces when the door is opened, as is the case with a hinged door. The vertical movement of the door is achieved by means of two pivoted arms on which the door is pivoted, and this results in a simpler form of construction and ensures easier manipulation. The door handles are well away from the muffle and keep comparatively cool, so that there is no danger of the operator burning his fingers. When in the up position, the door rests on the top of the furnace, as shown in the illustration, and when in the down position the door fits snugly against the muffle aperture. The door is built of sheet steel and is lined internally with the firm's BVC concrete, which is composed partly of a refractory material and partly of a thermal-insulating compound. The electrical control equipment, consisting of a heavy contactor, an energy regulator, an indicating light, and the necessary fuses, is housed in a drawer fitted in the base of the furnace. If required, a pyrometer can be mounted on the side of the furnace, and provision made for fitting a thermocouple. The makers state that standard furnaces can be supplied for any voltage between 190 and 250, but special models can be made for any other voltage.

## TRADE PUBLICATIONS.

*"Bibby" Resilient Couplings.*—The Wellman Bibby Co., Ltd., Parnell House, Wilton-road, London, S.W.1, have published a new illustrated catalogue of Bibby resilient couplings. The principle of the coupling, its assembly and some typical applications are described.

*Capstan Lathes, Motors and Castings.*—A booklet issued by Murad Developments, Ltd., Stocklake, Aylesbury, Bucks., deals with their capstan lathe and special machine tools; also with the products of their two subsidiary firms, British Bronson, Ltd. (electric motors and switchgear) and Technaloy, Ltd. (high-class castings).

*Vertical Boilers.*—Cochran vertical boilers with horizontal fire-tubes, for land use, are described, and a number of related topics (such as steam requirements, fuels, specifications, mountings, lagging, stokers, etc.), are discussed in a booklet issued by Cochran & Co., Annan, Ltd., Annan, Scotland.

*Grease Lubricators.*—Trier Bros., Ltd., Caldew-street, Camberwell, London, S.E.5, have prepared a leaflet on their Staufferlube-Multigreasors—automatic grease lubricators which have no valves and springs. They are suitable for pumping heavy oils and light, medium and heavy greases.

*Measuring Air in Concrete.*—A leaflet issued by Soil Testing Services, Inc., 4520, West North Avenue, Chicago, 39, Illinois, U.S.A., gives particulars of their Stebbins meter for measuring the percentage of air in air entrained concrete.

*Pneumatic Scaling Hammers.*—A leaflet describing their pneumatic scaling hammers, the pistons of which are fitted with tungsten-carbide tips, are described in a leaflet issued by Holman Bros., Ltd., Camborne, Cornwall. The hammers are intended to be used for the removal of rust or old paint from iron and steel surfaces or scale from boilers.

*Flexible Injection-Moulding Compounds.*—Bakelite, Ltd., 18, Grosvenor-gardens, London, S.W.1, have sent us a catalogue dealing with their "Vybak" flexible injection-moulding compounds, which are thermoplastic materials produced from vinyl resins. The compounds are available in a wide range of colours and the mouldings produced can be made to vary from a soft, rubber-like condition to a semi-rigid condition.

*Abrasive Papers and Cloths.*—In a well-illustrated brochure, Messrs. Union Glue and Gelatine Co., Ltd., Cransley Works, Garrett-street, Golden-lane, London, E.C.1, give detailed information on the nature, properties and applications of their "Coronet" abrasive papers and cloths in the woodworking, metalworking, tanning and other industries.

*Brazing and Annealing Service.*—A small brochure issued recently by Birlec, Ltd., describes the heat-treatment service which is available for continuous copper brazing and bright annealing at their Heat Treatment Division, 95, Tyburn-road, Erdington, Birmingham, 24.

*Aluminium Alloys.*—A publication entitled "Properties of Noral Alloys" has been issued by the Northern Aluminium Co., Ltd., Banbury, Oxfordshire, to replace the firm's earlier "Noral Data Sheet," over 30,000 copies of which have been distributed since it first appeared in October, 1945. In addition to general notes, the publication contains seven tables showing the properties of various aluminium alloys in the form of sheet, plate, extrusions, tube, wire, forgings and castings.

*Control of Magnesium Dust.*—An illustrated article on the control of magnesium dust, reprinted from an American publication, has been issued in leaflet form by Air Control Installations, Ltd., Ruislip, Middlesex. The methods of collection and disposal of the dust arising from a number of machining operations are described.

*Electric Furnaces.*—Horizontal batch-type furnaces for all kinds of heat-treatment processes and for brazing, nitriding, gas carburising and box carburising, and vitreous enamelling at temperatures up to 1,050 deg. C., are illustrated and described in a pamphlet issued by the General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2.

*Adhesives for Coachbuilding.*—Typical applications of industrial adhesives made by Dunlop Special Products, Ltd., Fort Dunlop, Erdington, Birmingham, 24, are contained in a booklet sent to us by the Dunlop Rubber Co., Ltd., St. James's House, St. James's-street, London, S.W.1. Numerous photographs taken in the coach-building and other shops of motor-car manufacturers are included.

*Trucks.*—H. H. Stark, Ltd., 193, Whitechapel-road, London, E.1, have sent us an illustrated catalogue describing their wide range of trucks and light wagons suitable for industrial and domestic uses. The catalogue also shows the firm's ladders and trestles.

## SINGLE-DECK TRAMCARS FOR BLACKPOOL.

BLACKPOOL CORPORATION have long been confirmed users of tramcars, and in the course of time they have built up what is probably the most modern fleet of such vehicles to be operated in this country. They have continued to put their faith in tramcars despite the present-day trend towards a replacement by motor omnibuses, and recently took delivery of the first of 25 single-deck tramcars of a new type which are being built by Charles Roberts and Company, Limited, Horbury Junction, Wakefield. This vehicle, which is illustrated in Fig. 1 herewith, has seating capacity for 56 passengers and is provided with a well-type underframe so as to give a low central platform with a minimum step height. The body is carried on two equal-wheel bogies, each of which is equipped with two 275 volt traction motors rated at 45 h.p.

The underframe and body-shell framing are of steel construction. The underframe is built up from mild-steel angle and channel sections and the floor bearers are arranged so that they form an integral part of the underframe structure. An impression of the design of the body-shell structure can be gained from Fig. 2, herewith, which shows the vehicle in course of construction at the works of Charles Roberts and Company, Limited. All the main pillars are made from high-tensile steel sections designed to receive the timber packings used in fixing the glazing and exterior panels. The fence rails are of a special section developed by the builders and extend the full length of the body sides, being reinforced at the joints with the pillars by brackets. The roof members are made up from mild-steel channel sections which are fitted with timber packings for securing the exterior roof, glazing and interior ceiling panels. The exterior of the body structure is clad with 16-gauge mild-steel panels which are secured to the timber packings by screws, the joints between the panels being covered by polished stainless-steel mouldings. A hinged door is fitted at the offside of each driving compartment and there are further doors in the bulkheads behind the driver's seat at each end to give access from the driving compartments into the saloon. The centre entrance doors are of the sliding pneumatically-operated type and are controlled by the conductor from the platform; they were supplied by G. D. Peters and Company, Limited, Slough, Buckinghamshire.

Each saloon is provided with six half-drop windows above which are smaller windows fitted with sliding glasses. The saloon roof has curved eaves which, as will be seen from Fig. 1, are filled in with glazing, thereby making the interior exceptionally light. Curved glasses are also provided at the sides of the two windscreens so that there is an uninterrupted view from the driving seat. Single-panel windscreens are provided and are hinged at the top so that they can be opened outwards. All glass fitted in the saloon and the two driving compartments is of the toughened safety type, manufactured by the Triplex Safety Glass Company, Limited, 1, Albemarle-street, London, W.1. The interior ceilings and bulkhead panels of the saloons are finished with Alhambrinal, which was supplied by the Waterproofing Company, Limited, Barrhead, Glasgow, and the floors of the saloon are covered with a non-slip rubber preparation. The seats, which were supplied by G. D. Peters and Company, Limited, have swing-over squabs to permit passengers to face in the direction of travel.

As previously mentioned, the body is carried on two four-wheel bogies. These were supplied by Maley and Taunton, Limited, Platt-street, King's Hill, Wednesbury, Staffordshire, and have been designed specially for high-speed operation. Two Crompton Parkinson traction motors are installed on each bogie, and these are arranged to drive separate driving axles through cardan shafts and spiral-bevel reduction gearing. This arrangement will be clear from an examination of Fig. 3, herewith, which shows one of the bogies removed from the vehicle. It will be appreciated that, with this design, all wheels are driven and the total weight of the vehicle, as a consequence, is available for adhesion. Furthermore, the motors are supported by the framework of the bogies and the unsprung weight, is therefore reduced to a minimum, with benefit to the track.

The weight of the vehicle is transferred to the axles through a combination of leaf-type semi-elliptical steel springs and rubber springs, the system being controlled by dampers. Springing is assisted by the wheels; these are of the resilient type, made by Crompton Parkinson, Limited, and incorporating rubber which isolates the wheel hubs from the tyre. In addition to reducing the road shocks transmitted to the bogies, the rubber also assists in removing some of the "snatch" in the drive to the wheels. The vehicle is braked rheostatically in the normal manner, compressed-air brakes being provided to bring it finally to rest

## 56-SEAT SINGLE-DECK TRAMCAR.

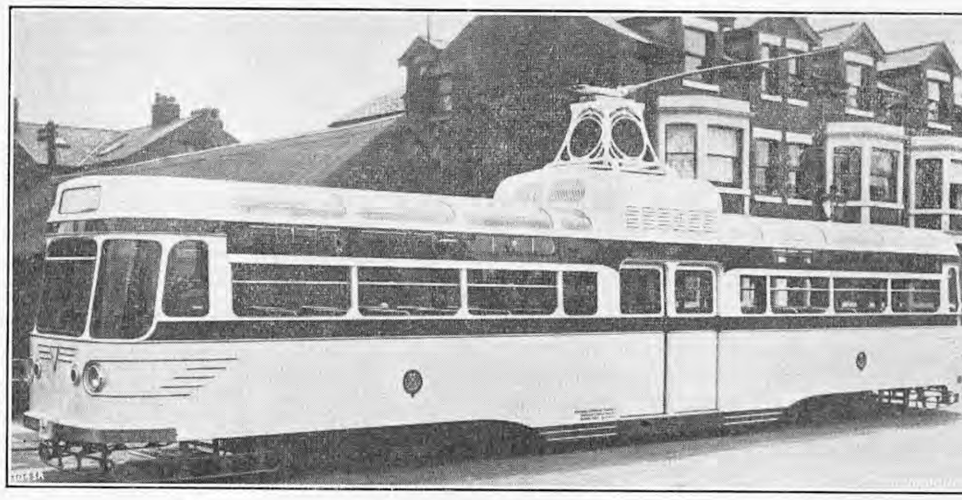


FIG. 1. THE FIRST OF THE NEW CARS.

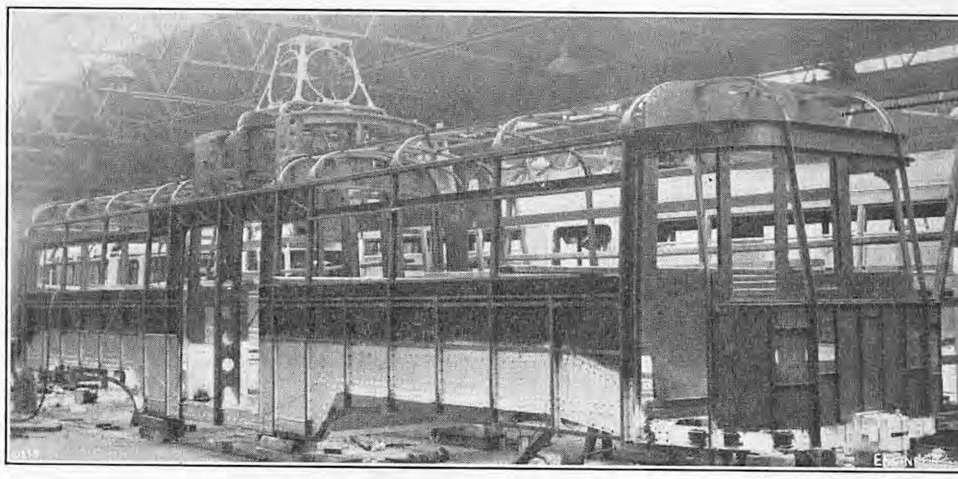


FIG. 2. BODY UNDER CONSTRUCTION.

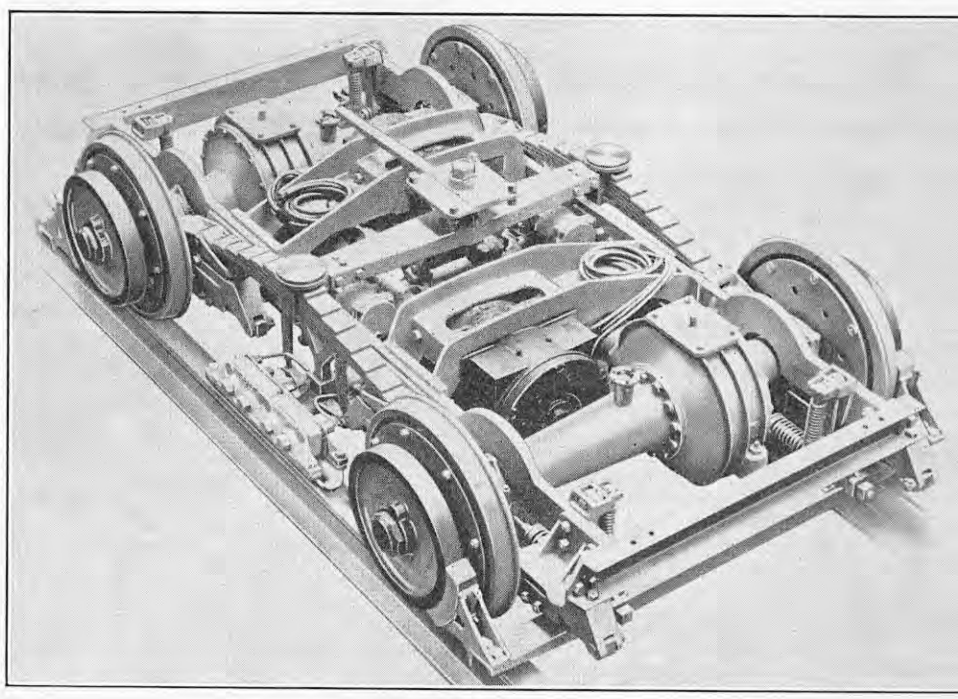
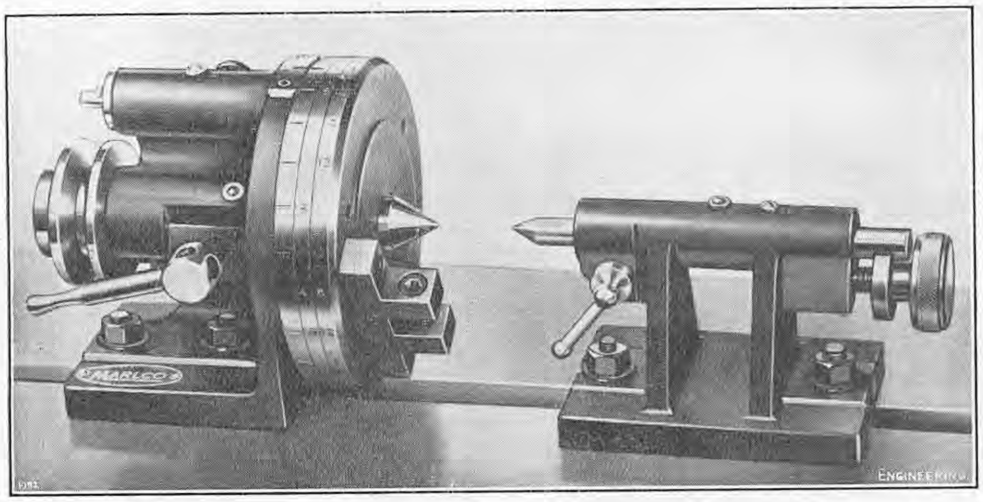


FIG. 3. HORNLESS BOGIE.

# 3-IN. HORIZONTAL INDEXING ATTACHMENT.



and hold it on gradients. The compressed-air brakes, however, do not act on the driving wheels but on separate drums mounted just outside the driving wheels, as shown in Fig. 3. Magnetic track brakes are also provided and these are located between the driving wheels in the normal position. The air brakes are arranged so that they can be applied by the conductor independently of the driver, and are provided with a safety feature which ensures that, in the event of any failure of the piping system, etc., they are automatically applied.

The control equipment was supplied by Allen West and Company, Limited, Brighton. It employs their Vambac system, in which control is obtained by a single lever that is pushed forward when accelerating and pulled back to give rheostatic braking. The outstanding feature of this system is the accelerator; this consists of a series of resistance grids arranged in a circular bank and switched in by means of a motor-driven arm. The arm rotates within the bank of resistance grids and is fitted with permanent magnets which operate the resistor-step switches, the equivalent of 90 notching positions being provided by this means. The speed of the motor is regulated automatically according to the setting of the single driving lever, and safeguards are incorporated in the system to prevent rates of acceleration that would overload the equipment. The accelerator is used similarly for rheostatic braking and in each case the rate is automatic, depending solely on the extent to which the control is moved. The accelerator unit is mounted within the superstructure that supports the trolley boom.

The overall length of the tramcar is 50 ft. and the distance between bogie pivot centres, 25 ft. The bogie wheelbase is 6 ft., the diameter of the wheels, 2 ft. 3 in. and the gauge 4 ft. 8½ in. The overall width is 7 ft. 11 in. and the width of the centre entrance, 6 ft. 3½ in. The overall height from the rails to the top of the roof is 9 ft. 11⅝ in., and the height from the floor to the ceiling inside the saloon, 6 ft. 10¾ in. The estimated maximum speed is between 40 and 50 miles an hour. The vehicle was transported from Horbury to Blackpool by road on a specially-adapted four-wheel trailer by Pickfords heavy haulage service of the Road Haulage Executive.

A EUROPEAN RAILWAY-WAGON POOL.—A proposal to develop a pool of railway wagons which would be used without restrictions on as many European railways as possible has been approved by the representatives of 12 European countries (including the United Kingdom) and the United States. The proposal has been under consideration by the Inland Transport Committee of the United Nations Economic Commission for Europe. If implemented, it will have the effect of reducing the number and average length of "empty hauls" and the average wagon turn-round time; the total European stock of wagons could then be reduced. It would be necessary, however, to build standard wagons to the designs of the International Union of Railways. A Franco-German pool of 100,000 wagons already exists and has given satisfactory results.

## 3-IN. HORIZONTAL INDEXING ATTACHMENT.

HEREWITH is illustrated a 3-in. horizontal indexing attachment, together with a rigid tailstock, which is suited for a variety of milling and drilling operations. It is made by Messrs. W. H. Marley and Company, Limited, New Southgate Works, 105, High-road, London, N.11. The standard equipment shown may be modified by the substitution of an extended centre or, alternatively, of a 3¼-in. self-centring chuck where the type of workpiece permits. There is also available a spring-loaded tailstock intended for use in grinding operations where it is necessary to provide for the expansion of the work as its temperature rises. Provision is made on both the head and tailstock for clamping the centres when actually working. The centre height of both the rigid and the spring-loaded tailstock, as well as the headstock, is guaranteed within 0·0005 in. to ensure interchangeability.

The attachment has been designed to speed up certain operations which normally require a dividing head, by eliminating the time lost in rotating the head through the worm drive, while maintaining accurate operation. The standard index plate is divided into 24 equal parts from which the factors of 2, 3, 4, 6, 8, 12 and 24 may be readily obtained, and the dial is engraved so as to minimise the possibility of error on the part of the operator. The initial position is obtained by setting the index head according to the number of divisions required; then, after each pass, the dial is rotated until a similar index number aligns with the datum mark. Alternative index plates with odd numbers of divisions can be supplied from stock.

TECHNICAL ABSTRACTS.—The first number of a new monthly digest in German of technical information on machinery and machine design made its appearance last month. Published by the Akademie-Verlag G.m.b.H., Schiffbauerdamm 19, Berlin, N.W.7, under the general editorship of Prof. Dr. Maximilian Pflücke, it is the second series of a number of such journals collectively designated "Technisches Zentralblatt." The first series, "Electrotechnik," started about a year ago; that now begun has the sub-title "Maschinenwesen." The contents consist of material abstracted from technical journals, proceedings of societies and institutions, and other relevant sources, which has been arranged in various main categories, condensed and appropriately classified. In all cases the source of the information is indicated and, in some instances, explanatory drawings accompany the text. The first number runs to 96 pages and its contents have been culled from 335 technical journals of many countries published subsequently to January 1, 1951. A list of all the journals currently consulted has been inserted in the first number. Explanatory information is also included on the classification system. A yearly index of all abstracts will be published. A list of patents, all American, appearing between January 1 and 15, 1952, has also been published as the first issue of a series devoted to this subject.

# NOTES ON NEW BOOKS.

*Electrical Engineering Economics. Volume Two: Costs and Tariffs in Electricity Supply.*

By D. J. BOLTON, M.Sc., M.I.E.E. Second edition, revised. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 30s. net.]

THE question of electricity tariffs has long been a subject of controversy. Many years ago, the two-part tariff was introduced by Dr. John Hopkinson, who, speaking of it, said "the ideal method of charge . . . is a fixed charge per quarter proportional to the greatest rate of supply the customer will ever take, and a charge by meter for the actual consumption." This elementary statement, although correct, is very far from being a guide to the determination of the "ideal method," and, in practice, the fixed charge has been settled in terms of the number of rooms in a house, the rateable value, or on some other arbitrary basis. The result has been that hundreds of different tariffs have been introduced. The Central Electricity Board are now engaged in introducing some uniformity. In this book, Mr. Bolton examines the subject from an economic point of view, pointing out, for instance, that different types of load, lighting, heating and industrial, have different characteristics and that methods of charging, to be economically sound, must take account of them. It is not his purpose to establish an "ideal tariff"—there can be no such thing of general applicability—but to examine the underlying principles on which correct judgments must be based. The book is of much interest and deals in detail with questions of load analysis, the effects of diversity factor and the allocation of demand costs. Although large numbers of independent supply authorities, each under the necessity of devising some type of tariff, no longer exist, the study presented should be of value to those concerned with the present work of standardisation and of professional interest to all concerned with electricity supply. Although this is a second edition, it is to a considerable extent a new book. It is an extension and revision of part of the author's earlier book on *Electrical Engineering Economics*, first published in 1928 and revised in 1935, and his book entitled *Costs and Tariffs*. These earlier works were destroyed in the war. Volume One of the pair, of which this forms Volume Two, deals with general principles and choice of plant.

*An Introduction to Applied Mathematics.*

By PROFESSOR J. C. JAEGER. Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 35s. net.]

IN the writing of this book, the author has evidently given considerable thought to the requirements of those reading the subject in universities and technical colleges. Following a fairly complete treatment of ordinary differential equations, he provides, in Chapters IV and V, ample opportunity for the serious reader to gain manipulative skill in applications to the vibration of mechanical systems, and to the theory of electric circuits, by way of inquiry into the impedance of complicated circuits, servo-mechanisms, triode oscillations up to van der Pol's equation, and the use of the Laplace transformation in the case of transient phenomena. Although the pace of the text gradually increases with the introduction of the dynamics of particles and rigid bodies, the subject-matter is always within easy grasp of the student, whether he is perusing the discussion on oscillations of non-linear systems by the method of Kryloff and Bogoliuboff, or the theory of the gyroscope. It is also gratifying to find, in a book of this standard, a chapter largely devoted to Lagrange's equations, since these formulæ can be employed with great advantage in several branches of engineering. A chapter on the subject of boundary values brings under review the bending of beams, and further exemplification of initial and boundary value problems occur in the subsequent treatment of Fourier series and integrals. Due attention is also paid to the theory of ordinary differential equations with variable coefficients, and to that of partial differential equations, where the important equations in two variables are derived and solved in interesting cases, and the use of

Bessel and Legendre functions is indicated in the solution of the corresponding equations in two and three dimensions. The book, which is replete with exercises, concludes with a useful chapter on numerical methods, in which the principal interpolation formulæ are given, together with a short account of step-by-step and relaxation methods for the solution of ordinary and partial differential equations.

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*British Fishing-Boats and Coastal Craft. Part II. Descriptive Catalogue and List of Plans.*

By E. W. White, A.M.Inst.N.A. H.M. Stationery Office, York House, Kingsway, London W.C.2. [Price 3*s*. 6*d*. net.]

The revised Part I of this admirable survey appeared in 1950 and was reviewed in our issue of June 23 in that year (vol. 169, page 716). The method of treating the exhibits catalogued in Part II is by working clockwise round the coast and taking the craft in successive sections—East Coast of England, the Thames and its estuary, the South Coast and the West Coast. Separate sections deal with Scotland and Ireland. The descriptions are liberally illustrated with half-tone plates, and there is an introductory map (on rather too small a scale for easy reading) of the British Isles, showing the various fishing ports, etc. Each section is prefaced by a short historical note, but this is no more than a general guide, the fuller particulars of the development of different kinds of craft being given in Part I, which the reader would do well to procure and study in conjunction with Part II. There is a useful bibliography and an excellent index; and the list of the plans that are available is gratifyingly extensive. It is probable that, for many of the craft, no other plans now exist.

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*High Quality Concrete.*

By D. A. Stewart, A.M.I.C.E., A.M.I.E.E. E. and F. N. Spon, Limited, 22, Henrietta-street, London, W.C.2. [Price 25*s*. net.]

The development of prestressed concrete, of high-duty concrete pavements for heavy road traffic and for aircraft runways, and the replacement of the older traditional materials by concrete, together require that all concerned with the manufacture of concrete should give serious thought to their subject. In the past, many concrete buildings and other products were doomed to a short unsatisfactory life, during which time they were public eyesores, by the casual methods used in the choice of materials, in mixing and in placing the concrete, and in the low class of labour employed. Mr. Stewart sets out to show the contractor the need for high-quality concrete and considers the problems that must be solved to achieve it; risking the criticisms of the quasi-engineer who prides himself on being "practical" and who scorns theory, by making extensive use of laboratory experiment and of theoretical arguments as well as of experience. Most contractors are aware by now of the need for clean, well-graded aggregates, a good water supply, and of the requirement of a high density to ensure good weathering properties, but this book is further concerned with the less known factors of workability, the characteristics of mixers and of designing a concrete, and the shutter work, when placing is done with the aid of vibrators.

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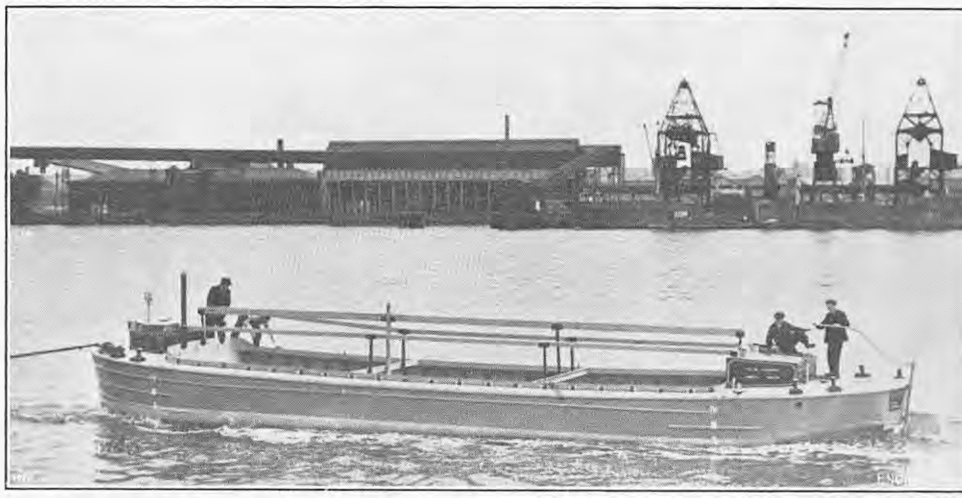
The City and Guilds of London Institute.—The Council of the City and Guilds of London Institute have conferred the Fellowship of the Institute (F.C.G.I.) upon five former students of the City and Guilds College who have attained to positions of distinction in the engineering profession. They are Mr. Leslie Herbert Bedford, O.B.E., chief television engineer of Marconi's Wireless Telegraph Co., Ltd.; Mr. Henry Francis Cronin, C.B.E., chief engineer of the Metropolitan Water Board and President-elect of the Institution of Civil Engineers; Mr. William Arthur Del Mar, chief engineer of the Habirshaw Cable and Wire Division, Phelps Dodge Copper Products Corporation, U.S.A.; Mr. Harold John Boyer Harding, director of John Mowlem & Co., Ltd., and of Soil Mechanics, Ltd.; and Mr. William Henry Gordon Roach, M.B.E., managing director of William Press and Son, Ltd., technical director of D. & C. and William Press, Ltd., and a director of the General Descaling Co., Ltd., and of John Paul & Co., Ltd., Dublin.

## HIGH-TENSILE STEEL BARGE.

FAIRMILE CONSTRUCTION COMPANY, LIMITED, COBHAM, SURREY.



## CANAL BOAT OF HIGH-TENSILE STEEL.

The North-Western Waterways Division of the Docks and Inland Waterways Executive have recently taken delivery of the first of three motor-driven canal boats of the so-called Liverpool type, as used on the Leeds and Liverpool Canal, but different in that the all-welded hull is constructed of high-tensile steel. The vessel, which has been named Darwen, is illustrated above. She has been built by Harland and Wolff, Limited, at their yard on the Thames, to the designs of the Fairmile Construction Company, Limited, Cobham, Surrey, who are the main contractors. The principal dimensions are: length, 61 ft.; beam, 14 ft. 3 in.; depth, 4 ft. 8 in.; draught light, 2 ft. 4 in., and in ballast, 2 ft. 11 in. The cargo capacity is 50 tons, and there is space for 4 tons of water ballast and 120 gallons of fuel oil. The power unit is a Diesel engine, with an output of 30 h.p. at 400 r.p.m., supplied by H. Widdop and Company, Limited, of Keighley. The hull is built of high-tensile steel to B.S.S. 968, with plating of Cor-Ten steel, containing 0·25 to 0·5 per cent. of copper, to improve its resistance to atmospheric corrosion. The other two boats are being built of B.S.S. 968 steel throughout and, therefore, each will cost about 30*l*. less than the Darwen. The B.S.S. 968 steel used has a tensile strength of 35 to 41 tons per square inch for the rolled sections and 37 to 43 tons for the plating. By its use, in conjunction with welding, it is calculated that the new boats will carry about 10 per cent. more cargo on the same draught of water as a boat built of ordinary mild steel. It was found that the deck, bulkheads, and much of the shell plating, when using the high-tensile steel, could be reduced in thickness from $\frac{1}{4}$ in. to $\frac{3}{16}$ in., the centre keelson from 5 in. by 3 in. by $\frac{3}{8}$ in. to 3 in. by 3 in. by $\frac{5}{16}$ in., and the frames and bulkhead stiffeners could be made of flat bar instead of angles. The cost worked out no higher than that of a mild-steel boat, assuming the use of B.S.S. 968 steel throughout. After trials on the Thames, the vessel was taken by road to Northwich. The new method of construction was adopted as an experiment on the recommendation of the research department of the Docks and Inland Waterways Executive, who also collaborated with the Fairmile Company in preparing the design.

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American Aid to British Laboratories.—Details of over one million dollars worth of new scientific equipment, supplied since 1949 by the United States Government to research laboratories in Great Britain, are contained in a statement issued by the Mutual Security-Agency Mission to the United Kingdom, 1, Grosvenor-square, London, W.1. The equipment was ordered and made available under the technical assistance programme of the Marshall Plan and its successor, the Mutual Security Programme. Much of it has gone to laboratories controlled or supported by the Department of Scientific and Industrial Research, who undertook the initial survey and drew up the list of all the equipment required.

## BOOKS RECEIVED.

*Callender-Hamilton Bridge Handbook. Highway Bridges Type "B."* By G. D. White-Parsons. British Insulated Callender's Construction Company, Limited, 21, Bloomsbury-street, London, W.C.1. [Price 21*s*.]

*Electronic Analog Computers. (D.C. Analog Computers.)* By Dr. Granino A. Korn and Theresa M. Korn. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 7 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 59*s*. 6*d*.]

*United States National Bureau of Standards.* Circular No. 532. *Measurement of the Thickness of Capacitor Paper.* By Wilmer Souder and Sanford B. Newman. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 15 cents.]

*United States National Bureau of Standards.* Applied Mathematics Series 21. *A Guide to Tables of the Normal Probability Integral.* The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 15 cents.]

*Australia. Third Annual Report of the Commonwealth Scientific and Industrial Research Organization for the Year Ending 30th June,* 1951. L. F. Johnston, Commonwealth Government Printer, Canberra, Australia. [Price 9*s*. 6*d*.]

*Guide to the Coalfields,* 1952. Edited by R. H. Walkerdine and C. Treharne Jones. The Colliery Guardian Company, Limited, 30 and 31, Furnival-street, London, E.C.4. [Price 20*s*.]

*Directory of Railway Officials & Year Book,* 1952-1953. Tothill Press, Limited, 33, Tothill-street, London, S.W.1. [Price 40*s*.]

*The Parsons and Marine Engineering Turbine Research and Development Association. Progress Report for the Year* 1951. Pametrada Research Station, Wallsend.

*Forest Products Research.* Bulletin No. 25. *Identification of Hardwood. A Lens Key.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 5*s*. net.]

*Prestressed Concrete Structures.* By Dr. August E. Komendant. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 5 dols.]; and McGraw-Hill Publishing Company Limited, 95, Farringdon-street, London, E.C.4. [Price 42*s*. 6*d*.]

*Definitions and Formulæ for Students. Electrical Installation Work.* By F. Peake Sexton. Seventh edition. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 1*s*. 3*d*.]

*Department of Scientific and Industrial Research. Report of the Water Pollution Research Board with the Report of the Director of Water Pollution Research for the Year* 1951. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s*. 6*d*. net.]

*Overseas Economic Surveys. Egypt.* By A. N. Cumberbatch. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 4*s*. 6*d*. net.]

*Materials Handling in Industry.* British Electrical Development Association, 2, Savoy-hill, London, W.C.2. [Price 8*s*. 6*d*.]

*Handbook for Constructional Engineers, Containing Tables Relating to Steel.* Dorman, Long and Company, Limited, Middlesbrough.

*Iron and Steel Corporation of Great Britain.* 1951 *Accounts, Covering the Period 15th February to 30th September,* 1951. Offices of the Corporation, 1, Chester-street, London, S.W.1. [Price 15*s*., postage 1*s*. 6*d*.]