# 50-B.H.P. DIESEL CRAWLER TRACTOR.

The Smithfield Show, which opens in London on December 3, continues to gain in popularity and an increasing number of firms make it the occasion for introducing new products to the farmer. This year, several firms will be showing new tractors, among which will be the Challenger I Diesel crawler tractor, made by John Fowler and Company (Leeds), Limited, Hunslet, Leeds, 10. This machine has been in process of development for several years, and, it is understood, will be produced in limited quantities during 1952. It is fitted with the Marshall E.D.5 two-cylinder loop-scavenge two-stroke Diesel engine developing 50 brake horse-power and, although primarily intended for agricultural work, is equally suitable for industrial applications. Fig. 1 shows the machine hauling a five-furrow plough, a task well within its capabilities, and Fig. 2, equipped as a bulldozer.

The power unit, which is manufactured by Marshall, Sons and Company, Limited, Gainsborough, is a twin-cylinder vertical engine having a bore and stroke of $5\frac{1}{4}$ in. and 6 in., respectively, and developing its maximum output of 50 brake horsepower at 1,250 r.p.m. It is illustrated in Fig. 3, on page 674. Performance and consumption curves are given in Figs. 4 and 5, on the same page, and transverse and longitudinal sections, respectively, in Figs. 9 and 10, on Plate XLV. A two-stroke design was chosen, as it gives an engine which is smaller, and cheaper to produce, than a four-stroke type of equivalent power and speed; moreover, maintenance costs of a two-stroke engine are considerably less. The engine is conservatively rated, the brake mean effective pressure being 61 lb. per square inch. The design of pistons and rings is such that it is capable of hard working for long periods with complete freedom from ring sticking. As will be seen from Figs. 6 and 7, the cylinder block is of the monobloc type; it is cast from high-duty iron and the crankshaft is supported from the integral crankcase by three main bearings. These are of the steel-backed copper-lead type, and similar bearings are employed for the big ends, the caps of which are each held in position by four bolts. The cylinder heads are cast separately and each embodies a central pre-combustion chamber, a decompression valve and a fuel injector. C.A.V. fuel-injection equipment is fitted, the pump, which incorporates a variable-speed governor of the mechanical type, being driven through a chain from the engine crankshaft.

The scavenging air is supplied by a Roots-type blower made by Sir George Godfrey and Partners, Limited, Hampton-road, Hanworth, Middlesex. The mean pressure of the air supply is approximately 3·5 lb. per square inch, with an air-delivery ratio of 1·25 times the swept cylinder volume. It is driven from the crankshaft through a duplex chain situated at the front of the engine. A second duplex chain drives the fuel pump and the lubricating-oil pump; both chains are provided with jockey tensioning sprockets. The coolant is circulated by a centrifugal pump mounted on the fan spindle and arranged to deliver to the cylinder jacket at a position just below the exhaust ports. After passing round the cylinders, the coolant flows through four large-diameter transfer holes into each cylinder head and then by a manifold to the radiator header tank. Twin V belts are used to drive the fan and water pump, the belt tensions being maintained by a jockey pulley. Lubrication of the main bearings, big ends, etc., is by a gear pump submerged in the oil sump. The main oil pressure is controlled by a relief valve, the by-pass from which is led to the timing case for lubrication of the ancillary chain drives, the oil subsequently draining back into the sump. Oil filtration is exceptionally thorough, there being a removable gauze filter at the suction side of the pump and metal-element and replaceable-cartridge type filters at the discharge side of the pump, the metal-element filter is self-cleaning.

Starting is effected by an opposed-twin 5 h.p. Coventry-Victor petrol engine, arranged at the rear of the main unit above the clutch housing. In extremely cold temperatures, starting of the main engine is facilitated by running the starting unit for a short period and allowing the warm circulating water to pass round the cylinder jackets, etc., of the main engine. The starting engine is connected to the main unit by a small clutch and Bendix pinion, the decompression valves being opened at the commencement of starting operations. To render starting easier in conditions of extreme cold, the main engine is fitted with holders for the insertion of starting papers.

The power from the engine is transmitted by a 14-in. Borg and Beck single dry-plate clutch through a propeller shaft to the input bevel pinion of the gearbox; this, in turn, meshes with a bevel wheel on the first-motion shaft, located transversely on the main gearbox casing. This arrangement will be clear from Fig. 8, on Plate XLV, which shows a plan view of the main gearbox and final drive assembly. The first-motion shaft carries three pinions of progressively varying size, which can be brought into mesh with mating gearwheels on the second-motion shaft, thereby giving a choice of three different ratios. A locking device is provided on the gear-shift lever to prevent more than one gear being engaged at the same time. In the middle of the second-motion shaft, however, there is a double pinion for transferring the drive to the clutch shaft, either of which can be engaged at any one time, thereby giving a full range of six forward speeds. Two reverse speeds are obtained by means of the gear cluster illustrated in Fig. 12; this is interposed between the first-motion and second-motion shafts and, when engaged, causes the second-motion shaft to rotate in the opposite direction to that produced by normal engagement of the three pinions on the first-motion shaft. All the shafts are kept as short as possible and in every case they are carried in ball bearings. The complete assembly of gears, shafts, etc., is contained in an oil-tight casing.

The drive from the change-speed section of the transmission to the right-hand and left-hand track-driving sprockets is identical, most of the parts being interchangeable. Each end of the clutch shaft is fitted with a clutch centre-piece having external serrations which engage with similar internal serrations formed in the bores of the metal clutch plates. Between these plates are externally-serrated fabric discs, engaging with internal serrations in the inner periphery of the combined driven member and brake drum, the driving and driven members of each clutch assembly being held in engagement by a spring-loaded clamping plate. To disengage the clamping plate and free the clutch, the springs are compressed by rotating a three-lobed face cam, each lobe of which makes contact with one of three rollers located in a fixed bracket. The driven member of the clutch assembly is splined to a separate shaft, arranged along the same axis as the clutch shaft and fitted with the final-driven pinion. The tractor is braked by externally-contracting flexible-steel bands lined with friction material, which operate on the outer peripheries


Fig. 1. Tractor Hauling a Five-Furrow Plough.


Fig. 2. Tractor Fitted with Bulldozing Equipment.

of the clutch-driven members. All shafts final-drive assembly, as in the gearbox, are supported in ball bearings and the units are effectively sealed against the ingress of dirt, etc., by means of spring-loaded diaphragms which make contact with the sprocket hubs. The engine and transmission casings together form a robust chassis which is independent of the track unit and designed so that all parts are easily accessible.

In general, the design of the track frames follows the manufacturers' standard practice. The track-frame assembly is shown coupled to the transmission in Fig. 6, and separately in Fig. 7, on page 675. The offside and nearside frames are separate structures which are coupled together at the rear by a large cross-tube on which they swivel, and at the front by a double-cranked axle, the crank being forward of the axle at one side and behind the axle at the other side. This form of construction will be clear from Fig. 8, on page 675, which shows one end of the cranked axle in position on the frame, the crank in this case being behind the centre line of the axle. With this arrangement, oscillation of the axle gives the track frames at the front end opposite motions in the vertical planes, the rear of each frame swivelling on the cross beam; the frames, therefore, are held in the correct alignment and are prevented from "heeling and toeing," a common cause of track wear. The forward track idlers slide horizontally in guides on the frames, each idler being located between forks in the usual manner. Between each idler and cross-beam swivel bracket is a recoil spring, contained in a grease-packed tubular cover, the purpose of which is to absorb shocks imposed on the idler and permit the idler to recoil slightly should any obstruction be caught between the track and the driving sprocket or the track and idler. Four rollers are provided for each track; these are of the centre-thrust bushed type and are fitted with efficient oil and water seals. The oscillations of the cranked axle are damped by two leaf springs, one at each side of the transmission unit, which also control the movement of the crank throws; one of these springs can be seen in Fig. 8.

The tracks are of the pin-and-bush type with the links, pins and bushes suitably heat-treated to resist wear. To facilitate servicing there are two master track bars at each side. The track plates are of rolled section and can be fitted with sheet plates, designed to be rapidly put in place and removed. The tractor is easy to drive, the controls consisting of a gear lever with a further lever to select high or low range, two steering levers, a clutch pedal and a brake pedal, which is connected to the brakes through a compensating linkage and arranged so that it can be locked in the applied position for packing purposes. When a slower turn is required, the clutch at the appropriate side of the tractor is released by pulling the steering lever through half of its total movement, the brake not being applied until the lever is pulled hard back, at which position the trace will be locked.

There are four power take-off points for operating auxiliary equipment. For operating hydraulic pumps used in connection with bulldozers or mounted agricultural implements, a drive is taken from the forward end of the crankshaft through a resilient coupling or from a chain sprocket fitted to the crankshaft fan pulley, both drives operating, of course, at engine speed. A belt-pulley power take-off is fitted to the first-motion shaft of the transmission assembly at the near side of the tractor and operated at a speed of 686 r.p.m. with the engine at maximum governed speed; the full engine power can be transmitted. The rear power take-off, which also can transmit the full power of the engine, has a neutral position and high and low ratios, giving speeds of 1,250 r.p.m. and 535 r.p.m., respectively. A belt-pulley drive is available for coupling into the rear power take-off, the operating speed being 1,062 r.p.m. and the pulley diameter 12 in., the required direction of rotation being obtained by mounting the drive so that the pulley is either to the right or the left of the first-motion shaft. The two forward power take-off drives run continuously, but the side and rear power take-off drives can be disconnected by releasing the engine clutch.

The weight of the complete tractor in full working

# TWO-STROKE ENGINE FOR FOWLER TRACTOR.

MARSHALL, SONS AND COMPANY, LIMITED, GAINSBOROUGH.

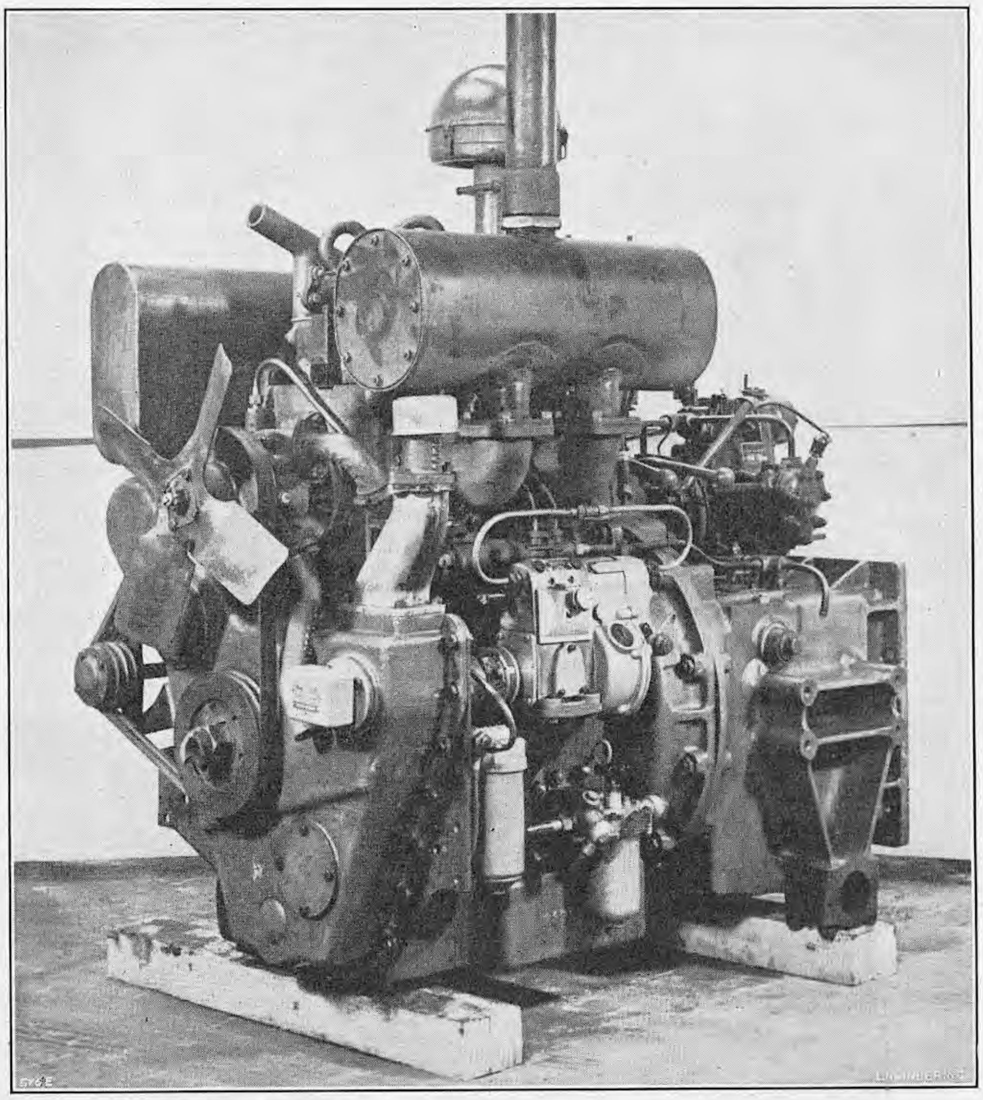
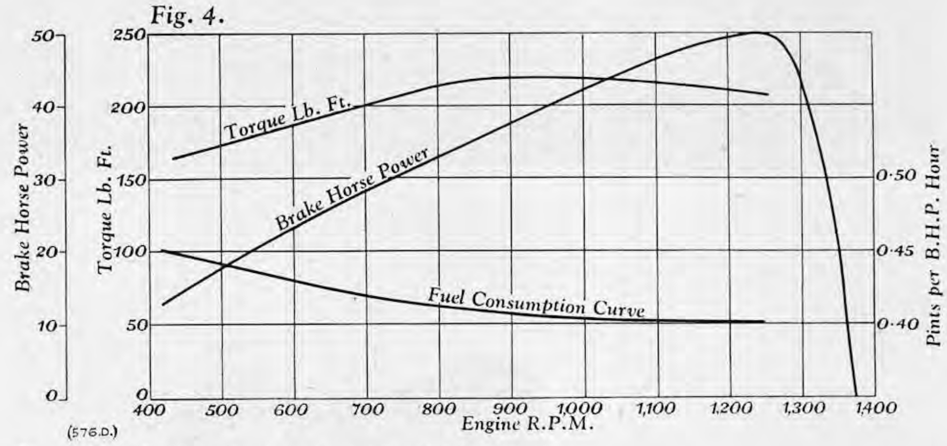
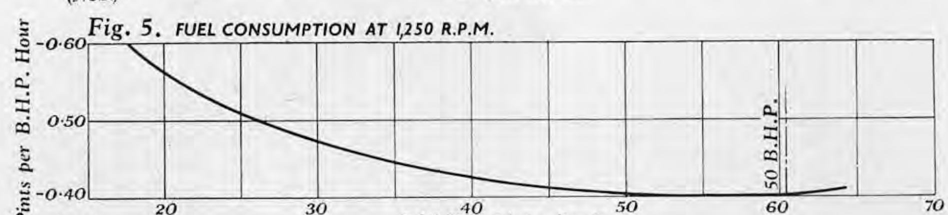


Fig. 3. Two-Cylinder Two-Stroke Diesel Engine.

Fig. 4.




order is 10,900 lb., the overall length 10 ft. 4½ in., the overall width 6 ft., and the height, excluding the exhaust pipe and air cleaner, 5 ft. 9½ in. The gauge of the tracks, measured from centre to centre, is 4 ft. 8 in., and the width of the track plates 16 in., which, with a length of ground contact of 5 ft. 0¼ in., gives an area of contact of 1,930 sq. in. and the low ground pressure of 5·65 lb. per square inch. The speeds in the various forward ratios are 1·68 miles an hour in first ratio; 2·25 miles an hour in second; 3·11 miles an hour in third; 3·86 miles an hour in fourth; 5·2 miles an hour in fifth; and 7·2 miles an hour in top ratio. For the two reverse ratios, the speeds are 1·27 miles an hour and 2·96 miles an hour, respectively. The drawbar pulls, according to the gear in use, are 10,000 lb. in first gear; 6,880 lb. in second; 4,500 lb. in third; 3,400 lb. in fourth; 2,160 lb. in fifth, and 1,150 lb. in top gear.

# "CHALLENGER" 50-HORSE-POWER DIESEL CRAWLER TRACTOR.

JOHN FOWLER AND COMPANY (LEEDS) LIMITED, LEEDS.

(*For Description, see Page* 673.)

SECTIONAL ARRANGEMENT OF TWIN VERTICAL OIL ENGINE.

Fig. 9.

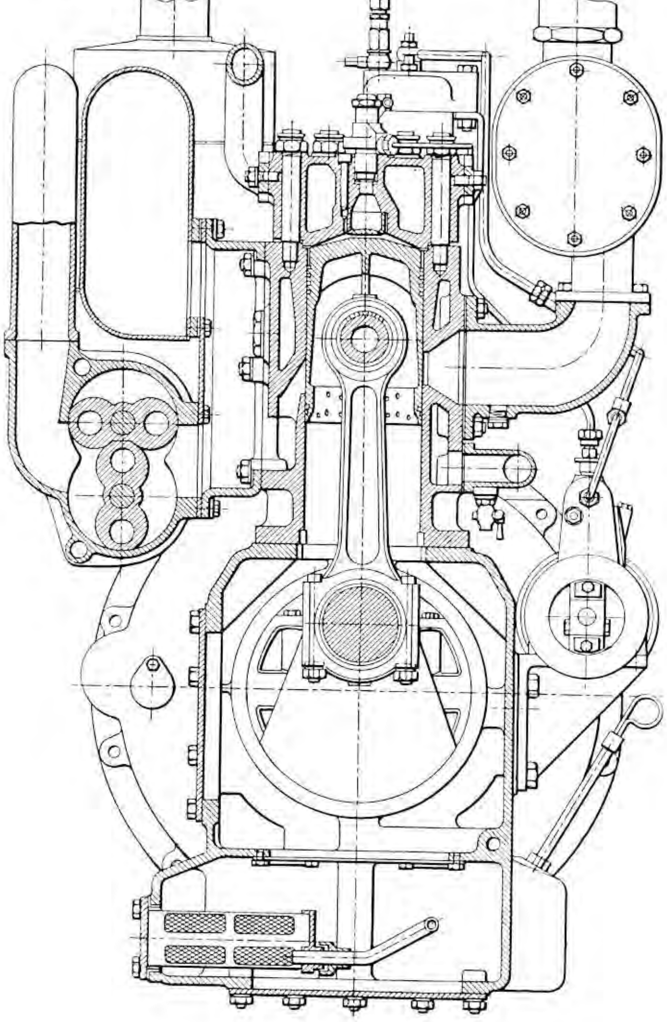


Fig. 10.

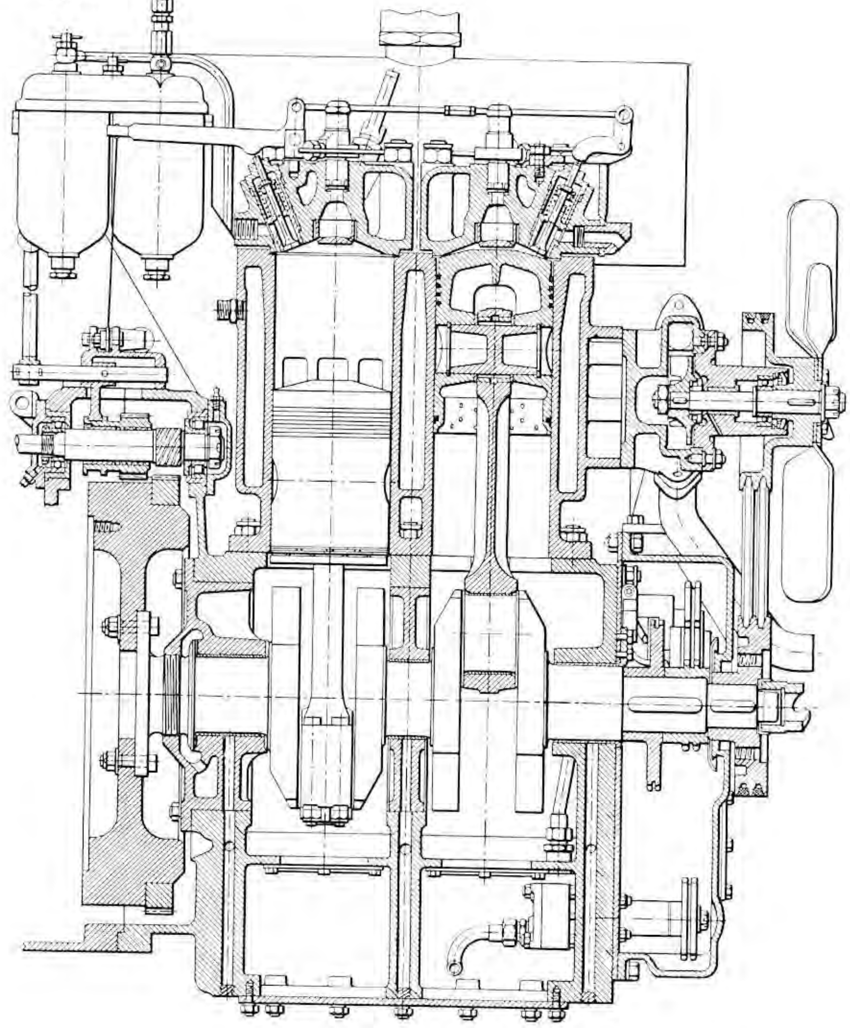


Fig. 11.
ARRANGEMENT OF TRANSMISSION.

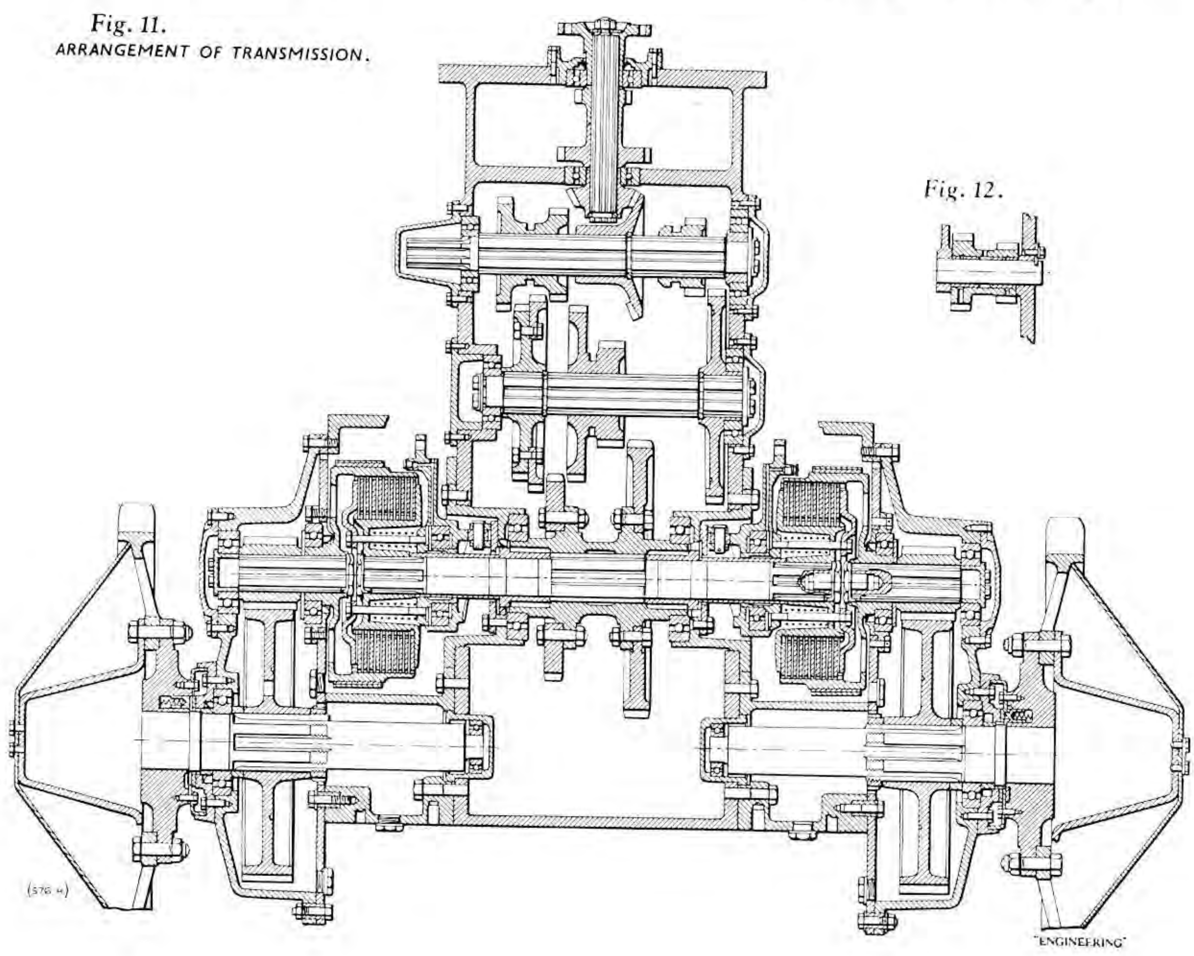



Fig. 12.

# "CHALLENGER" 50-H.P. DIESEL CRAWLER TRACTOR.

JOHN FOWLER AND COMPANY (LEEDS), LIMITED, LEEDS.

(*For Description, see Opposite Page.*)

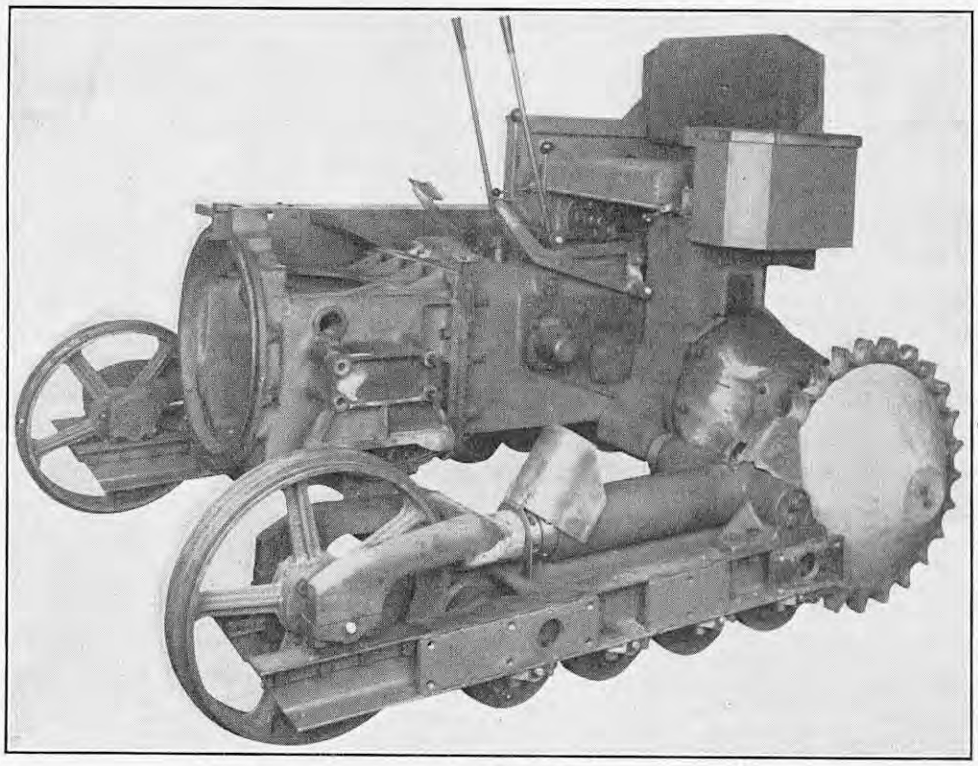


Fig. 6. Transmission and Track-Frame Assembly.

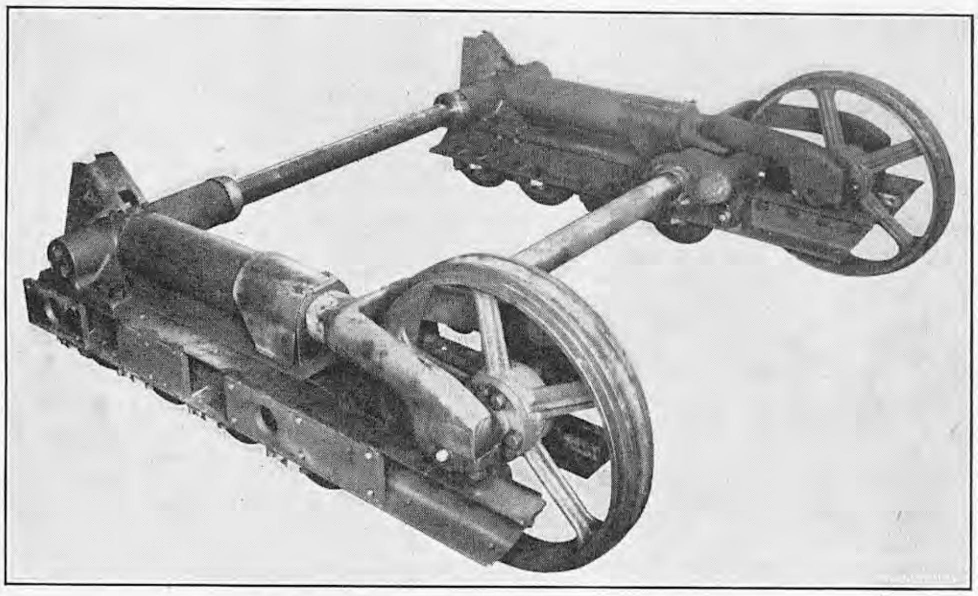


Fig. 7. Side Frames and Track Idlers.

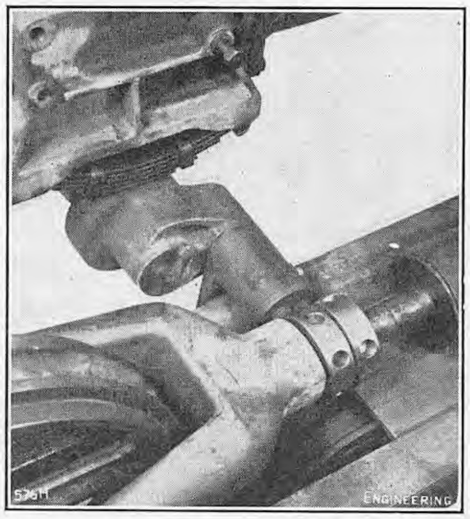



Fig. 8. Cranked Axle.

## LITERATURE.

*Chemical Thermodynamics.*

By Frederick D. Rossini. 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.]

Since every chemical reaction may be regarded as a particular example of the conversion of energy, the chemist has a vastly greater field for the application of thermodynamic principles than the man whose interest in the subject is confined to the behaviour of heat engines. The work of both is governed by the two fundamental laws of the conservation of energy and the increase of entropy, but, beyond this, their outlooks differ as widely as their respective aims. Chemical thermodynamics has therefore come to have a literature of its own which is well exemplified in the present volume. The author, who is professor of chemistry at the Carnegie Institute of Technology, has assumed his readers to be equipped with a good knowledge of mathematics and physical chemistry, and it might be said, without casting any reflections on the lucidity of his text, that some understanding of ordinary thermodynamics and of atomic physics would be a further advantage to the student. The author's aim is to give a comprehensive review of modern chemical thermodynamics presented as a logical sequence of ideas without regard to the chronological order in which they arose. Thus, the Einstein equivalence of mass and energy, and the consequent changes in mass in chemical and nuclear reactions, follow immediately after a brief explanation of the First Law, and before such relatively simple matters as specific heats and the behaviour of perfect gases are considered. Entropy is introduced as a property associated with the capacity of a system for spontaneous change, rather than as a mere mathematical expression, and its conservation during reversible changes is then stated as the Second Law of Thermodynamics.

Except for the omission of the theory of jets, which, however, does not concern the chemist, all or more than the average engineer needs to know about thermodynamics is covered in about one-third of the book. Then, after a discussion of the heat capacity of substances according to the theories of Einstein and Debye, and of free energy and heats of reaction, the longest chapter in the volume is devoted to the calculation of the various thermodynamical functions by the methods of statistical mechanics, the distribution of molecules among their possible states of energy being assumed to correspond with the Boltzmann law. A consideration of the contributions to the entropy of a substance made, respectively, by the translational, rotational and vibrational degrees of freedom, the electronic states and the nuclear spins of the molecules, leads naturally to a chapter on the so-called Third Law of Thermodynamics. This states that, at the absolute zero of temperature, the entropy will fall to zero provided that the molecules then only have one quantum state of existence available to them. The carbon molecules in both diamond and graphite fulfil this condition, although their energies at zero temperature are different. Substances that retain some entropy at zero temperature may do so because of nuclear spin, being mixtures of different molecules or isotopes, having a randomness in the structure of their crystals, existing in a glassy or non-crystalline form, etc. The effect of each of these conditions is considered in detail.

The book is particularly interesting to engineers as showing how the outlook of a chemist may differ from their own on many matters. An engineer, for example, is not used to regarding the temperature of a substance as a measure of the escaping tendency of the heat it contains. Nor does it probably occur to him that a state of thermodynamic equilibrium between two phases of the same substance, such as steam and water, can only exist when the escaping tendency of the molecules of one phase is balanced by an equal tendency in the other phase; otherwise, one of the phases must disappear. He may well know that, under equilibrium conditions, the molal free energy of the water must be equal to that of the steam, without deducing from this fact that the free energy of a phase may also be looked upon as an escaping tendency of the molecules. This conception serves well enough for liquid and solid phases, but for gases the free energy is an inconvenient measure of the escaping tendency, because the free energy of a perfect gas approaches minus infinity as the pressure approaches zero. Hence, the chemist has been led to devise a property called "fugacity" which, if substituted for the pressure in the equation for the free energy of a perfect gas at constant temperature ($dF = VdP$), enables the simplicity of this relationship to be retained in calculations on actual gases. The value of the fugacity of any gas is determined from its equation of state. A further artificial property called the "activity," which is related to the fugacity, and therefore to the free energy, permits calculations on actual solutions to be performed with corresponding ease.

In a chapter on thermodynamic calculations, among a number of diagrams showing the equilibrium conditions of the reactions for the synthetic production of such substances as toluene, rubber, alcohols, hydrocarbon fuels, etc., there is one concerning the possibility of converting graphite into diamond. Thermodynamic considerations show that the transformation would be favoured by low temperatures and high pressures, the pressure required at ordinary room temperature being about 15,000 atmospheres. It still remains, however, to find a catalyst that will make the reaction proceed at a reasonable rate. Some useful appendices giving the values of the constants of special interest to the theoretical chemist, conversion factors, etc., terminate a book of exceptional value to students of the thermodynamical basis of chemistry. It is particularly well written, and appears to cover the whole range of the subject, especially in view of the very full references to detailed publications on particular matters which are to be found at the end of every chapter. The volume undoubtedly deserves a place in every chemical library.

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*Investment in Empire.*

By Daniel Thorner. University of Pennsylvania Press, Philadelphia, U.S.A. [Price 3.75 dols.]; and Geoffrey Cumberlege, Oxford University Press, Amen House, Warwick-square, London, E.C.4. [Price 30s. net.]

The subtitle to this book, "British Railway and Steam Shipping Enterprise in India, 1825-1849," indicates that it is more than a philosophical dissertation on the abstract theme suggested by the main title. It is, in fact, as the preface makes clear, a study of the process by which the steamship lines to India, and the railway systems in India, were established; a process which, it is pointed out, resulted in a movement of capital from England to India that "formed the largest single unit of international investment in the Nineteenth Century," and "gave rise to the Indian business class which provided the core of modern Indian nationalism." The survey, being essentially one of economic facts and influences, is not directly concerned with technical considerations, though the developments which stimulated the economic changes were entirely technical and scientific; but the book may be commended to the engineering reader as an excellent example of the enormous influence that engineers have had, and have still, on the course of human affairs.

Dr. Thorner, who has been since 1948 a research assistant professor of economic history in the University of Pennsylvania, has had a varied experience. His initial researches were carried out between 1938 and 1940, with the aid of postgraduate fellowships, in the archives of the United States and England. In the early part of the war, he was an officer in a merchant ship; then, from 1944 to 1946, in India, with the United States Foreign Economic Administration, in which he was directly concerned with railway matters. The actual text of the book is remarkably concise—almost to a fault, for some parts might have been somewhat elaborated for the benefit of readers who have not ready access to the numerous original sources which are cited. To some extent, however, this brevity is amended by the notes appended to the individual chapters. These notes are supplemented by a well-arranged bibliography and an adequate index. As might be expected, a large proportion of the bibliographical references are to works studied by the author in American libraries; but most of them are available also in London. Considerable use has been made of the remarkable collection of records in the former India Office in London, and previously in that of the Honourable East India Company. The author has adhered fairly strictly to the period indicated in the subtitle, which is perhaps the reason why no mention appears to be made of Dr. C. N. Parkinson's *Trade in the Eastern Seas*, published by the Cambridge University Press in 1937, which dealt with the period from 1793 to 1813; but those who wish to know more of the background to the introduction of steam in Indian transportation may be interested to add this reference to Dr. Thorner's selected list.

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*Elements of Ore Dressing.*

By Professor Arthur F. Taggart. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 10 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 80s. net.]

"Taggart" and the classic *Handbook of Mineral Dressing* are synonymous terms in the minds of most people who are interested in the subject of ore dressing, and no better compliment than this could be paid to the world-famous Professor of Mineral Engineering in the School of Mines, Columbia University. In his new treatise, the emphasis is on the basic principles of mineral-dressing machines and processes rather than on structural and operating details. It is essentially a text-book for the student who wishes to understand the fundamental aspects of the subject. All important treatments to which crude ores are subjected in order to separate and discard the worthless fractions are reduced to their simplest forms, clearly explained and thoughtfully analysed, and the large number of review questions at the end of each chapter should ensure that the reader has absorbed and properly digested the textual material.

The author's foreword to students contains 35 "elements," summarising his wide experience and factual knowledge of ore-dressing processes. He then devotes more than 500 pages of informative text, adequately illustrated with line diagrams, to the numerous separating and concentrating processes in general use at the present time. Hand picking, screening and filtration are followed by explanations of magnetic and electric concentration. After a general introduction to sedimentation and gravity separation, he deals with heavy-media separators, jigs, trough concentrators and shaking tables. Six of the 24 chapters are occupied with explanations of the ramifications of froth flotation and the final chapters cover the subjects of crushing, grinding, transport and controls, and mill flow-sheets. The author's style is unusually refreshing for a text-book and the whole work is clearly presented and printed.

There is an excellent 50-page appendix on laboratory instruction and experimental work, which is obviously designed to encourage observation and deductive reasoning. As the author states in his preface: "The function of a mill is to integrate a number of individual operations into a unit treatment for making one or more valuable products. The purpose of laboratory study is to gain understanding of the individual operations, invariably in themselves complex." It can be imagined, in reading the book, that Professor Taggart himself treated each chapter like a laboratory experiment, and many students, in the mill as well as in the class room, should derive great benefits from his method of treatment.

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Recovery of Gold from Disused Mine Dumps.—In the early days of gold mining in South Africa, the methods of extracting the gold were somewhat crude; as a consequence, the gold content of the old dumps is comparatively high and is worth recovering now that improved extraction processes are available. The Victory Gold Recovery Company, who began such operations a few years ago, are at present engaged on reworking the dumps at the site of the old Robinson shaft on the Witwatersand. At first, they used large gangs of native labourers to break down the dumps manually as a preliminary to the process of extraction. This method proved extremely costly and tended to be unsatisfactory as large lumps of hard sand were left which were not suitable for the ensuing processing. This trouble has been overcome, however, by employing four Gem rotary hoes for breaking down the dumps, the machines having proved so efficient for this purpose that it has been estimated that each does the work of 44 native labourers. Standard 6 horse-power series III Gem Rotovators, as manufactured by Rotary Hoes, Limited, East Horndon, Essex, are being used, the only modification found necessary being the fitting of a special bladed rotor with a working width of 20 in.

# PRESTRESSED-CONCRETE STATICALLY-INDETERMINATE STRUCTURES.

A symposium on prestressed-concrete statically-indeterminate structures, organised by the Cement and Concrete Association in conjunction with the Prestressed Concrete Development Group, was held at the Institution of Civil Engineers, London, on September 24 and 25. The programme was opened by Mr. A. Kirkwood Dodds, M.C., F.R.I.B.A. M.I.Struct.E., chairman of the Group. The seven papers covered the whole field of the problem, namely, theoretical considerations, experiment, design and practical construction. The titles and authors of the papers were as follows: "Continuity of Prestressed Concrete Structures: the Practical Aspect," by A. J. Harris, B.Sc. (Eng.), A.M.I.C.E.; "The Analysis of Statically Indeterminate Structures Subjected to Prestress," by D. W. Cracknell, A.M.I.C.E., A.M.I.Struct.E., and W. A. Knight, B.Sc.; "Some Experimental Work on Interconnected Prestressed Beams," by P. B. Morice, B.Sc.; "Continuity in Prestressed Concrete," by Professor G. Magnel, A.S.C.I., M.A.C.I., M.I.C.E.; "Determination of Continuity Bending Moments in Prestressed Continuous Beams," by E. G. Trimble, B.Sc. (Eng.), A.M.I.C.E., A.M.I.Struct.E.; "Continuity Using Post-Tensioned High-Tensile Alloy-Steel Bars," by G. O. Kee, B.Sc. (Eng.), A.M.I.C.E., and S. Jampel, M.Sc., A.M.I.C.E.; and "A Theoretical Treatment of Continuity in Prestressed Concrete," by Y. Guyon. The following report opens with a general introduction to the subject and is then a digest of the papers by topics rather than as presented by the several authors.

## Principles of Prestressed Concrete.

Consider first a rectangular beam, simply supported and loaded from above, so that the underside is in tension and the top-side in compression. Now suppose that a cable is threaded through the unloaded beam and tensioned, as shown in Fig. 1, opposite; this action will induce a compressive stress in the beam. If the cable is placed through the centre of gravity of the section, the compressive stress caused by the cable will be uniformly distributed over the section; if, however, the cable is dropped towards the lower face of the beam the action of the force in the cable will be similar to that of the action of an eccentric load on a column, and so long as the cable lies within the middle third no tensile stress will be raised in the beam. Since, however, the weight of the beam will cause bending stresses in the beam, it is possible to lay the cable just outside the middle third and still not raise any tensile stresses in the beam. The stress distribution due to the cable force will be of the form shown in Fig. 2. The application of the working load will cause bending stresses of the form shown in Fig. 3, and when added to those already existing in the beam by virtue of the prestress, the stress distribution shown in Fig. 4 will result.

These remarks apply to central portions of the beam, where under normal types of loading, such as concentrated point loads and uniformly-distributed loads, the bending moments are greatest; but in a simply-supported beam the bending moment, and hence the bending stresses, fall off to zero at the ends of the beam and it is not then necessary to provide the high prestresses that are required at the mid-sections. It is therefore usual to reduce the eccentricity of the cable toward the ends of the beam (see Fig. 5, opposite) so that a condition of uniform compressive stress is produced at these end sections. This raising of the cable line has a similar advantage to that of the turned-up bars in ordinary reinforced concrete by providing a resistance to the higher shear stresses which exist at the ends of a simply-supported beam.

The great advantage of construction by prestressed concrete, in comparison with normal reinforced concrete, is the considerable reduction in beam section that is achieved. The saving in concrete and steel may easily be 50 and 75 per cent., respectively. Furthermore, there are the resulting advantages of increased headroom and more slender lines that are then possible in certain types of

# PRESTRESSED-CONCRETE STATICALLY-INDETERMINATE STRUCTURES.

Fig. 1.
SIMPLY - SUPPORTED RECTANGULAR BEAM WITH STRAIGHT CABLE.

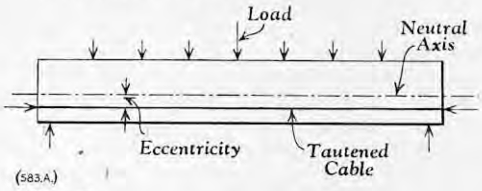



Fig. 2.
STRESSES DUE TO ACTION OF CABLE ALONE.

Fig. 3.
STRESSES DUE TO APPLIED LOAD.

Fig. 4.
RESULTANT STRESSES WHEN "CABLE STRESS" EQUALS "APPLIED LOAD STRESS".

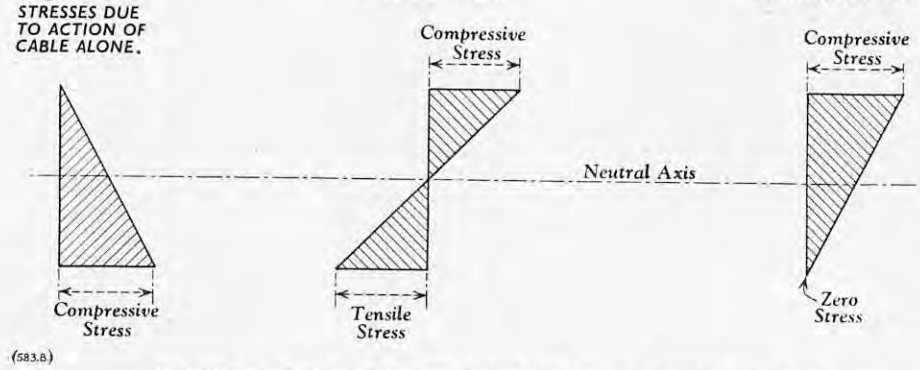
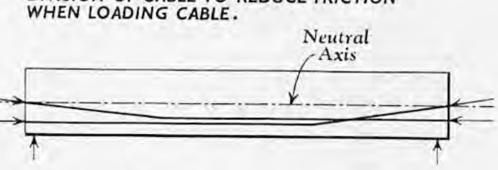



Fig. 7.
DIVISION OF CABLE TO REDUCE FRICTION WHEN LOADING CABLE.




ALTERNATIVE FORMS OF CURVED CABLES FOR SIMPLY-SUPPORTED BEAMS.

Fig. 5.

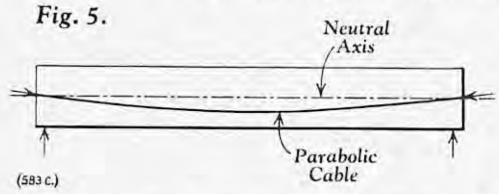



Fig. 6.

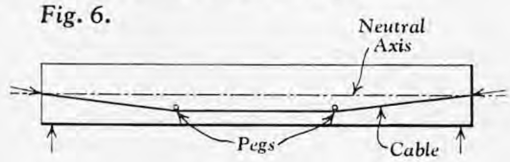



Fig. 8.
HAUNCHED BEAM WITH STRAIGHT CABLE.

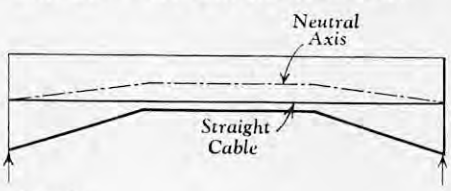
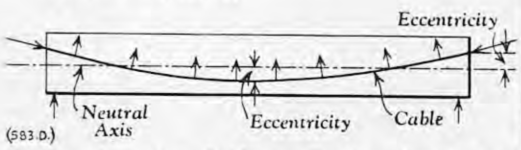



Fig. 9.
FORCES PRODUCING SECONDARY BENDING MOMENTS.




structures, such as bridges. Partly offsetting the saving in cost of materials, there are the increased cost of the higher quality steel (since prestressing becomes most economical when the initial prestress is of the order of 120,000 lb. per square inch) and the added cost of the provisions that must be made to obtain the prestress. Two practical methods of prestressing exist. Either a specially-strengthened framework or other external anchorage has to be provided so that the concrete can be placed about an already tautened cable; the prestress is then maintained during the beam's working life by the action of the bonding of the concrete to the steel. Alternatively, the cable can be kept free from the concrete, either by suitable sheathing or, with particular forms of beam such as hollow boxes, I and T beams, by keeping the cable outside the concrete altogether. The cable is then tautened after the concrete has hardened and strengthened, by using the beam itself as the abutment for jacking the prestressing load into the cable. The cable is then wedged by grips that are often finally buried in *insitu* concrete. This process is occasionally referred to as post-tensioning.

One of the difficulties encountered is due to the creep and shrinkage of the concrete that tend to release the load in the cable, thus reducing the working load that can be applied to the beam without introducing serious tensile stresses on the underside face. The combined effect of shrinkage and creep is such that the prestress may, in the course of time, fall to about 85 per cent. of the initial figure, but since sufficient information is available for this loss to be accurately assessed, prestressed concrete beams can be designed that have economic advantages over ordinary reinforced concrete.

Another problem is that of obtaining the curved form of the cable shown in Fig. 6, on this page. If the beam is being manufactured by first tautening the cable and then casting the concrete *in situ*, suitable means have to be found for holding the loaded cable in the required shape. Alternatively, if the beam is being post-tensioned, part of the load goes in overcoming friction either at the pegs, if the cables are outside the concrete, or against the side of the sheaths. The loss of load due to friction cannot be assessed accurately, and consequently the resultant prestress is not known accurately either. This difficulty can be overcome in the case of post-stressed beams by dividing the cables into pairs, as in Fig. 7, so that each cable changes direction only once along its length. If the cables are external to the concrete they pass round only one peg, and by jacking from both ends simultaneously the loss due to friction can be avoided entirely. If the cables are sheathed within the body of the concrete, the total change of direction in the cable has still been considerably reduced and friction losses minimised.

This problem of shaping the cable and of tautening a curved cable can be side-stepped in certain circumstances by keeping the cable straight and by haunching the beam, as in Fig. 8. A little consideration will show that this has the same effect of inducing a uniform compressive stress as turning up the cable, since the effective eccentricity of the cable is reduced from a maximum at the mid-section to zero at the ends. This practice is limited when the number of cables required, and hence the number of anchorages, is so large that there is insufficient space at the ends of the beam to place all the anchorages across the width of the beam section. This method of bending the neutral axis is not possible if headroom is restricted so that haunches cannot be allowed. One more limitation must be mentioned here: the cables cannot be accurately tautened to a given degree of prestress *in situ* or under normal factory conditions if they are too short. In general, the longer the cable the greater the accuracy with which the prestress may be applied. Furthermore, assuming the length of cable to be independent of all other factors, the number (and, therefore, the cost) of providing anchorages is reduced by the use of longer cables.

Another advantage of prestressed cables should be mentioned. After the cable—which usually consists of a large number of independent wires—has been initially loaded it is never likely to be so heavily strained again, for the following reason. Immediately after prestressing, the cable stress falls due to creep and shrinkage in the concrete, but the increase in strain, due to the application of the working load, is only 4 or 5 per cent. of the initial prestress, the cable load being nearly independent of the working load. Hence, if the cable does not fail under the action of prestressing, every confidence may be expressed that the cable will not fail under working conditions.

### Need for Prestressing Continuous Concrete Structures.

Professor Magnel went to the heart of the problem in the opening paragraphs of his paper. He pointed out that all of the pioneers in the field of prestressing started by making exclusive use of simply-supported beams. This was a natural approach, as it was necessary to become thoroughly acquainted with the problems of the new technique by applying them to the more simple cases first. Furthermore, it was unlikely that authorities would agree to the erection of buildings designed on principles that were untried; but the need to construct statically-indeterminate structures in prestressed concrete was recognised from the beginning. Indeed, it is impossible to avoid the problem in many instances; for example, in the construction of multi-storey buildings, or even one-storey buildings in areas subject to earthquakes, and in the construction of bridges of two or more spans.

The advantages of continuity are well known. In general, more satisfactory structures result, unless there is any doubt of the foundations, so that differential settlement may occur. Where such doubtful foundations exist and are recognised in the design stage, continuity may provide the solution of the difficulties for certain types of building. Continuity in beams usually results in both a reduction in the depth of construction and the omission of artificial joints, and, taken together, a more slender and finer line of construction will result. The use of continuous beams reduces the number of anchorages that have to be provided, and therefore makes feasible the construction of short prestressed-concrete beams that would not be as economical as simply-supported beams.

The disadvantages of continuity are both theoretical and practical. They include the tendency of continuous prestressed-concrete beams to develop secondary moments, which may be either advantageous or disadvantageous; these moments are often tedious to calculate. Alternatively, in order to avoid the causes of such secondary moments, special bar or cable arrangements have to be designed, a procedure that may be as tedious as the calculation of the secondary bending moments that are being avoided. Such arrangements may introduce practical difficulties in placing and controlling the cable during prestressing. Calculation and experiment show that a small mis-placement of the cable may easily produce secondary moments far larger than can be accommodated by the structure.

### Problem of Continuity in Prestressed Structures.

The theoretical difficulties of continous prestressed structures result from the fact that the prestress cannot be induced in any member of the structure without causing strains. Now, if the structure is statically determinate, i.e., if there is only just a sufficiency of members and all the connections are pin-jointed, then each member may be internally prestressed without modifying the external reactions in any way and without communicating any load to any other member of the structure. The members of such a statically-determinate structure will simply dispose themselves to take up the slight alteration in the length of the member that is prestressed. With an indeterminate structure, however, the problem is far more complex, since the act of prestressing one member will cause secondary moments and forces to be induced in adjacent members. Furthermore, the external reactions may be modified by the deformations of members that are occasioned by prestressing, and this modifying of the reactions will, in turn, change the loads in the members of the structure. In consequence, the effect of prestressing may be twofold: the immediate effect within the member concerned and a secondary effect due to the change of external reaction brought about by the prestressing.

The method of design is not at first straightforward, although no new principles are involved. The methods available for calculating the fixed-end moments and the "carry-over" moments over supports are well known, and use of a familiar method is the sole criterion of choice of method for design calculations. More important than new methods is the need to be aware of factors that are normally neglected when dealing with steel or ordinary reinforced-concrete structures. For example, the shortening of members of a framework is normally neglected in structural design without serious damage, but in prestressed concrete the shortening of members due to prestress, shrinkage and creep must be taken into consideration. Fortunately, the principle of superposition holds good for prestressed concrete; if this were not so, the problem would be difficult and even intractable.

The assumptions made in respect of elasticity of concrete, of the effects of creep and shrinkage on the prestressing force, are such that great finesse in calculation is not justified. The varying properties of concrete do not warrant a too refined calculation, and the facility of concrete in adapting itself to the conditions of local over-stress, together with the high factors of safety allowed with concrete, do not make slight under-estimation of secondary moments of great importance. To quote Professor Magnel again: "Consequently, do not let us make long calculations in order to increase the accuracy; let us rather concentrate on a good general conception of the structure to be made, and see that the prestressing is done in the best possible manner."

### Practical Treatment of the Problem.

Four methods of treatment can be considered when dealing with the problem of continuity in prestressed-concrete structures. The form of the structure will often determine which of the methods of treatment is to be used. The four methods are as follows.

(1) Avoiding the problem by prestressing the structure in a statically-determinate condition, or by the use of individually prestressed members, and finally rendering the whole into a single continuous structure without affecting the prestress. This usually involves the thickening of hinges or joints that have been left free; the hinges are packed with *in situ* concrete that is often strengthened by ordinary rod reinforcement or by prestressed cap-cables. Such treatment has proved successful in the construction of multi-framed buildings.

(2) Stressing the structure and adjusting the redundant reactions to either their initial values or to some other value found to be more advantageous. This method is of particular value when dealing with indeterminate arch structures or with continuous beam structures.

(3) Stressing the structure in such a way as not to affect the redundant reactions. This is most usually done—for example, in continuous-beam structures—by the use of an undulating cable. The difficulties of a curved cable and possible losses of prestress due to friction during straining have already been mentioned for simply-supported prestressed beams, and the difficulties are multiplied in the case of continuous beams.

(4) Stressing the structure in the most convenient manner and calculating the total effect of the prestressing forces. This treatment is restricted to such forms as continuous beams, portal frames and arches that are themselves attuned to structural analysis.

In designing continuous prestressed structures two practical difficulties have to be borne clearly in mind from the initial stages. The cables have to be kept in the required position during the act of prestressing; or for post-stressing, if the cable is too curved, either the frictional forces will be too large for accurate tautening of the cable, or large transverse forces may be realised that will develop troublesome secondary moments. Secondly, at least one end, and preferably both ends, of the cable must be accessible in order that it may be tensioned and finally enclosed in cases where other than bond-anchorage is used.

### Mathematical Analysis of the Problem.

Four of the papers discussed the problem wholly or partly in terms of mathematical analysis. The paper by Mr. Guyon, of the Société Technique pour l'Utilisation de la Précontrainte, was the most purely mathematical and set out in general terms the problem of determining the most suitable line for the cable so that no additional reactions at the supports are caused by the act of prestressing. The additional effects of the superposition of external loading were then considered and the ideal requirements for the cable arrangements were determined for given instances. The paper concluded with a general statement of the technique of adjusting the reactions on a structure by means of jacks at critical points of support.

Mr. Trimble, in his paper, analysed the problem of continuity moments in a set of prestressed-concrete beams. In particular, he discussed the moments induced in a set of such beams during the act of prestressing an undulating cable, due to the forces that such a curved cable will set up in the vertical plane, as shown in Fig. 9, page 677; these moments will act, of course, over and above those moments due to the eccentric force in the cable. The problem was tackled for individual beams that were considered to be fixed ended, and the author showed how the resultant end moments may be divided into two parts: one part due to the eccentricity of the prestressing force and the other due to the curvature of the cable. The first part is the same in magnitude, although of opposite sense, for the two sections of a continuous beam meeting over a support, and there is therefore no need to include this moment in the balance sheet when estimating the "carry-over" moments. This moment must, however, be included in the final summation of moments at the support in question. The paper included two tables designed to assist in the calculation of the fixed end moments of prismatic beams with either straight or parabolic haunches.

The theoretical problem of continuous beams was also briefly dwelt upon in the paper by Messrs. Kee and Jampel, who pointed out that there would be no secondary moments due to the act of prestressing if the position of the cable and shape of the beam were arranged so that $\int \frac{e}{I} dx = 0$, as shown in Fig. 10. The authors gave a useful set of curves to assist calculation of the cable position to obtain this condition in a beam with straight haunches. The paper also gave a number of formulæ, including some for estimating secondary moments due to prestressing in the case of portal frames with tapering columns.

Fig. 10.

UNDULATING CABLE IN CONTINUOUS BEAM ARRANGED SO THAT $\int \frac{e}{I} ds = 0$

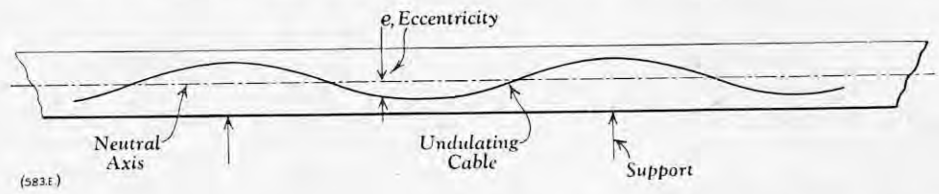
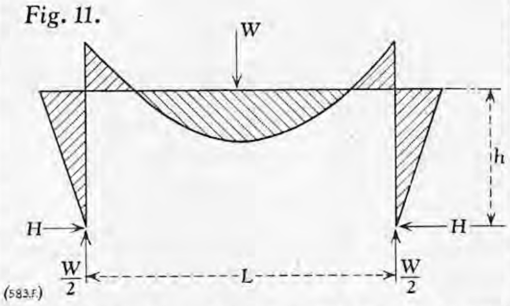



Fig. 11.




The paper by Messrs. D. W. Cracknell and W. A. Knight, dealt with the fundamental aspects of the behaviour of statically-indeterminate structures and the application of some suitable methods of analysis. In an analysis of the simple portal frame the paper referred to the relative significance of the prestressing forces and the applied loads. The argument showed that the presence of a uniform prestress, designed to offset the stresses due to an applied load at the centre of the beam, is such as to reduce the horizontal thrust at the foot of the columns due to the axial shortening of the beam (Fig. 11). The thrust is reduced to H $\left(1 - \frac{d}{h}\right)$, where H is the thrust in the absence of prestress, $d$ the depth of the beam and $h$ the height of the portal. It was then shown that shrinkage will account for a shortening of the beam of about $1\frac{1}{2}$ times that due to prestressing; the conclusion, therefore, was that the combined effect of prestress and shrinkage must be allowed for in a prestressed portal frame. Though the reduction of the thrust at the foot of the column lessens the bending moment in the columns, there is, of course, a simultaneous increase in the bending moment in the beam for which allowance must be made. The discussion of the effects of shortening of members was carried a stage farther in relation to multi-storey buildings; the effect varies with the proportions of the building, but for a typical frame the modification of moments in the column may be a reduction of about 15 per cent. and, in the beams, an increase of 5 per cent.

Three methods of analysis were discussed in this paper in considerable detail with the aid of examples, namely, the "method of cut," the column analogy and the theory of a beam on an elastic foundation. The explanation of the last-named method was greatly amplified by the inclusion of an extensive appendix of data for many standard basic cases from which any particular case in practice may be synthesised. By the "method of cut," the authors determined the moment required at a support to re-establish continuity in a system of beams that has been "cut" at the support in the individual members. The relative slope of the ends of successive members at a point of cut, due to the internal bending moment, is determined and the continuity moment required to produce an equal but opposite slope is calculated. Use is made of two propositions that are extensions of Mohr's theorems: firstly, the slope at any point in a beam relative to the line joining its supports is numerically equal to the shear force at that point in the conjugate beam loaded with the $\frac{M}{EI}$ diagram; and, secondly, the deflection at any point in a beam relative to the line joining its supports is numerically equal to the bending moment at that point in the conjugate beam loaded with the $\frac{M}{EI}$ diagram.

The column analogy, developed by Professor Hardy Cross, is based upon the similarity between the expressions giving the end-fixing moments for an *encastré* beam and those giving the stresses in the extreme fibres of a short column that is eccentrically loaded. The authors developed the analogy so that it might be applied directly to portal frames. The theory of beams on elastic foundations, which is based on the conception of a reactive pressure that is everywhere proportional to the deflection in the beam, was discussed at length, and by example it was shown how the results of the theory may be applied to cases other than that suggested by its title. For example, walls of cylindrical tanks containing liquids may be considered as vertical beams supported by elastic horizontal circular rings; the radial expansion of the ring corresponds to the depression caused in the elastic medium supporting the beam in the basic theory.

Unfortunately, parts of the mathematics of most of the papers can only be followed with difficulty, due to the brevity of the presentation and the paucity of initial explanations of what the authors were attempting to determine.

*(To be continued.)*

# DE JOUFFROY D'ABBANS: PIONEER OF STEAM NAVIGATION.

Who first applied steam to ship propulsion is a question which is never likely to be settled, because there is no certain evidence that some of the earliest designs were ever built. William Symington, Robert Fulton and Henry Bell all have their assured places in the history of steam navigation, but there are incontestable historical records to show that a Frenchman, de Jouffroy d'Abbans, was, in all probability, the first to achieve practical results. The bicentenary of his birth has recently been celebrated extensively in France, and the following record of his work has been prepared from a series of addresses delivered in his honour at the Sorbonne, on Friday, October 26, in the presence of the President of the Republic and a large and distinguished company.

Claude-Françoise-Dorothée de Jouffroy d'Abbans, whose portrait is reproduced in Fig. 1, herewith, was the son of a noble family. He was born in 1751 at Roche-sur-Rognon, near Lyons, and brought up in France during that period of transition when the old order was crumbling and the spirit of revolution was in the air. Nevertheless, although grievously affected by the tide of events, he remained throughout his life faithful to his f mily traditions, and to the belief, inculcated in him by his father, that the first duty of a gentleman is to serve his King. His father destined his son for the army, and, by way of preparation, enlisted him at the age of 13 as a page in the service of the Dauphine, Marie Josèphe. At the school attached to the court, he studied mathematics under a celebrated teacher, Trincano, and developed a lively interest in mechanics and mechanisms. It is said that he frequently took to pieces clocks and other mechanisms at his father's chateau.

On the death of the Dauphine, he returned to his family home at Abbans where he struck up a friendship with two of his neighbours, d'Auxiron and de Follenay, considerably older than himself and officers in the artillery. D'Auxiron was passionately interested in the steam engine, and had already proposed to apply it to supply water to towns, in particular, Paris. He had also, in manuscript, a proposal for using the "fire pump" to propel ships. His stimulating conversation developed in the young de Jouffroy a taste for science, and he begged to be allowed to follow in d'Auxiron's footsteps by entering the artillery school at Metz. His father, however, shared the prejudices of many of the nobility against that branch of the army and it was, therefore, to a regiment of the Bourbon infantry that the lad was assigned as a subaltern.

This submission to his father's will would have ended his career as an inventor had it not been for a providential incident. In 1772, after an altercation with his colonel over a love-affair with a lady of rank, which induced him to issue a challenge to a duel, he was unexpectedly packed off to the fortress at Sainte-Marguerite on the Iles de Lérins to serve a term of imprisonment in expiation of his crime of insubordination. In prison, he dreamed and schemed. From the window of his cell, he could watch the action of the rowers in the King's galleys in Cannes roads and he drew up plans for the experiment which he was to try later on the river Doubs at Baume-les-Dames. On the death of Louis XV, he was freed and returned to Abbans, his military career broken. Thenceforth, he resolved to devote himself to science. In the eyes of his father, this was a kind of *mésalliance* which was soon to cause grave family dissensions. His younger brother replaced him in the army, married into wealthy circles and received the marquisate and lands of Abbans, while de Jouffroy, reduced to his legitimate inheritance, could only style himself Comte. He was, however, a free man.

During de Jouffroy's captivity, his friend d'Auxiron, aided by certain associates, had made certain proposals in official quarters, and, in 1772, had obtained a licence to undertake steam navigation on rivers on condition that the system employed was approved by the Academy of Sciences. The latter body delegated its task of supervision to one of its number, J. C. Périer, an able technician and industrialist who was greatly interested in Watt's engine, first patented in 1765. D'Auxiron set to work and a small boat was built at Ile des Cignes. The engine was a twin-cylinder one, brought from England; details of it are lacking. In any case, the boat, which had been taken to Meudon, sank during a night in September, 1774, probably owing


Fig. 1.

to malevolent action and despite the guard which was kept over it. D'Auxiron, ruined, appealed to Périer for assistance, but the latter suggested that d'Auxiron should turn his attention instead to the proposal he had made some years earlier to supply water to Paris from the Seine by means of steam-driven pumps. Shortly afterwards, d'Auxiron died without having achieved his ambition, and his associates, who had fallen out with Périer, thereupon invited de Jouffroy to take over.

De Jouffroy, however, asked time to reflect. During 1775 and 1776, there had been several conferences which had brought together persons who, for divers reasons, were interested in steam navigation. Among these were Périer, the Abbé d'Arnal, and also de Jouffroy. In the course of the discussion, Périer took the view that the power required in an engine used to propel a boat was equal to that of the horses needed to tow it at the same speed. De Jouffroy, on the other hand, maintained that, since the propulsive force was applied to water, which yielded to the paddles, a considerably greater power—three times, he suggested—was required in the engine. He had, therefore, arrived intuitively at a result verified later with screw propellers. Nevertheless, it was Périer who prevailed and who installed in a small boat an engine constructed in his own workshops at Chaillot. This craft, it is said, sailed down the Seine, in 1775, in the presence of the Marquis du Creot, who was also a member of the Academy, but—although this may be true, it was unable to sail up-river for its engine was too feeble. Périer did not consider the scheme worth pursuing.

De Jouffroy, the correctness of whose views had to some extent been proved by this failure of Périer, had meanwhile returned to Abbans, where he built a small mill, the action of which enabled him to perfect his knowledge of hydrodynamics. Then, since his father had definitely refused him any assistance, he set off for Baume-les-Dames, where he had a sister who had promised to help him. There, with the help of the village blacksmith, he constructed an atmospheric engine which was installed in a 40-ft. boat on the river Doubs. The cylinder of this engine was made of copper, beaten and polished, and furnished on the outside with longitudinal stiffeners and iron hoops. For the propulsive system, Jouffroy had recollected his observations made in captivity and employed two frames, one on each side of the boat, supporting hinged paddles like articulated oars. In its descent, the piston, which was vertical, acted through a chain running over a pulley, and pulled the frames of oars astern. Counterweights carried the frames forward during the rise of the piston, and the paddles, which were hinged towards the rear, folded back on the return stroke.

The "Pyroscaphe," as de Jouffroy called his vessel, manœuvred successfully on the Doubs in June and July, 1778. It was a real achievement, but a modest one, since the propulsive mechanism was very inefficient. De Jouffroy was sufficiently encouraged to return to Paris and declare himself ready to succeed d'Auxiron on condition that he was allowed to modify the plans of his predecessor. This proposal was accepted and, with the assistance of de Follenay, the necessary funds were collected and the company was re-formed on June 9, 1781. The Comptroller-General, M. de Calonne, confirmed his promise to d'Auxiron, ten years before, that he should enjoy sole operating rights for a period of 15 years. De Jouffroy thereupon returned to Lyons, where he arranged for a boat to be built at Vaise, on the outskirts of the town, and an engine to be made for it in the celebrated workshops of Frèrejean. The boat was 45 m. long and $4\frac{1}{2}$ m. in beam, with a draught of almost a metre, and was fitted with paddlewheels.

De Jouffroy has given an incomplete description of the engine, in a memoir dated 1816. From a comparison of this description with one given to the Academy of Sciences by his son Achille, in 1834, and another unpublished memoir by de Jouffroy himself which appears to date from 1784 and which is preserved at Besançon, it seems that the inventor employed successively two types of engine. The first was an atmospheric one comprising two brass cylinders side by side, open at the top, and inclined at about 20 deg. to the horizontal. These cylinders, to which steam was admitted alternately, turned the paddle wheels continuously by means of chains connected to the pistons, which were returned by counterpoises. The second, and improved, model corresponds to the description given by de Jouffroy in 1816 and to the drawing attached to his patent of the same year, which is indicated as representing the boat used at Lyons in 1783. It is also fairly certainly the engine represented in the model, illustrated in Figs. 2 and 3, on page 680, and now in the Marine Museum in Paris, which is thought to be the one which was sent by de Jouffroy to Périer at the Academy of Sciences in 1784.

The engine had a double-acting horizontal cylinder to the ends of which the steam was admitted alternately through a swivelling valve actuated by chains. The cylinder was integral with the boiler, and the steam pressure was applied through the piston and piston rod to two racks fixed, one above the other, in a frame. It was transmitted to the shaft carrying the paddle wheels through a rack and pinion or rack and pawl mechanism. A transmission system almost identical with this is to be found in a model steamboat made by Desblancs which dates from 1802 and is now in the museum of the Conservatoire des Arts et Métiers in Paris. This similarity is not surprising when it is remembered that Desblancs had been employed at Frèrejean's works. In other respects, his engine shows the advances which had been made in 20 years. Desblancs had replaced the paddle wheels by endless chains carrying paddles.

The trials of de Jouffroy's new boat took place on July 15, 1783, before several thousand spectators. In the presence of many notabilities from Lyons, the vessel steamed up the Saône from Lyons to Ile Barbe in 15 minutes. A document testifying to the success of the venture was immediately drawn up and signed by eight of the dignitaries present. It is still preserved in the office of a lawyer at Lyons.

De Jouffroy now felt assured of success, especially after his boat had made several trips between Lyons and Ile Barbe. His success was more apparent than real, however, for he had not reckoned with administrative prudence or with the enmity of others. He hastened to Calonne and requested him to implement his promised grant of exclusive steam-navigation rights. The latter, however, was not convinced that the new departure would pay and referred the matter to the Academy of Sciences, who appointed a commission of four persons to investigate de Jouffroy's claims. It is significant that one of the four was Périer. In the meantime, the river-transport undertakings saw in the steamboat the ruin of their trade and inflamed public opinion against de Jouffroy by pretending that the high fuel consumption of the steam engine would exhaust the country's stocks of fuel and that the fumes would pollute the air of the towns. De Jouffroy's rivals, the Abbé d'Arnal and, more especially, Périer, who had spent a fortune in importing engines from England, saw in his success a development which might ruin them. The members of the Academy were hostile to "this obscure gentleman," who was a member of no academy and who had been foolish enough not to place himself under the patronage of Messieurs d'Alembert and Condorcet, who disposed, it was said, of all the favours and positions. For this reason, the press, which devoted whole pages to experiments by Montgolfier, said not a word about de Jouffroy. As for the Academy of Sciences, its members had no intention of going to Lyons to see the "Pyroscaphe." Their reply to Calonne was laconic. "Messieurs de Borda and Périer have reported on Comte de Jouffroy's steam boat. Further experiments are necessary."

In due course, Calonne notified de Jouffroy and requested him to resume his experiments, but this time on the Seine in Paris, where he might demonstrate the advantages of his scheme convincingly. For de Jouffroy, this was a shattering blow, for it obliged him to be at the expense of building a new boat. Completely without funds, he sought in vain for assistance. He even went to Périer, who, of course, turned him down; nevertheless, he summarily rejected an offer made to him to sell his invention in England. Then 1789 and the Revolution arrived. Faithful to his principles, de Jouffroy considered it his duty as a gentleman to emigrate for a time and carry on the struggle from abroad. He returned to France during the period of the Empire, but could expect nothing from Napoleon, whom he called "The Usurper" and, indeed, he scorned the idea of offering him his invention. The return of the Bourbons brought him no reward, for he was not one of those who assailed the Tuileries with petitions. Besides, his opportunity had passed; others had taken his place. The American, Robert Fulton, who was a lad of 18 when de Jouffroy made his successful trials on the Saône, in 1783, had constructed his first boat in 1803, and had tried it out successfully on the Seine in August of the same year. Having failed to interest the First Consul, however, and meeting with no better success in England, he returned to the United States where, in 1807, he built the famous Clermont.

De Jouffroy had not taken out a patent, for the good reason that the relevant legislation in France dated only from 1791. He kept silent during the Empire because of his political convictions but, on the return of the Bourbons, he applied for a patent, which was granted to him on April 23, 1816. In the same year, aided by the Comte d'Artois, he was able to launch, at Bercy, a new steamboat, named the Charles-Philippe. This vessel, though the Parisian watermen tried to wreck it, was a success and repeatedly sailed up the Seine from la Râpée to Charenton. By then, however, his rivals were too powerful. A new undertaking which he started at Lyons, with a boat named the Persévérant, got into financial difficulties and he was completely ruined. He rejoined the army and, after some years of roving, found refuge in the Invalides, where he died of cholera on July 18, 1832. As a final

## DE JOUFFROY'S STEAMBOAT.

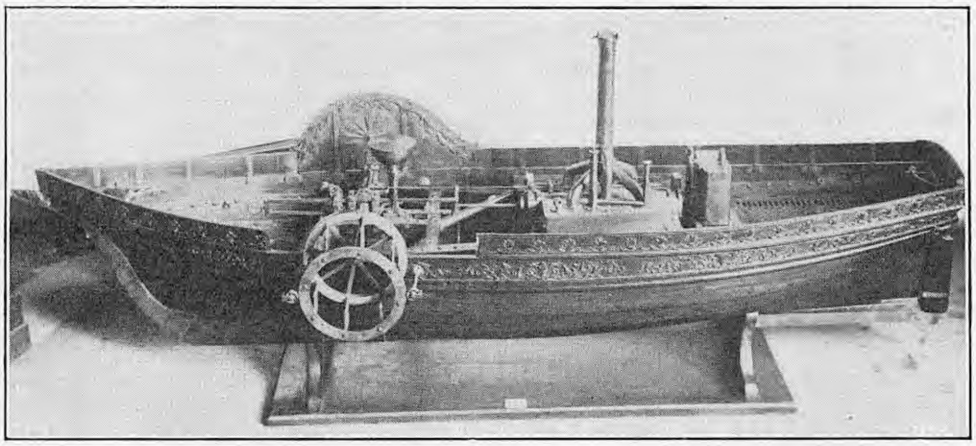


Fig. 2.

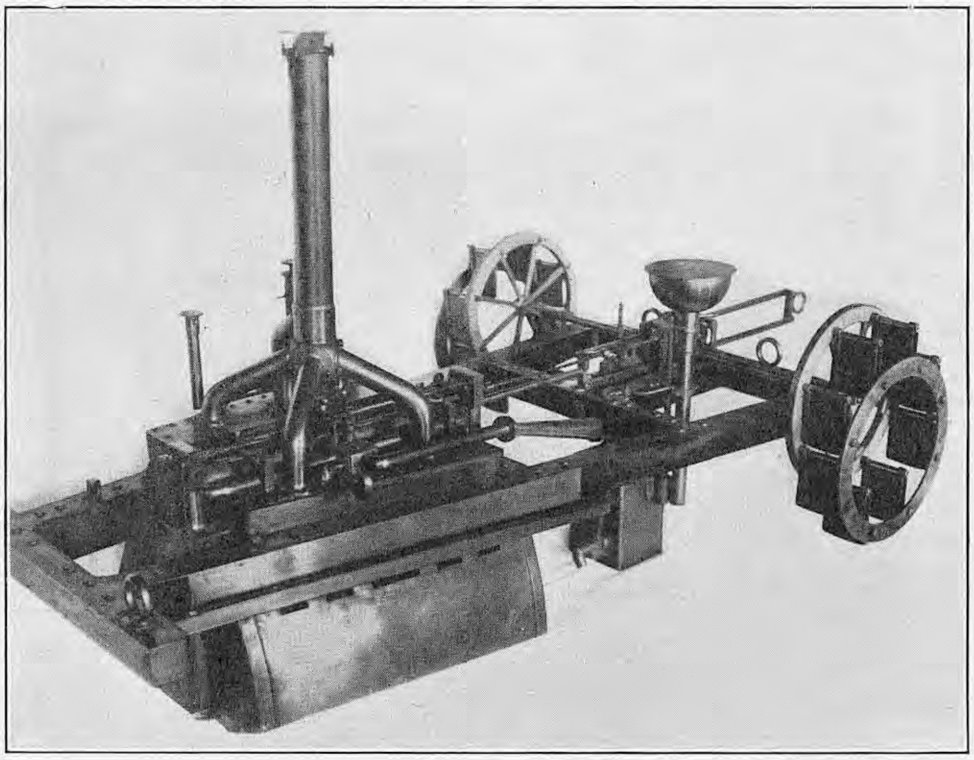


Fig. 3.

misfortune, when the cemetery of the Invalides was done away with in 1859 his remains were disinterred and cast into the great boneheap of the Catacombs.

These details of the life and work of de Jouffroy d'Abbans have been taken, as stated above, from the addresses delivered by Monsieur René Théry, Professor of Marine Engineering at the Conservatoire des Arts et Métiers, Paris, and Monsieur L. A. Boiteux, a member of the Académie de Marine and secretary-general of the committee which arranged the recent celebrations in honour of de Jouffroy d'Abbans. The president of this committee, who also delivered an address at the Sorbonne, was Monsieur Jean Marie, well known in shipping circles as president of the Compagnie Générale Transatlantique. At the commemoration ceremony in the Grand Amphitheatre of the Sorbonne the present Marquis de Jouffroy d'Abbans also delivered an address, which included some personal details of his ancestor, taken from the family archives. Later in the evening, a radio programme dealing with episodes in the life of de Jouffroy was projected through a stereophonic sound system with realistic effect. On the next day, an exhibition of family relics, documents and models was opened at 52, Rue de Bassano, Paris. Other celebrations took place at Iles de Lérins, Roches-sur-Rognon, Baume-les-Dames, Abbans, Besançon and Lyons. At Lyons, we are informed by Monsieur Charles Dollfus, curator of the Musée de l'Air, Paris, and himself a historian of steam navigation, a small flotilla proceeded up the Saône from Vaise, traversing the route covered by the Pyroscaphe in 1783. It was led by an old steamboat belonging to the Compagnie Générale de Navigation at Lyons, the machinery in which dated from 1854 and had been constructed by the Lyons engineering firm of Verpilleux. This firm formerly made a special type of boat known as a *grappin*, driven by a large toothed wheel rolling on the bottom of the river. The engine of the old steamer had been used originally in a *grappin* and was a twin-cylinder horizontal type with spur gearing to the paddles.

The Newcomen Society.—At the annual general meeting of the Newcomen Society for the Study of the History of Engineering and Technology, which was held at the Institution of Civil Engineers, London, on November 21, Mr. J. Foster Petree, M.I.Mech.E., A.M.Inst.N.A., was elected President in succession to Dr. C. H. Desch, F.R.S. New members of the Council elected were Dr. F. Sherwood Taylor, Director of the Science Museum, and Dr. W. H. Chaloner, of the University of Manchester. Dr. H. W. Dickinson having intimated that, on account of advancing years, he would be obliged to relinquish his duties as joint honorary secretary, a special resolution was adopted, appointing him Secretary Emeritus in recognition of his long and distinguished services to the Society. Mr. A. S. Crosley, who had previously acted jointly with Dr. Dickinson, was appointed honorary secretary.

# THE STEPHENSON BUILDING, KING'S COLLEGE, NEWCASTLE-UPON-TYNE.

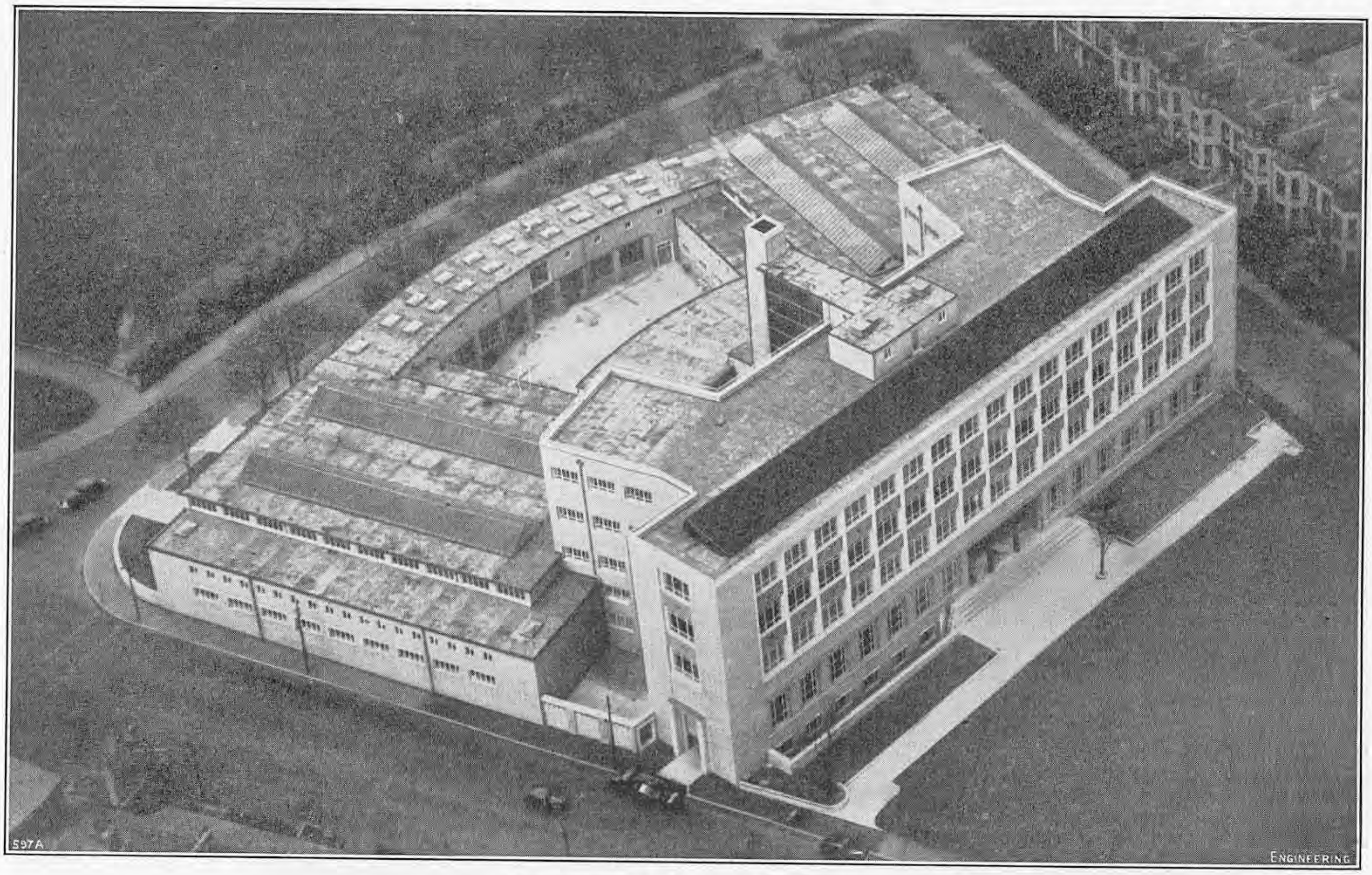


Fig. 1. Aerial View of Buildings.

## THE STEPHENSON BUILDING, KING'S COLLEGE, NEWCASTLE-UPON-TYNE.

A noteworthy addition to the ever-growing facilities in Britain for the training of under-graduate and post-graduate students of engineering, and for the advancement of engineering science by research, was made this week, when, as reported elsewhere in this issue, H.R.H. the Duke of Edinburgh, K.G., F.R.S., opened the Stephenson Building at Newcastle-upon-Tyne, as part of King's College, University of Durham. The new building, which is illustrated in Fig. 1, on this page, is not only a fine example of modern architecture, of which Tyneside may be proud, but its name perpetuates the memory of one of the most illustrious of those who have made the North-East famous in the annals of engineering. George Stephenson had many associations with Newcastle and lived for a time not far from the site of the new building. His portrait in oils, a copy of that made of him when he was the first President of the Institution of Mechanical Engineers, in 1847, has been presented to King's College by a former student, Dr. S. F. Dorey, F.R.S., himself a past-President of that Institution, and occupies a prominent position in the new building. It cannot, we imagine, fail to be an inspiration to those who look upon it.

For the history of engineering instruction in King's College, it is necessary to go back to 1891, when the first professor of the subject, R. L. Weighton, was appointed; though some engineering had been taught in the Department of Mining as early as 1873, that is, only two years after the foundation of the College. The establishment of a department of engineering resulted from negotiations between the then Principal of the College and the North East Coast Institution of Engineers and Shipbuilders, a body which still retains an active interest in the department's work. The first occupant of the chair was styled Professor of Engineering and Naval Architecture, but, before his retirement in 1919, separate departments of Naval Architecture and Electrical Engineering had been established. In 1944, Civil Engineering, also, acquired its own chair, with the result that the former professor of engineering came to be styled Professor of Mechanical and Marine Engineering, which is the designation of the present holder, Professor A. F. Burstall, D.Sc., Ph.D., who commenced his duties in 1946.

The immediate post-war years saw a rapid growth in the demand for university training everywhere, and particularly so in the engineering faculty of King's College, where the number of students increased from 190 in 1939 to 420 in 1948. New schools in Agricultural, Chemical and Production Engineering made further demands on the limited space available in what had formerly been known as Armstrong College, which, in spite of extensions in 1947, was fast becoming inadequate. Plans for new accommodation, however, had been laid earlier, in 1946, when it was decided to proceed as soon as possible with accommodation for 650 students and to make provision for future expansion by erecting a building which could, in the meantime, also house other departments of the College which were outgrowing their accommodation. A site was made available by the Freemen and Council of Newcastle-upon-Tyne, Messrs. Edwards and Manby, of Newcastle, were appointed architects, and Messrs. Leslie and Company, Limited, of London and Darlington, became the main contractors. The consulting engineers were Messrs. R. W. Gregory and Partners and Messrs. L. G. Mouchel and Partners. Work on the new building began on January 3, 1949, and it was completed early this year, some of the workshop equipment being transferred from the Armstrong Building at the same time. Most of the remaining equipment was installed during the summer vacation.

The building occupies an island site adjacent to Claremont-road, conveniently near to the centre of the city and close to the Great North Road. Full advantage has been taken of the ease of access provided by this excellent situation and the building has no fewer than seven entrances suitable for the delivery of heavy equipment. There are three main parts to the structure, namely, a large five-storey block which faces south, illustrated in Fig. 2, on page 682, and two diverging wings, each two storeys high. The north ends of the latter are joined by a building, also of two storeys, with the result that a courtyard is formed. This enclosed space is not only of value as an open-air store, but also as a space wherein work involving a risk of fire, explosion or fumes may be conducted.

Most of the ground floor of the building is occupied by laboratories and workshops, and provision has also been made there for research by the individual members of the staff and senior students, by the construction of a number of small rooms adjoining the main laboratory. The staff rooms, and class and study rooms for senior students, are situated, for the most part, on a mezzanine floor, which overlooks the larger laboratories and the workshop. The lecture theatres, classrooms, library and reading room are in the main block on the first and second floors above the mezzanine floor, and the top floor of the building is almost entirely occupied by a large drawing office, extending the whole length of the block.

Of the two-storey laboratories, overlooked by the mezzanine floor, that on the west side was designed as a heat-engines laboratory, although one quarter of it is divided off at present for use by the Department of Agricultural Engineering. This laboratory and some of the equipment installed in it are illustrated in Fig. 3, on page 682. One of its principal features is a tiled pit round which the steam engines and turbines are placed so that their condensate can be discharged into tanks and measured by weighing. The largest and most impressive item of equipment in the laboratory is the experimental quadruple-expansion steam engine designed by Professor R. L. Weighton, who was Professor of Engineering and Naval Architecture at Newcastle from 1891 to 1919. It was this engine which was used in the historic series of the "Newcastle trials," an extended programme of original research into the

# THE STEPHENSON BUILDING, KING'S COLLEGE, NEWCASTLE-UPON-TYNE.

Fig. 2. Frontage of Stephenson Building.

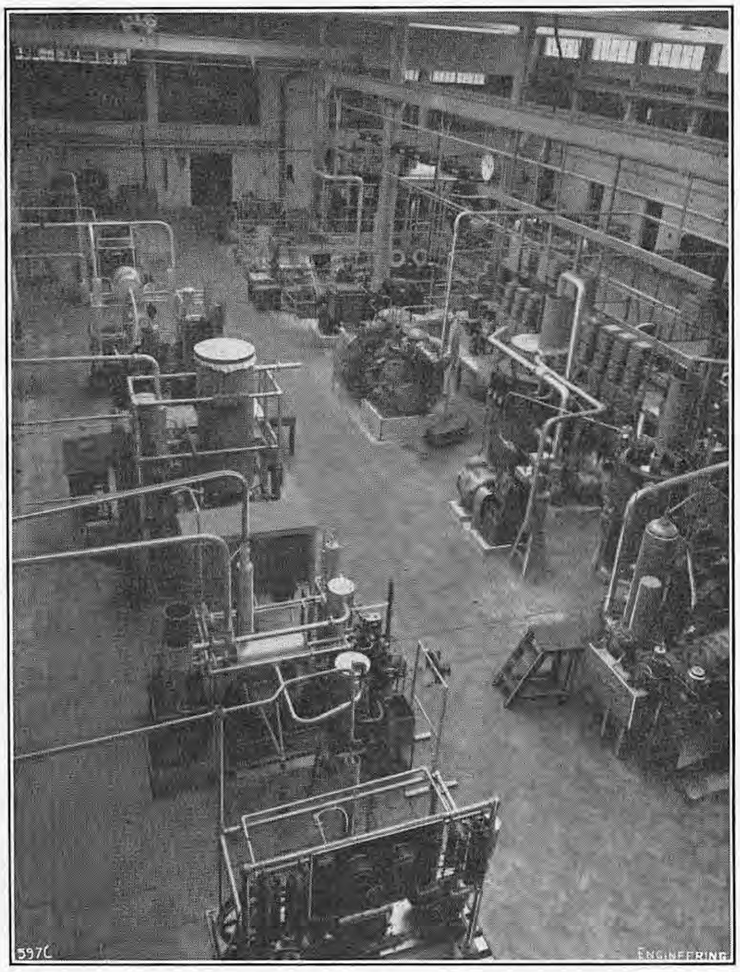


Fig. 3. Heat-Engines Laboratory.

economy of steam engines, which established for Professor Weighton a world-wide reputation. The engine is now used for instructional purposes. In contrast to it, there is, on the opposite side of the hotwell, a modern Parsons steam turbine, presented to the college by the makers, Messrs. C. A. Parsons and Company, Limited, Heaton Works, Newcastle-upon-Tyne. This turbine, which is of 50-kW capacity, has a running speed of 8,000 r.p.m. A full description of it will be found in Engineering of June 17, 1949 (vol. 167, page 560). In addition to these major items there is another small Parsons turbine, a compound reciprocating engine, a single-cylinder steam engine and some smaller units. The east side of the laboratory contains a number of internal-combustion engines, a refrigerating machine, and an air compressor which supplies compressed air to various other laboratories in the building. Items particular to research include a Ricardo E6 variable-compression engine, which can be run on gas, petrol, or Diesel oil; an 11-h.p. Junkers opposed-piston two-stroke engine—a recent acquisition which is at present in course of erection and will be used for experiments on scavenging —and apparatus for demonstrating the Kadenacy effect. A National gas-oil engine and a variety of special instruments, including electronic indicating units, Farnborough indicators, fuel flowmeters and a viscous-flow air meter, are also provided.

In the section of the laboratories at present devoted to agricultural engineering, the equipment ranges from full-size farm machinery to small models. An experimental drier and other apparatus for fundamental investigations into agricultural processes contrasts with miniature ploughs operating in a soil bath. The instrumentation is modern and consists largely of equipment developed and constructed within the department, a remark which applies equally to the other laboratories, it being the policy of the College to construct as much equipment as possible on the premises.

Two laboratories on the ground floor, on each side of the main entrance hall of the building, are used for the study of strength of materials and hydraulics. The former of these contains several items of standard equipment, including universal testing machines of from 5 tons to 50 tons capacity, a torsion-testing machine and other apparatus for determining the physical properties of materials, and does not require special mention. The other laboratory is used for hydraulics and contains equipment for testing hydraulic machinery, including pumps and turbines, as well as various pieces of apparatus for experiments on the flow of water over weirs and notches, and for determining pressure losses in pipes. It is intended to add a Pelton wheel, and Francis and Kaplan turbines.

Below the hydraulics laboratory, and in communication with it by the removal of floor slabs, is a long basement laboratory where there is ample room for conducting experiments on flow in open channels, model river beds, spillways, etc. In the centre of the laboratory is a large covered-in storage tank, and other smaller tanks to which the water used in hydraulics work is discharged and from which it can be pumped to elevated storage tanks. The latter, of which there are two, are situated in a tower at the rear of the main block and provide a constant head of water for the experiments. They are connected to the laboratories by means of a number of 4-in. diameter pipes, arranged in parallel.

A short passage leads from the heat-engines laboratory into the courtyard, the main access to which is a central archway opening on to Park-terrace, at the rear of the building. On one side of the gateway is a laboratory for gas-turbine research, at present being used for studies of blade cooling. In the near future, the laboratory will be equipped with a six-stage turbo-compressor capable of delivering 1,200 cub. ft. of free air per minute, at pressures up to 5 lb. per square inch gauge. On the other side of the gateway is the Fuel Technology Laboratory, illustrated in Fig. 4, on Plate XLVI. This laboratory has been equipped to meet the requirements of students in the Mining, Metallurgy and Chemical Engineering Departments, as well as those of the Mechanical and Marine Engineering Department, and contains a wide range of facilities for the analysis of solid, liquid and gaseous fuels and for the determination of calorific values. Equipment for the carbonisation and assay of coal, for coke testing, gas analysis. and laboratory methods of distillation, employing various types of fractionating columns, are also provided. Some of the apparatus, including electric furnaces, was made in the College workshops. The courses of instruction available in fuel technology include pass and honours degree courses for B.Sc. students of mechanical and marine engineering, two-year courses leading to the M.Sc. degree, for senior students of chemical and agricultural engineering, and two courses, each of one year's duration, securing a certificate for students of fuel technology and production engineering.

Instruction in chemical engineering, which is also the responsibility of the Professor of Mechanical and Marine Engineering, is given in a laboratory in the east wing of the building. The equipment covers a wide range and includes a natural-circulation evaporator, a stainless-steel autoclave, a filter-press unit, centrifuge, mixing vessel, ball and hammer mills, a drier, heat exchangers and a distillation unit which is at present under construction. There is also laboratory apparatus for measuring particle sizes, for the fractionation of liquid mixtures and for studying catalytic reactions on a micro scale. As in other laboratories, much of the equipment was designed and constructed in the department. Students can attend a two-year post-graduate course in chemical engineering.

The workshop, part of which is illustrated in Fig. 6, on Plate XLVI, serves a dual purpose. Its primary function, namely, to supply the laboratories with such equipment as can be manufactured on the premises, has already been mentioned. For this purpose a large number of modern machine tools have been installed, including nine centre lathes ranging in size from a 21-in. lathe by Dean, Smith and Grace, which is capable of dealing with the

(To face page 682.)



# STEPHENSON BUILDING, KING'S COLLEGE, UNIVERSITY OF DURHAM.

(*For Description, see Page* 681).

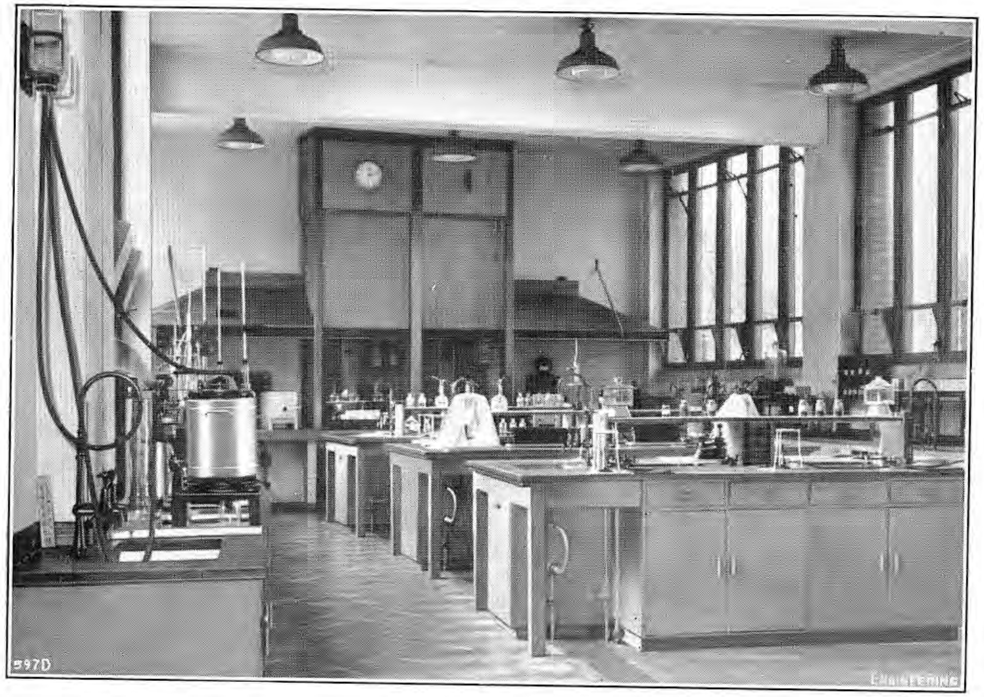



Fig. 4. Fuel Technology Laboratory.


Fig. 5. Drawing Office.


Fig. 6. Workshop: Machine Tool Section.

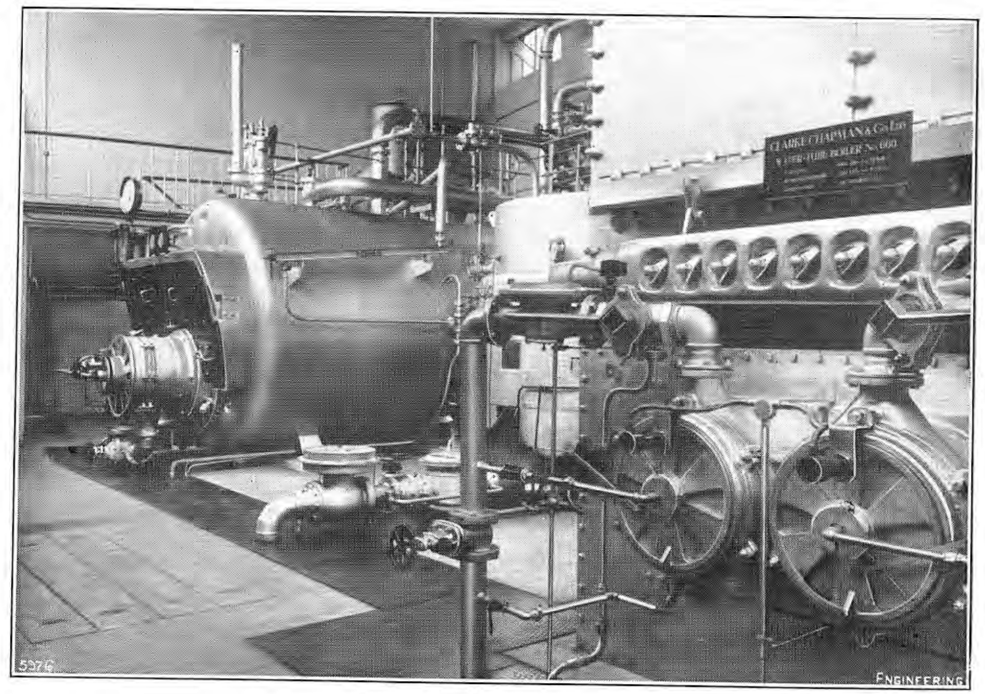



Fig. 7. Interior of Boiler House.

# KING'S COLLEGE, NEWCASTLE-UPON-TYNE.

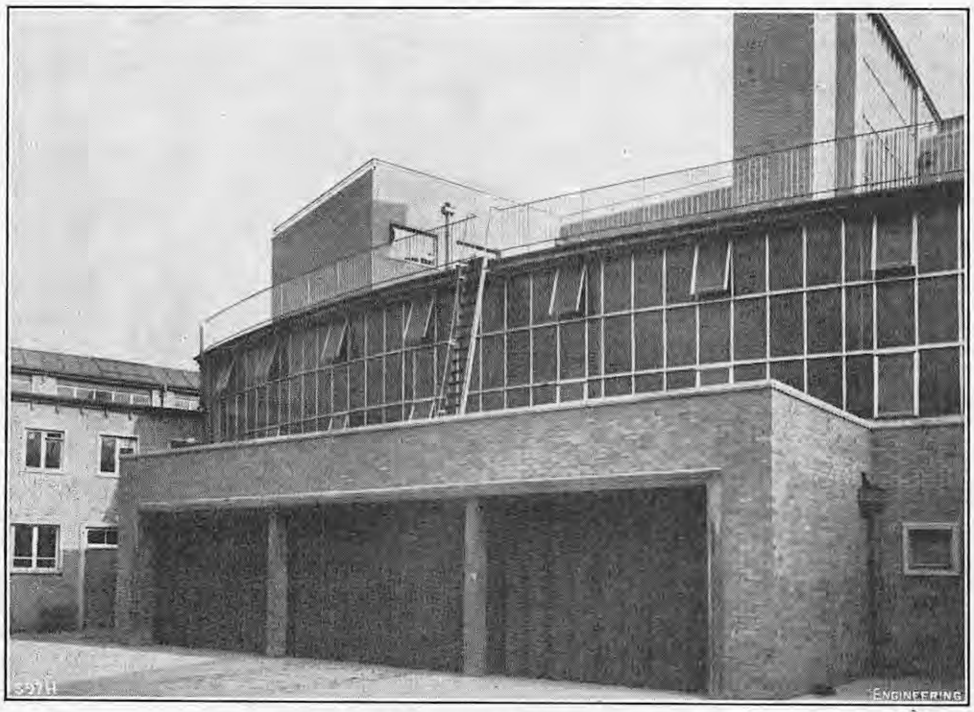


Fig. 8. Exterior of Boiler House.

largest work normally encountered, to a precision watchmaker's lathe. The latter is housed in an instrument shop which adjoins the main workshop. Other lathes in the toolroom are a Holbrook 13-in. lathe, a Smart and Brown 4-in. lathe, and a Pultra bench-lathe. Milling can be done in the instrument shop on a Toolmaster universal milling machine and, in the toolroom, on a Cincinnati universal horizontal milling machine and an Archdale 34-in. vertical machine. Requirements for shaping, slotting and screwing are met by a 24-in. Invicta shaping machine, a Butler 8-in. toolroom slotting machine and a Kendall and Gent 3-in. screwing machine with tangential dies. A precision horizontal boring machine is on order. These machines are supplemented by a range of drilling machines of various sizes, and saws, including a Do-all contour machine.

An adjoining grinding room contains a Churchill 24-in. by 10-in. universal grinding machine, a Cincinnati tool and cutter grinder, a Norton surface grinder, a Delapina honing machine and a South Bend lathe which has been adapted for superfinishing. Next to this room is another which contains a variety of welding equipment and plate-working machines. Woodworking machinery is housed elsewhere. Among equipment at present under construction in the workshop are parts for a twin-cylinder hot-air engine which will, however, when completed, run on inert gas. This engine, which will be of V-type, with the regenerator connecting the arms of the V, will be used to study the effect of the adiabatic indices of the gases employed on the engine's performance. The other function provided by the workshop is that of a training ground for students of Production Engineering. A Ward lathe has been installed for small batch work and for demonstrating tool-setting.

A metrology laboratory, the temperature of which can be thermostatically controlled, adjoins the instrument shop. It contains a number of standard pieces of equipment the largest of which are an S.I.P. universal measuring machine, a Hilger universal profile projector and a Talysurf surface-measuring machine. These are supplemented by a wide range of smaller instruments, including vertical comparators, pitch and diameter measuring machines for screw threads, a Coventry optical dividing head, a Watts auto-collimator and angle Dekkor, and ranges of length bars, slip and angle gauges, surface plates, optical flats, micrometers, etc.

Before dealing with the remaining laboratories, mention must be made of certain features common to all those already mentioned. Each is provided with an overhead travelling crane, generally of 5 tons capacity, so that heavy machinery can be transported and handled readily anywhere within the building. Special arrangements have also been made to provide both direct and alternating electrical power supplies, up to 20 or 40 h.p., throughout the ground floor without the need for special wiring. For this purpose, each room is provided with a number of "test points" into which flexible leads, similar to those used in arc-welding sets, may be plugged. The current is obtained from a 6,000-volt substation, in which the supply is reduced to 415 volts and, in part, rectified by three mercury-arc rectifiers to provide direct current at 240 volts and 480 volts on a three-wire system. The switchgear was installed by Messrs. Reyrolle and Company, Limited, Hebburn.

On the mezzanine floor, there are 28 study rooms, work rooms and offices, including a drawing office for senior students of chemical engineering. A laboratory for honours students, two photographic dark-rooms, a work-study laboratory and a staff common-room are also on this floor, and rooms have been set aside for the use of honours students in mechanical and marine engineering and for post-graduate students of chemical, agricultural and production engineering, and fuel technology. On the first floor of the main block there are two large laboratories for the study of fluid mechanics and two others for mechanics and the theory of machines. Much of the experimental equipment required by the fluid mechanics laboratory has yet to be constructed as it represents a new departure. Meanwhile, a portion of the laboratory is being used to house and demonstrate equipment.

Two of the main lecture theatres, each of which can accommodate 160 persons, are situated on the first floor, and these have certain features worthy of note. Both are equipped for the projection of sound-films or lantern slides, and the projection room separates the two, so that the projector or lantern may be swung round and directed into either room, as desired. Blacking-out in each case is accomplished by the use of a single pair of curtains which can be closed and reopened automatically by the operation of push buttons on the lecture table. From the same position, and by the same method, the lights may be dimmed or raised, or set at any desired level of brightness so that, for example, sufficient light may be retained for students to see to make notes during the projection of lantern slides. The dimming process, which is a gradual one, is accomplished by means of a motor-driven variable inductance, consisting of a solenoid with an adjustable core, which varies the wattless current. One of the rooms is comfortably furnished with upholstered tip-up seats and both have twin roller black boards.

The second floor above the mezzanine floor at present accommodates the Department of Mathematics, but also contains the reading room and library of the Mechanical and Marine Engineering Department. This geographically close relationship of the two departments cannot fail to be to their mutual advantage. Three of the lecture rooms on this floor are used by both departments. The top floor, as has been mentioned, contains a large drawing office, illustrated in Fig. 5, on Plate XLVI. This fine room, lighted from without by windows along the whole of its south side and by northern roof-lights, is also equipped with fluorescent electric lighting. When the whole of the space is not required or when some of it is required for purposes other than instruction in machine drawing and design, the room may be subdivided by folding partitions of the type used in aircraft hangars. There are three such partitions, as may be seen from the illustration. The room has accommodation for 200 students and each is provided with a drawer for keeping his drawing instruments, board and T-square under lock and key. A small room on this floor is to be let annually, under competitive conditions, to a purveyor of stationery, etc.

One other important section of the building requires to be mentioned, namely, the boiler house, which is much more than a source of heating, although this is one of its functions. This building, the interior of which is illustrated in Fig. 7, on Plate XLVI, is situated at the rear of the main building and is really an adjunct to the heat-engines laboratory, being used for the instruction of both mechanical and marine engineering students. It contains three gas-fired boilers of different capacities which supply steam at different pressures but, for the purposes of steam distribution, each boiler discharges into a header and the three headers are interconnected through reducing valves so that any boiler can supply steam at its own normal pressure or at any lower pressure. Such an arrangement makes for flexibility and economy. The three boilers, which are all visible in the illustration are, from left to right, a Ruston and Hornsby horizontal Thermax boiler rated at 6,000 lb. of steam per hour at a gauge pressure of 120 lb. per square inch; a Cochran-Kirke vertical Sinuflo boiler rated at 4,000 lb. of steam per hour at 150 lb. per square inch; and a Clarke Chapman water-tube boiler with economiser and superheater rated at 6,000 lb. per hour at 220 lb. per square inch, and a temperature of 440 deg. F.

The feed water for the boilers is treated in a water-softening plant, additional processing being provided for the Clarke Chapman boiler. A large panel containing gauges and other indicating and recording devices relating to the operation of the boilers faces the latter. It was made and fitted up in the college workshop. Also facing the boilers is a large enclosed bunker space, access to which is through three folding doors opening into the courtyard, as can be seen in Fig. 8, herewith. This space is intended for storing emergency fuel to be used in case of failure of the gas supply. Failure of the electrical supply is catered for by a small emergency generating set capable of lighting the corridors of the building. One other feature of the building may be mentioned at the same time, as a stairway in the boiler house gives access to it. This is a large duct which accommodates gas, steam and water pipes and electrical supply cables, which are thus readily accessible.

The Stephenson Building is at present housing other departments temporarily, but even so, there is room in the Mechanical and Marine Engineering Department for more students and for additional equipment. References have been made to the fact that much equipment has been made on the premises. It is Professor Burstall's policy to allot each honours student a specific task, which involves designing some piece of equipment, either a piece of laboratory apparatus, or part of an experimental set-up. The student is required to supervise its production or, in some cases, to build it himself and make it function. Not only is this a valuable way of adding to the department's store of apparatus; it is also an excellent training for students.

# "HICO" SECTIONAL CENTRING.

BLAW KNOX, LIMITED, LONDON.

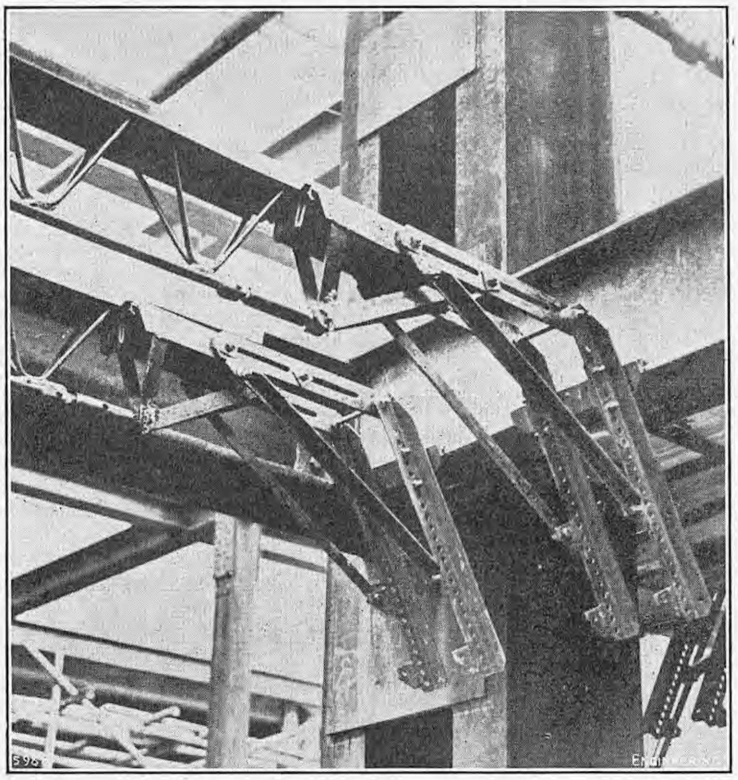


Fig. 1. End Brackets Resting on Joists.

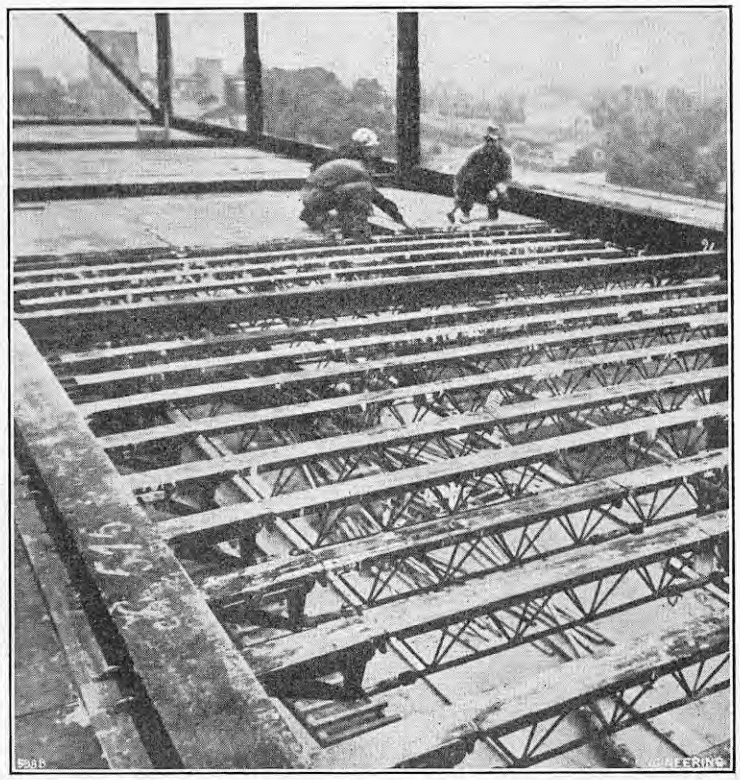


Fig. 2. Typical Layout of Centring.

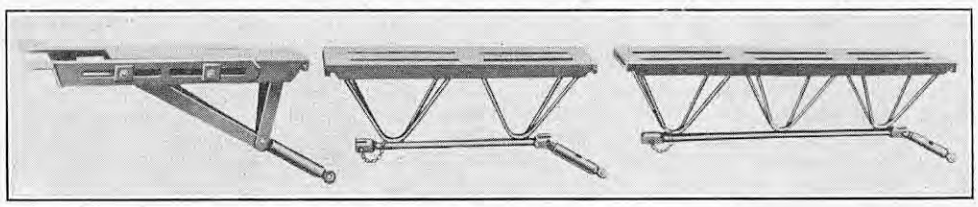


Fig. 3. Components of "Hico" Centring.

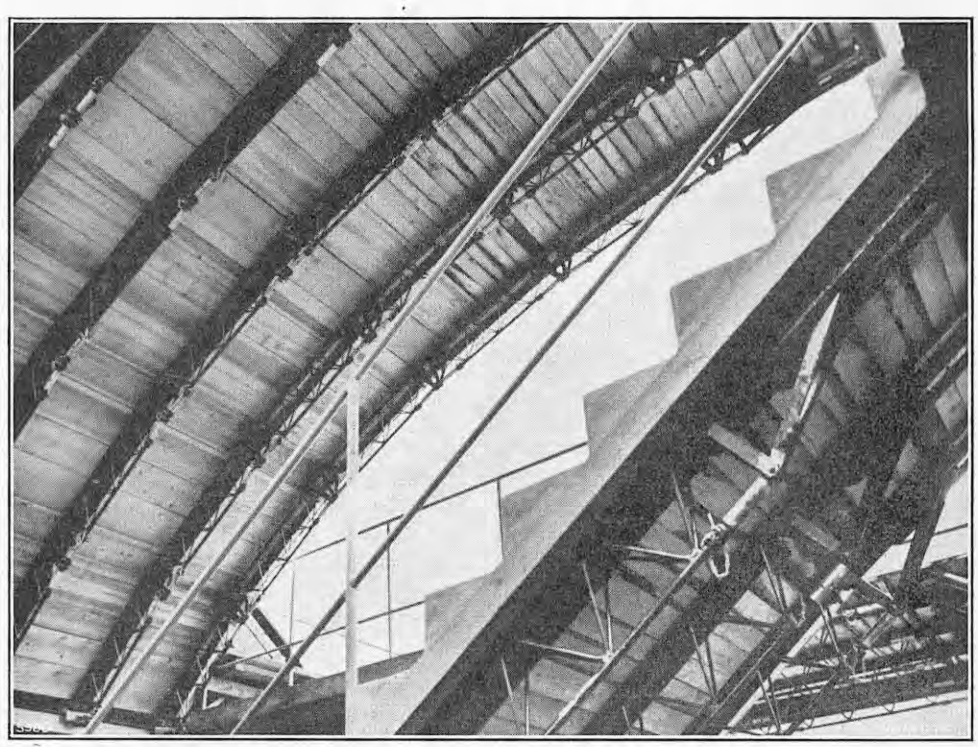


Fig. 4. Centring Adapted to Arched Roof.

## "HICO" SECTIONAL STEEL CENTRING.

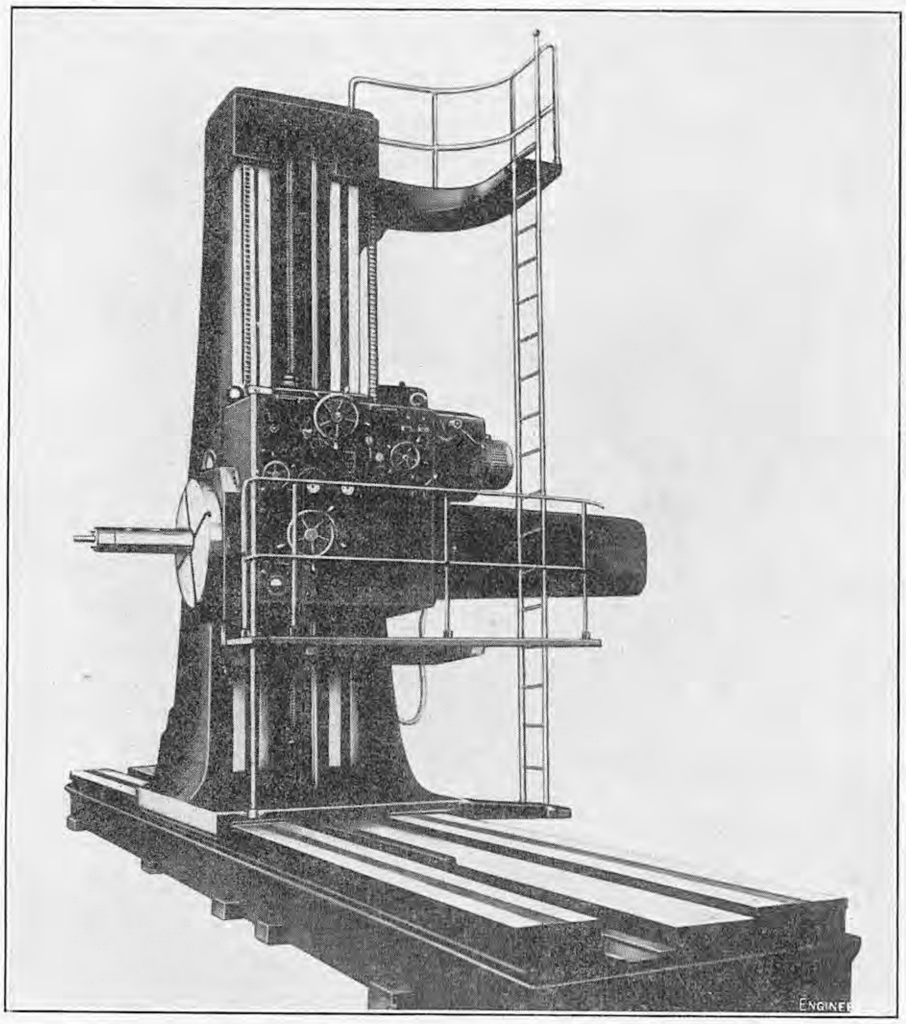
A neat form of sectional steel centring, for use in constructing floors or roofs of poured or slab concrete, is shown in the accompanying illustrations, Figs. 1 to 5. It is made by Messrs. Blaw Knox, Limited, 94, Brompton-road, London, S.W.3, and is marked under the name of "Hico" falsework centring. The method of construction can be seen in Fig. 3, and Figs. 1, 2, 4 and 5 show various applications. It consists of parallel framework bearers, the top boom of which is formed as a light pressed-steel inverted channel, 6 in. wide, connected to the bottom boom, a round steel tie-bar, by round steel lattice members, welded to the booms. The units, which are supplied in lengths of 24½ in., 37 in. and 49¼ in., are connected on the top booms by a tongue-and-groove clamp, which effectively resists lateral distortion, and in the line of the bottom boom by plug bolts and sockets, tightened by turnbuckles. By means of the turnbuckles, any desired camber can be given to the centring to counteract sagging in large spans when the concrete is poured, or to provide a cambered surface; an example is shown in Fig. 4.

One of the principal advantages claimed for the centring is that it is supported only at the ends and, in consequence, puts no load on the floor below; in a multi-storey building, this enables erection to proceed more quickly. Each length is carried on end bearers supported on the walls or wall framing, as shown in Fig. 1. The top sections of these bearers can slide in slotted guides, so that the overall length of each span can be adjusted fractionally to suit the width of the building. The amount of this adjustment is about 9 in., allowing this variation to be accommodated, in buildings that are not of uniform section, without dismounting and re-assembling the parts of the individual centres. Tables showing the permissible free spans for different centre spacings can be supplied by the makers; they range from 3 ft. 3 in. to 26 ft. 11 in. Greater spans can be covered, of course, if the junctions can be supported from the ground or from the floor below. It is pointed out that the props should be applied, in such cases, at the end junctions only, as the "Hico" centre must not be regarded as a through centre on more than two props.

Various special fittings are available, such as cross-members of different types and lengths, and others provided with rotatable bearers, enabling them to be laid directly along the wall, even in rooms which are not truly rectangular in plan. The centres weigh only 25 lb. per lineal yard and can be readily handled by unskilled labour: it is stated that two men can erect or dismantle the centring needed to cover 1,000 sq. ft. in less than 40 minutes.

United Kingdom Production of Iron and Steel.—Statistics issued by the British Iron and Steel Federation, Steel House, Tothill-street, Westminster, London, S.W.1, indicate that the production of steel ingots and castings in the country, during October, was at an annual rate of 15,629,000 tons, compared with a rate of 15,749,000 tons in the previous month and of 17,040,000 tons in October, 1950. The output of pig iron was at an annual rate of 9,865,000 tons in October, 1951, against 10,084,000 tons in October, 1950.

# SCHIESS HORIZONTAL BORING MACHINE.



## SCHIESS HORIZONTAL BORING MACHINES.

Since the end of the war in 1945, Messrs. Schiess, of Dusseldorf, have concentrated on the production of vertical turret lathes and vertical boring mills, but they have also made a number of horizontal boring and milling machines of fairly large dimensions. Messrs. Alfred Herbert, Limited, Coventry, who are agents for Messrs. Schiess in the United Kingdom, have supplied us with the following particulars of these boring and milling machines.

The smallest machine in the range has a spindle 6·3 in. in diameter and is made in two forms: with fixed column and traversing table, and with traversing column and fixed floor-plate. The larger machines are made with a fixed floor-plate only, as shown in the accompanying illustration, which is of a machine with 7½-in. spindle. Other machines are made with 8¾ in., 10⅝ in., and 12⅝ in. spindles. Messrs. Schiess have been making these large boring machines for over 70 years. All the machines have fully-automatic lubrication and scales and verniers for the horizontal travel of the column or table, the vertical travel of the spindle head and the travel of the spindle. A tachometer on the spindle head gives the spindle revolutions per minute without reference to the gear-lever positions. Provision is also made for mounting an ammeter, which is useful in detecting when the cutting tools need to be re-sharpened. Also, on the floor-plate machines, the face-plate, has axial adjustment for applying the cut.

For large boring operations, on the smallest machine, the main spindle has speeds ranging from 1·8 to 290 r.p.m. and from 0·7 to 125 r.p.m. on the largest, but for drilling and boring small holes the machines can be provided with a high-speed spindle running inside the main spindle. This has speeds ranging from 75 to 700 r.p.m. and from 60 to 400 r.p.m., depending on the size of the machine. The illustration shows the WBF 19 machine (7½-in. spindle) without floor plate but with the central high-speed spindle.

Further Restrictions on Copper and Zinc.—The Minister of Supply has issued the Copper and Zinc Prohibited Uses (Ministry of Supply) (No. 2) Order, 1951 (S.I. 1951, No. 1960), which extends the list of articles in which the use of copper and zinc is banned.

## P. W. WILLANS: EXHIBITION AT THE SCIENCE MUSEUM.

The centenary of the birth of Peter William Willans, M.I.C.E., M.I.Mech.E., M.I.E.E., who was born on November 8, 1851, and died on May 23, 1892, was marked by a lecture given to the Newcomen Society at the Institution of Civil Engineers, London, S.W.1, on November 21, by Mr. Kyrle W. Willans, M.I.Mech.E., who recorded numerous incidents and personal details in the life and work of his father. The event is also being commemorated by the grouping together in the East Hall at the Science Museum, South Kensington, S.W.7, for a few weeks, of a number of exhibits of particular interest, including three original Willans high-speed vertical steam engines. The first, made in 1884, is of his earliest single-acting type, in which the three high-pressure pistons act as valves for adjacent cylinders. This engine worked for many years at the Royal Laundry, Kew, and was presented to the Museum by King George V in 1929. The second is of the well-known central-valve triple-expansion type and is the actual engine tested by P. W. Willans in the classic series of economy trials, the results of which were published by the Institution of Civil Engineers in 1888 and for which he was awarded the Watt Medal and a Telford Premium. This engine was sectioned afterwards and has been lent to the Museum by the English Electric Company, Limited, who are the present owners of the Willans Works at Rugby. The third main exhibit is a small generating set on one baseplate with a twin-tandem compound central-valve engine, directly coupled to a 9·5-kW 80-volt Siemens dynamo, which ran at 450 r.p.m. A peculiarity of this set is that the flywheel is mounted on the end of the dynamo shaft farthest away from the engine. It was made in 1888, and worked for over 30 years lighting the seed-crushing mill of Messrs. Chambers and Fargus, Limited, at Hull, who presented it to the Science Museum this year.

Other exhibits include historical photographs of P. W. Willans as a young man, early Willans engines and launches, the machine and erecting shops in 1891 at Ferry Works, Thames Ditton, and copies of early drawings. There are also shown one of his earliest notebooks, dating from 1880, the John Scott Medal awarded to him posthumously by the city of Philadelphia in 1895. All these relics have been lent to the Museum by Mr. Kyrle W. Willans.

## PROBLEMS OF TRANSONIC FLIGHT.

The factors affecting the increased weight, complexity and cost of military aircraft were discussed by Mr. A. N. Clifton, B.Sc., F.R.Ae.S., in a paper presented to the Royal Aeronautical Society at Cheltenham on Thursday, November 22. Dealing firstly with problems of drag and thrust, Mr. Clifton said that in order to keep down the large drag increase as the aircraft approached and passed through the speed of sound, it was worthwhile to use a thin swept-back wing of considerably larger area than the straight wing of conventional thickness having the same stalling speed; even so, the wing drag at a Mach number of 1·3 would be about 20 times that of the conventional wing at a Mach number of 0·7. Similarly, it paid to increase the length-to-diameter ratio of the fuselage at transonic speeds and, therefore, longer and thinner engines were required for fighter aircraft. Surface roughness due to a poor paint finish could increase the drag by about 20 per cent. Although the maintenance of laminar flow on aerofoils was of less importance than at high subsonic speeds, skin waviness could give rise to local shock waves and separations causing local loss of lift which might lead to wing dropping, buffeting or stalling in turns. The use of light-alloy skins with integral stiffeners should reduce both skin roughness and skin waviness. The thrusts required for transonic flight were enormous, and more knowledge was required on air-intake efficiencies at the speed of sound.

Considering stability and control, Mr. Clifton showed that whereas the rate of change of lift with incidence on a fixed control surface improved with increasing Mach number, the opposite was true of the moving surface; the elevator effectiveness decreased considerably as the speed approached that of sound. The increasing effect of structural distortion also had a marked influence on elevator effectiveness, and again a structure was required with integral stiffness. There was a trend, particularly in the United States, to deal rapid changes of trim in the transonic region by adjusting the tailplane incidence in flight; in some cases it was used for longitudinal control. The control-column loads for a given manœuvring acceleration would increase considerably at high Mach numbers, both as a result of the backward shift of the aerodynamic centre and of the loss in elevator effectiveness; probably the best longitudinal-control arrangement for transonic flying would be a small-chord elevator, power-boosted, with a variable tail-incidence actuated automatically by the elevator angle. By using hydraulic boosters and an electrically-operated incidence change, the possibility of simultaneous failure of both would be reduced.

There was a tendency for swept-back wings to become longitudinally unstable at large angles of attack, due to loss of lift at the tips occurring at progressively lower lift coefficients as Mach number increased; with the result that, in tight turns, the control-column load might become zero or negative under certain conditions of flight. This led to a possible danger of overloading the aircraft unintentionally. Considering lateral control, swept-back wings required both high torsional and flexural stiffness to avoid the onset of aileron reversal.

In the final section of the paper, Mr. Clifton considered temperature effects at transonic speeds. Skin temperatures of about 100 deg. C. would be experienced in the tropics at the speed of sound at low altitudes. It would no longer be possible to use canopies made of acrylic resin beyond Mach numbers of 1·4. Until a better material was available, glass transparencies would have to be used. At 150 deg. C., the strength of light-alloy bar and sheet material decreased appreciably. Since engine temperatures would tend to increase as powers increased, and the clearances between the engine and aircraft structure were small, large quantities of air would be required to keep the temperature of the structure down to 150 deg. C., resulting in large increases in drag and weight, and in a loss of thrust. It was already necessary to provide cooling air for the pilot, gun ammunition, and some radar components; for the Vickers-Armstrongs Attacker aircraft, at a Mach number of 0·8, the weight of the air-conditioning equipment was about 75 lb.; it would be nearly 2½ times that value at a Mach number of 1·2.

The present lack of full-scale data was causing designers of high-speed aircraft to add weight and complication in their efforts to solve the problem of transonic flight. In the case of naval aircraft, this might lead to a demand for larger lifts and wider decks and hangars on aircraft carriers. These complexities should not be accepted as a permanent feature; as new aircraft came into production, some of them should be allocated to research and development immediately, so that the steepness of the rising cost of aircraft production might be alleviated and a better product might be obtained.

# NOTES FROM THE INDUSTRIAL CENTRES.

## SCOTLAND.

Hoover Electric-Motor Works at Cambuslang.—Hoover, Ltd., 211-213, Regent-street, London, W.1, announce that Hoover (Electric Motors) Ltd., Cambuslang, near Glasgow, will nearly double the size of their original factory by bringing a big extension, now being built, into operation early next year. Of the motors produced at present, upwards of 60 per cent. are exported. This will be the second extension since the company opened a factory of 82,000 sq. ft. at Cambuslang in 1946. About two years ago, a further 15,000 sq. ft. were added and the new extension will bring the floor area to 161,000 sq. ft. The employees are drawn mainly from the East Glasgow and neighbouring Lanarkshire areas. In 1943 the Hoover organisation began to make aircraft wiring equipment at Rutherglen for the Ministry of Aircraft Production. In 1946, as part of the national scheme for the encouragement of light engineering in the Clyde Valley, the company opened the factory at Cambuslang for the manufacture of fractional horse-power motors.

Coal Export Statistics.—Scottish coal exports rose to 79,171 tons in October, compared to 77,058 tons in September and 73,843 tons in August. Despatches of 666,019 tons during the first 10 months of this year, however, remained well below the total of 815,140 tons in the corresponding period of 1950. Among the principal importing countries, shipments to Eire from the beginning of 1951 declined substantially to 95,835 tons against 195,513 tons; while Denmark received only 226,984 tons compared with 294,650 tons, and Sweden 129,580 tons against 174,126 tons. Belgian consignments, on the other hand, previously nil, amounted to 47,510 tons; and Italy, which took 10,168 tons, appeared among the list of importing countries for the first time since before the war.

Shortage of Cold-Rolled Steel Strip.—Out of the general shortage of steel there has arisen in Scotland a scarcity of small sizes of bars and cold-rolled strip amounting almost to a famine. There is only one firm in the district making the latter, and the demand for the material has been increasing rapidly year by year. Similarly, the demand for bright bars, either drawn or turned, far exceeds current supplies. While the capacity for producing small round bars has been substantially expanded in recent years by an up-to-date mill producing reinforcing bars and wire rods, the capacity for the production of flats does not appear to be keeping pace with the demand.

Light Industries at Peterhead.—The formation a new company, known as the Premier Tyre Service, Ltd., which will carry out the retreading of tyres at a factory on a former Royal Air Force hospital site at Forehill, near Peterhead, Aberdeenshire, was announced on November 14 by Mr. Peter Reid, jun., of Peterhead, who hoped the factory would start operations in a few weeks. It was stated also, on November 13, by Mr. J. A. Dickie, the Provost, that a precision engineering works was to be established in the town.

Increased Dues for Clyde Lighthouse Trust.—On account of increased costs of materials and higher wages, the Clyde Lighthouse Trust have found it necessary to increase their dues by 25 per cent. This was announced on November 21 at a meeting of Greenock Chamber of Commerce. Ex-Provost Drummond said that the trustees were to install a new lighting system at the Cumbrae lighthouse and that this would increase its power. Inquiries were also being made into the possible use of propane which would further raise the efficiency of the lights.

Proposed Oil Depot at Dundee.—Dundee Harbour Board decided on November 21 by 16 votes to 5 to instruct a sub-committee to consider the offer by Scottish Oils & Shell Mex, Ltd., to lease harbour ground at the Stannergate for the purposes of establishing an oil depot. This reversed a previous decision.

## CLEVELAND AND THE NORTHERN COUNTIES.

Unsatisfactory Steel Situation.—A rise in fuel prices is considered unavoidable if the wage claims of the miners are conceded and this, together with the higher steelmaking costs, will have to be passed on to the consumer of steel products. Recognised market values, however, are of little moment just at present. Distributable parcels of foreign iron and steel are being purchased at double the quotation ruling for home-made commodities and numerous operations in a "black market" for steel have an additional disquieting effect on the present unsatisfactory industrial situation. The small business that conditions permit, however, is understood to be entirely at fixed market prices. Supplies are vastly below the pressing current needs of customers and threaten to be still further curtailed. The acute scarcity of iron and steel scrap is contributing largely to the interruption of operations at plants engaged in the manufacture of commodities urgently needed in large quantities. The news that imports of 4,000 tons of German scrap may be unloaded this month is most welcome, though the quantity involved is below the average monthly intake last year.

Industrial-Accident Prevention.—Speaking at a meeting of the Tees-side Industrial Accident Prevention Group in Middlesbrough, on November 21, Mr. B. Inshaw, director, Industrial Division, Royal Society for the Prevention of Accidents, stated that upwards of 11,500 firms in this country, each employing more than 1,000 persons, had no connection with the Society. Far from being a parochial concern, accident prevention was a question of international importance, but many firms had had no dealings with the Society because they were not aware of what it had to offer. Their suggestions and ideas might have far-reaching effects in preventing accidents and thus could be useful to the Society, which had embarked on a campaign of accident-prevention practice in all branches of industry.

## LANCASHIRE AND SOUTH YORKSHIRE.

Firms Immune from Power Cuts.—Some leading firms in the Sheffield district are in the fortunate position of being immune from power cuts and the working of staggered hours. At the Thorncliffe works of Newton Chambers & Co., the firm's generating plant was retained as a stand-by when it was decided, some four years ago, to take current from the public supply, and it has saved the situation ever since. The Lee Mills of the David Brown Group at Scholes, Rotherham, are in a similar position, having a vertical steam engine which is performing good service in spite of its age. The engine began duty at Lee Mills 65 years ago, when the premises were owned by a textile concern, and it is still working efficiently.

Steel Research Station.—It is expected that, early in the New Year, equipment will be installed at the new research station which is being built at Sheffield for the British Iron and Steel Research Association. An experimental 10-cwt. arc furnace for steel melting has arrived on the site recently. There will be two main laboratory buildings, one of which will be used for research into the mechanical working of steel, and will house rolling mills, and forging and wire-drawing plant. An experimental two-hole non-slip wire-drawing machine will work at speeds from three to five times as great as those in existing production practice. A large administrative block and laboratories, it is hoped, will be finished by the end of next year.

Cutlery Imports.—It is announced that the import of cutlery into the United Kingdom is to be cut by at least 50 per cent. in the next six months. This follows the withdrawal of the open general licence under which, in the six months from April to September this year, nearly 50,000*l*. worth of cutlery, not including spoons and forks, was brought into the country. Imports to the total value of 125,000*l*. are to be permitted on licence up to June 30 next year, and this figure will include imports of spoons and forks.

High Rate of Employment.—A very high rate of employment continues at Sheffield, where the percentage of unemployment is much less than half the average for the whole of the country. There were 1,241 unemployed in October, compared with 1,225 in the previous month, including 342 women. In the East and West Ridings region the total unemployed rose from 13,644 to 19,281 during October. The percentage rate of unemployment in Sheffield is less than 0·5 per cent. compared with 1·1 per cent. for the region and 1·3 per cent. for the whole country.

## THE MIDLANDS.

Blast Furnace Restarted at Bilston Steelworks.—No. 5 blast furnace at the Bilston steelworks of Stewarts and Lloyds, Ltd., which was blown out recently for re-lining, has been blown in again, and is now in production. The furnace, which supplies the company's adjacent steelworks, was out of operation for only 24 days.

The Late Mr. Francis Fraser.—We regret to record the death on November 21 of Mr. Francis Fraser, F.C.I.S., who was secretary of the British Thomson-Houston Co., Ltd., for 40 years, and had been a director of the company for 27 years, when he retired at the end of 1941. Mr. Fraser was born in Scotland in 1863. After experience with a shipping firm and in a solicitor's office in Edinburgh, he went to the United States, and, in 1890, joined the Edison General Electric Co. in Denver. He returned to England in 1901, to become secretary to the British Thomson-Houston Company.

New Cycle Factory in India.—The Wearwell Cycle Co., Ltd., of Wolverhampton, are forming an associated company, the Wearwell Cycle Co. (India), Ltd., to handle sales in the Indian market. At first the Indian company, which will operate from New Delhi, will assemble cycles from components made in Great Britain, but they are expected to produce more of their own components in the future.

Boring for Coal in Cannock Chase.—The National Coal Board are to sink a borehole, 3,000 ft. deep, at Satnall Hill, about four miles east of Stafford, and in the northern part of Cannock Chase, where at present there are no collieries.

Film on the Life of William Murdock.—A documentary film on the life of William Murdock, the pioneer of gas lighting, is being made at Malvern Link, Worcestershire. The film, which will run for 20 minutes, is being produced and directed by Mr. John Stewart, and will include shots of a replica of Murdock's 1784 locomotive engine, and of a model, 30 ft. high, of the gas-lighted pagoda erected in St. James's Park, London, in 1814. The pagoda, which was illuminated by 10,000 gas lights, was destroyed by fire on the day before it was to have been exhibited to the public.

Heat-Resisting Enamels.—Ferro Enamels, Ltd., of Wombourn, Staffordshire, state that they have developed a vitreous enamel capable of resisting temperatures in the region of 900 deg. C. A gas-turbine flame tube, lined internally with this material, has been exhibited at Wolverhampton.

Motor Vehicle Exports.—The Rootes Group have chartered the M.S. Hoperidge to carry motor vehicles to Australia. The ship has been loaded with a full cargo of Humber, Hillman and Sunbeam Talbot cars, some assembled and some completely "knocked down," and Commer and Karrier commercial vehicles. The ship is also carrying a consignment of spare parts and components.

## SOUTH-WEST ENGLAND AND SOUTH WALES.

Chairman of S.W. Divisional Coal Board.—It was announced during the past week that, on account of ill-health, Mr. G. E. Aeron-Thomas was resigning his position of chairman of the South Western Divisional Coal Board at the end of the present year. His resignation has been accepted "with extreme reluctance" by Sir Hubert Houldsworth, chairman of the National Coal Board. Mr. Aeron-Thomas, who is 65, met with an accident in Cardiff 18 months ago, from the effects of which he is still suffering. He is the second chairman of the Division.

Threatened Strike at Nantgarw Colliery.—Pit-workers at the Nantgarw Colliery, where 5,000,000*l*. has been spent by the Coal Board on the mine and by-product plant, have tendered 14 days' notice to terminate contracts. The dispute concerns arrangements for Saturday working. Two strikes in the Welsh coalfields, at the Parc and Dare Colliery, involving 2,500 men, and at the Lewis Merthyr Collieries, involving 160 men, have ended, the men returning to work so that their grievances can be discussed with officials of the Board.

Objectionable Industrial Fumes.—The Ministries of Housing and Local Government and of Health have been asked by the Caerphilly Urban Council to call a conference to discuss problems caused by fumes from the new by-product plant at the Nantgarw Colliery. It was stated that these fumes had discoloured paintwork on houses opposite and deposited a brown stain on baths. It was also contended that the problem affected industries on the Treforest Trading Estate.

Effect of Water Pollution on Fisheries.—The South Wales Sea Fisheries District Committee were told, when they met at Cardiff on November 23 to discuss a report on the pollution of the New Dafen River, Llanelly, through the discharge of acid effluent from the new Steel Company of Wales tin plate works at Trostre, that they must choose between fish and industry. Recovery plant installed at Trostre, at a cost of 300,000*l*., was an economic process for recovering sulphuric acid and not to prevent pollution. It was stated that the committee's officials were doing everything possible and the Steel Company of Wales were spending very large sums of money on plant to mitigate the damage caused by pollution. The committee and the Steel Company will continue to work together to improve the position.

## NOTICES OF MEETINGS.

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

Society of Engineers.—Monday, December 3, 5.30 p.m., Geological Society, Burlington House, Piccadilly, W.1. "Some Aspects of Industrial Filtration," by Mr. R. E. Gray.

Institution of Electrical Engineers.—Monday, December 3, 5.30 p.m., Victoria-embankment, W.C.2. Informal Meeting. Discussion: "Are Sales Engineer Representatives Necessary?" opened by Commander R. B. Fairthorne. *South Midland Centre:* Monday, December 3, 6 p.m., James Watt Memorial Institute, Birmingham. "Sutton Coldfield Television Broadcasting Station," by Mr. P. A. T. Bevan and Mr. H. Page; and "the Vision Transmitter at Sutton Coldfield," by Mr. E. A. Nind and Mr. E. McP. Leyton. *Mersey and North Wales Centre:* Monday, December 3, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. "The London-Birmingham Television-Cable System," by Mr. T. Kilvington, Mr. F. J. M. Laver and Mr. H. Stanesby. *Measurements Section:* Tuesday, December 4, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "Servicing of Electrical Instruments in Large Industrial Undertakings," opened by Mr. A. J. Young; and Discussion on "Maintenance of Electrical Instruments in Atomic-Energy Factories," opened by Dr. Denis Taylor. *North-Western Centre:* Tuesday, December 4, 6.15 p.m., Engineers' Club, Manchester. "Technical Colleges and Education for the Electrical Industry," by Dr. H. L. Haslegrave. *Radio Section:* Wednesday, December 5, 5.30 p.m., Victoria-embankment, W.C.2. "An Investigation into the Mechanism of Magnetic-Tape Recording," by Mr. P. E. Axon. *Scottish Centre:* Wednesday, December 5, 7 p.m., Heriot-Watt College, Edinburgh. "Effect of Friction on Servo Mechanisms at Creep Speeds," by Mr. J. G. L. Michel and Dr. A. Porter. *Institution:* Thursday, December 6, 5.30 p.m., Victoria-embankment, W.C.2. "Technical Colleges and Education for the Electrical Industry," by Dr. H. L. Haslegrave.

Institution of Mechanical Engineers. *North-Eastern Branch:* Monday, December 3, 6 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. "Steam Piping for High Pressures and High Temperatures," by Dr. R. W. Bailey. *Scottish Branch:* Thursday, December 6, 7.30 p.m., Royal Technical College, Glasgow. "Technical Education in America," by Dr. D. S. Anderson and Mr. James Ferguson. *Institution (Administration and Production Group):* Friday, December 7, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Measurement and Interpretation of Machinery Noise, with Special Reference to Oil Engines," by Mr. C. H. Bradbury. Automobile Division.—*Derby Centre:* Monday, December 3, 6.15 p.m., Rolls-Royce Welfare Hall, Nightingale-road, Derby. "The Aviation Engine," by Air-Commodore F. R. Banks. *Coventry Centre:* Tuesday, December 4, 7.15 p.m., Craven Arms Hotel, High-street, Coventry, "Independent Rear Suspension," by Mr. Donald Bastow.

Institute of Road Transport Engineers.—*Scottish Centre:* Monday, December 3, 7.30 p.m., 39, Elmbank-crescent, Glasgow. Discussion on "Transmission." *Eastern Group:* Tuesday, December 4, 6.15 p.m., 60, Cremorne-lane, Norwich. "Use of Light-Weight Sandwich Materials in Road-Transport Vehicles," by Mr. F. C. Lynam.

Institute of British Foundrymen.—*Sheffield Branch:* Monday, December 3, 7.30 p.m., College of Technology, Sheffield. "Unskilled Labour in the Foundry Industry," by Mr. F. H. Hoult. *Burnley Section:* Tuesday, December 4, 7.30 p.m., Municipal College, Burnley. "Pattern Making," by Mr. N. Gott. *Newcastle Branch:* Saturday, December 8, 6 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. "Production of Heavy Castings for Electrical Generating Equipment," by Mr. N. Charlton.

Junior Institution of Engineers.—*North Western Section:* Monday, December 3, 7.30 p.m., 16, St. Mary's Parsonage, Manchester. "Power Stations," by Mr. F. Marshall. *Midland Section:* Wednesday, December 5, 7 p.m., James Watt Memorial Institute, Birmingham. "Printing and Allied Machinery," by Mr. J. F. Elsworth. *Institution:* Friday, December 7, 6.30 p.m., 39, Victoria-street, S.W.1. Film Evening.

Institution of Chemical Engineers.—Tuesday, December 4, 5.30 p.m., Geological Society, Burlington House, Piccadilly, W.1. "Design of Process Equipment with Special Hygenic Requirements," by Mr. J. Matthews, Mr. H. F. Goodman and Mr. G. H. Botham.

Illuminating Engineering Society.—*Cardiff Centre:* Tuesday, December 4, 5.45 p.m., South Wales Electricity Board's Offices, Cardiff. "Lighting in the New House of Commons," by Mr. C. Dykes Brown. *Newcastle Centre:* Wednesday, December 5, 6.15 p.m., Minor Durrant Hall, Oxford-street, Newcastle-upon-Tyne, 1. "Black Light: Its Effect and Application," by Mr. H. L. Privett. *Birmingham Centre:* Friday, December 7, 6 p.m., Imperial Hotel, Temple-street, Birmingham. "The Architect's Approach to Artificial Lighting," by Mr. R. G. Cox. *Bath and Bristol Centre:* Friday, December 7, 6.15 p.m., South Western Electricity Board's Offices, Colston-avenue, Bristol. "Lighting for the Prevention of Industrial Accidents," by Mr. E. W. Murray.

Institution of Engineers and Shipbuilders in Scotland.—Tuesday, December 4, 6.30 p.m., 39, Elmbank-crescent, Glasgow. "Higher Tensile Short-Link Steel Chain and Chain Slings," by Mr. W. Gibson Biggart.

Institution of Structural Engineers.—*Northern Counties Branch:* Tuesday, December 4, 6.30 p.m., Cleveland Scientific and Technical Institution, Corporation-road, Middlesbrough. "Factory Extension at Silvertown," by Mr. Frank G. Etches. *Wales and Monmouthshire Branch:* Tuesday, December 4, 6.30 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Discussion on "Structural Engineering Problems."

Institute of Metals.—*South Wales Local Section:* Tuesday, December 4, 6.30 p.m., University College, Singleton Park, Swansea. "The Solidification of Castings," by Mr. R. W. Ruddle. *Sheffield Local Section:* Friday, December 7, 6.30 p.m., The University, St. George's-square, Sheffield. "Precious Metals in Industry," by Mr. H. G. Dale.

Women's Engineering Society.—*London Branch:* Tuesday, December 4, 7 p.m., 35, Grosvenor-place, S.W.1. "Opening Doors," by Miss L. Chitty; and "Power Station Design," by Miss J. C. Thompson.

Institution of Production Engineers.—*Reading Section:* Tuesday, December 4, 7.15 p.m., Apprentice School, Morris Motors, Ltd., Cowley. "Productivity and the Machine Tool," by Mr. N. Stubbs. *Coventry Section:* Wednesday, December 5, 7 p.m., Church House, Church-street, Rugby. "Planning for Batch Production," by Mr. B. C. Harrison. *Nottingham Section:* Wednesday, December 5, 7 p.m., Victoria Station Hotel, Nottingham. "Arc Welding," by Mr. G. D. Earl. *Institution:* Thursday, December 6, 7 p.m., Royal Empire Society, Northumberland-avenue, W.C.2. "High-Speed Press Work," by Mr. J. A. Grainger.

Royal Society of Arts.—Wednesday, December 5, 2.30 p.m., John Adam-street, Adelphi, W.C.2. "Carriages and Their History," by Sir Garrard Tyrwhitt-Drake.

Royal Meteorological Society.—Wednesday, December 5, 5.30 p.m., Royal Institution, Albemarle-street, W.1. "The Optical Properties of the Atmosphere," by Mr. J. Paton.

Reinforced Concrete Association.—Wednesday, December 5, 6 p.m., 11, Upper Belgrave-street, S.W.1. "Circular Liquid-Retaining Structures in Prestressed Concrete," by Mr. J. W. A. Ager.

Institution of Heating and Ventilating Engineers.—Wednesday, December 5, 6 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Ventilation of Coal Mines," by Mr. J. G. Bromilow. *Manchester Branch:* Friday, December 7, 6.30 p.m., Engineers' Club, Manchester. "Heating and Air Conditioning in the New House of Commons," by Mr. J. R. Kell.

Institution of Works Managers.—*Notts and Derby Branch:* Wednesday, December 5, 7.30 p.m., Welbeck Hotel, Nottingham. "Economic Aspect of the Small Factory Competing with Larger Organisations," by Mr. A. H. Huckle.

Royal Aeronautical Society.—Thursday, December 6, 6 p.m., Institution of Civil Engineers, Great George-street, S.W.1. "Air Intakes for Gas Turbines," by Mr. J. Seddon.

Engineers' Guild.—Thursday, December 6, 6 p.m., Caxton Hall, Victoria-street, S.W.1. Film Evening.

Leeds Metallurgical Society.—Thursday, December 6, 7 p.m., The University, Leeds. Film on "Process Heating Equipment."

British Institution of Radio Engineers.—*Scottish Section:* Thursday, December 6, 7 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Automatic Precision Temperature Recorders," by Mr. C. H. Offord.

Institution of Water Engineers.—Friday, December 7, 10 a.m., Institution of Civil Engineers, Great George-street, S.W.1. "The Low Worsall to Wilton Raw-Water Supply," by Mr. T. S. R. Winter; "Prestressed Concrete Pipes," by Mr. G. A. P. Ooykaas; and Report on "Problems Concerning the Distribution of Water."

Institute of Fuel.—*South Wales Section:* Friday, December 7, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Tests on Commercial $CO_2$ Recorders," by Mr. L. J. Flaws and Mr. W. Hill.

North East Coast Institution of Engineers and Shipbuilders.—Friday, December 7, 6.15 p.m., Mining Institute, Newcastle-upon-Tyne. Annual Meeting. "External Ship Corrosion Due to Bacterial Action," by Dr. W. S. Patterson.

## PERSONAL.

H.H. Sir Hamidullah Khan, G.C.S.I., G.C.I.E., G.C.V.O., Sir Joseph W. Bhore, K.C.S.I., K.C.I.E., C.B.E., Mr. G. W. Odey, C.B.E., M.P., Sir Jwala Prasad Srivastava, K.C.S.I., K.B.E., and Professor L. F. R. Williams, C.B.E., J.P., have resigned from the board of Darwins Ltd., Sheffield. Sir Alexander Dunbar, Mr. A. Torry, A.I.M., and Mr. P. E. H. Wilde have been elected directors and Sir Alexander Dunbar has been made deputy chairman.

Mr. Donald F. Anderson has been appointed chairman of the shipowners' side of the National Maritime Board, in succession to Mr. Basil Sanderson.

Commander (E) T. J. Turner, R.N. ret., A.M.I. Mech.E., has been appointed general manager of Prat-Daniel (Stanmore) Ltd., Dalston-gardens, Stanmore, Middlesex, as from November 1.

Mr. S. R. Halsey, who has been 20 years with James Gordon & Co., Ltd., has now been appointed a director of the company.

Mr. A. E. Shave, A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E., who became senior assistant to the purchasing officer of the London Transport Executive, 55, Broadway, S.W.1, in 1949, has now been appointed supplies officer. Mr. J. Morgan has been appointed chief ratefixer (omnibuses and coaches) at the Chiswick and Aldenham Works of the Executive.

Mr. F. Fawcett, A.M.I.C.E., hitherto assistant district engineer, Walsall, has been appointed district engineer, Derby (South), British Railways, London Midland Region.

Mr. P. W. Howard has been appointed managing director of the British Tyre & Rubber Co., Ltd., Herga House, Vincent-square, London, S.W.1, in succession to the late Mr. Alan Sinclair.

Mr. E. B. Watton, A.M.I.E.E., until recently assistant editor of the *Electrical Times*, has joined the publicity department of Babcock & Wilcox, Ltd., Babcock House, Farringdon-street, London, E.C.4, as editorial assistant to Mr. G. M. C. Peacock, the publicity manager.

Mr. M. Vercoe has been appointed official representative of the Institution of Engineering Draughtsmen and Designers, Grand Buildings, Trafalgar-square, London, W.C.2, on the Standardisation of Drawing-Office Materials Sub-Committee of the Engineering Standards Co-ordinating Committee under the Joint War Production Committee of the Ministry of Supply.

Mr. W. E. Davis has been appointed Midland regional controller, Ministry of Labour and National Service, in succession to Mr. H. S. Gosney, who is moving to the Ministry's southern region to take up a similar post.

In consequence of the death, on November 6, of Mr. F. M. Selson, managing director of the Selson Machine Tool Co., Ltd., Cunard Works, Chase-road, North Acton, London, N.W.10, Mr. D. W. Cooper has been appointed managing director, and Mr. J. Simpson, who is a director, will discharge the duties of general manager. Mr. C. M. Cohen remains chairman.

Mr. I. A. Gray has been appointed assistant to the President of Canadian Pacific Airlines, at his headquarters in Vancouver. Mr. Gray vacates the post of general superintendent of engineering for Canadian Pacific Airlines upon taking up his new appointment and he is succeeded by his former assistant, Mr. F. M. Francis, of Vancouver.

Mr. W. W. Shorter, director and general sales manager of the Westinghouse Brake and Signal Co. Ltd., 82, York Way, King's Cross, London, N.1, has been appointed to the board of W. R. Sykes Interlocking Signal Co., Ltd., Clapham, London, S.W.4.

Mr. P. W. Darnell is relinquishing his post as Press officer to the Ministry of Transport, Berkeley-square House, London, W.1, to-day, November 30. The Ministry's information branch is now under Mr. S. W. Bainbridge, principal information officer, who is assisted on the Press side by Mr. K. J. Ley.

Mr. S. A. Mousley, sales manager, rubber-goods division, Dunlop Rubber Co., Ltd., Manchester, has been elected a member of the firm's local board in that city.

The Aluminium Wire and Cable Co. Ltd., have opened a Midlands branch office at Great Western Buildings, 6, Livery-street, Birmingham, 3. (Telephone: CEN. 5370.)

The Rockwell Machine Tool Co., Ltd., Welsh Harp, Edgware-road, London, N.W.2, have been appointed sole agents in this country for four German manufacturers of machine tools, namely, Messrs. Drabert, Minden-i-West; Delisle und Ziegele, Stuttgart; Kraumendahl, Lorrach-Baden; and Hartex, Berlin.

The address of the London office of Harbormaster Ltd., is now 42, Walmer-road, W.10. (Telephone: LADbroke 1221.)

The address of the Hull Office of British Insulated Callender's Cables Ltd., is now 199, Anlaby-road Hull. (Telephone (unchanged): Central 16367.)

# RUBBER RESEARCH STATION AT DELFT, HOLLAND.

(*For Description, see Page* 694.)

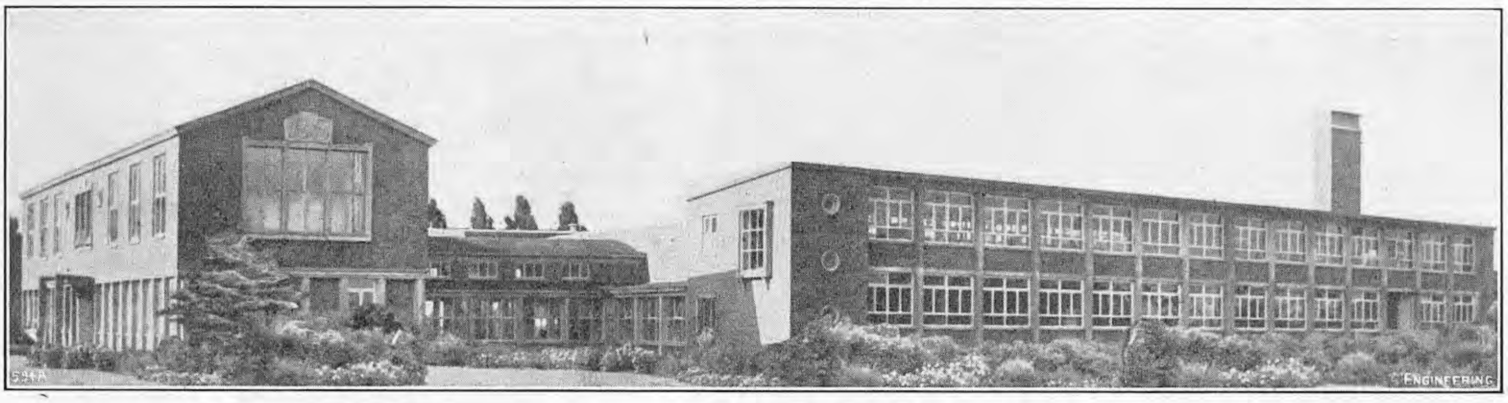


Fig. 1. General View of Buildings.

Fig. 2. Exhibition Hall.

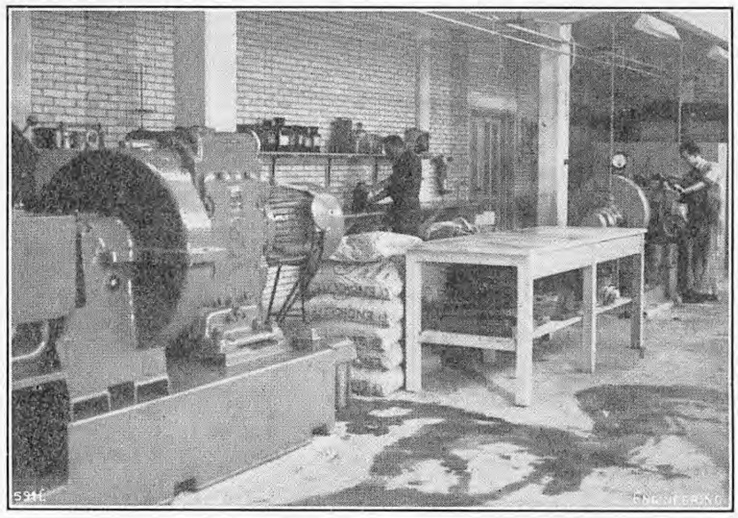


Fig. 3. Rubber Machinery Room.

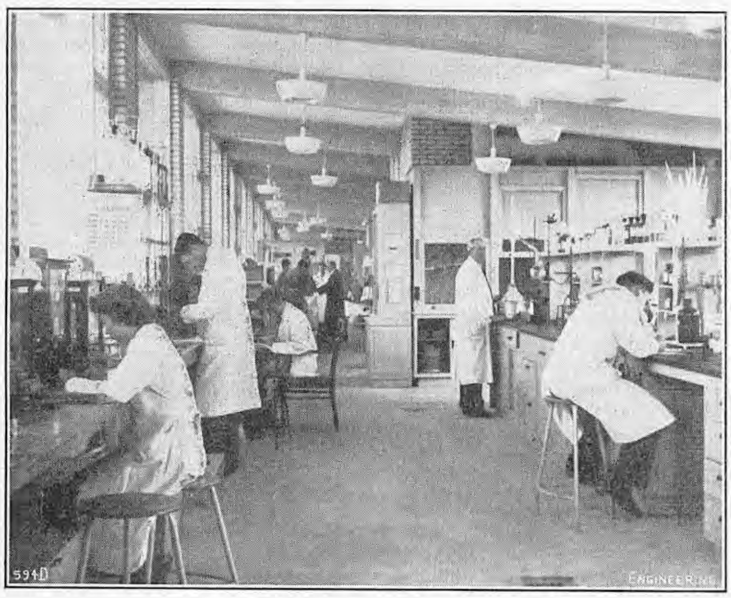


Fig. 4. Chemical Laboratory.

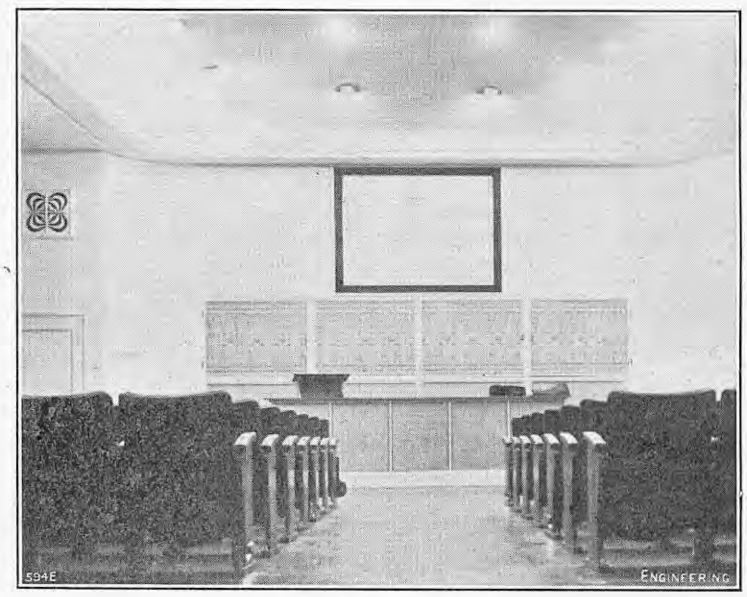


Fig. 5. Lecture Hall.

## CONTRACTS.

Leyland Motors Ltd., Leyland, Lancashire, have received an order worth nearly 250,000*l*. from the Corporacion Automotriz S.A., Montevideo, Uruguay, for over 100 motor-vehicle chassis, 80 of which are of the new Comet " 90 " range. The latter is a long-wheelbase haulage model fitted with a 90-h.p. high-speed Diesel engine and a two-speed rear axle, which, together with a five-speed gearbox provides 10 forward speeds. Other recent orders include the purchase of 30 Titan passenger models by Ribble Motor Services Ltd., 20 Titan chassis by Southdown Motor Services, Ltd., and 10 Royal Tiger coaches by the North Western Road Car Co., Ltd.

Hunting Aerosurveys Ltd., 20, Old Bond-street, London, W.1, have been awarded an aerial survey contract by the Iraq Government, involving the air photography and contoured mapping of a large portion of Iraq. This contract is the first step in the economic development of the country, as drawn up by the Iraq Government Development Board. The survey photographs will take two seasons to complete and the mapping work will be spread over a five-year period.

The de Havilland Aircraft Co., Ltd., Hatfield, Hertfordshire, announces that Air France intends to purchase three Series 1 Comet aircraft and that an agreement in principle to purchase these machines, subject to the formalities of French Government approval, has now been signed.

Ferguson Brothers (Port Glasgow), Ltd., Newark Works, Port Glasgow, have received an order from the Aden Port Trust for a powerful twin-screw sea-going salvage and towing steamer. Reciprocating engines of Ferguson Brothers manufacture will be installed.

The North British Locomotive Co., Ltd., Glasgow, have received an order from the South African Railways and Harbours Administration for locomotives and tenders valued at about 5,000,000*l*. This, it is stated, should mean two years of steady employment at the company's Springburn and Polmadie Works. Recently, the company booked an order for 60 locomotives and tenders of the new " 25 " class, but in the interval this class has been improved and the original order replaced by one for 100 locomotives. With the exception of ten, all will be fitted with condenser equipment, because of water shortage on some South African Railway lines.

# ENGINEERING,

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# ENGINEERING

*FRIDAY, NOVEMBER* 30, 1951.

VOL. 172. No. 4479.


## THE ELECTRIC LAMP "MONOPOLY."

IN March, 1949, the Monopolies and Restrictive Practices Commission was instructed by the Board of Trade to discover whether the conditions to which the Monopolies and Restrictive Practices (Inquiry and Control) Act, 1948, applied prevailed in the British electric-lamp industry ; and whether what was taking place in that industry was contrary to the public interest. A report* of some 100 pages, which was published last week, contains the result of their investigations ; and, in the manner of its kind, is accompanied by nearly another 100 pages of appendices. Its perusal may be recommended to those who are interested in the history of a not unimportant branch of the electrical industry, but this recommendation must be accompanied by the warning that many of the statements are *ex parte* and that the treatment is sometimes so detailed as to confuse the issue. An even graver criticism is that there are signs that the case has been prejudged. To some extent this is, perhaps, inevitable, from the nature of the terms of reference, which rendered it unlikely that a verdict of " not guilty " would be returned. The best that could have been expected would have been the unsatisfactory Scottish judgment of " not proven," which is frequently much the same as " not guilty, but don't do it again."

This result is, we think, partly due to the fact that the Commission has considered it necessary to inquire closely into past history. Their investigations show that the first step towards monopoly in the electric-lamp industry was taken as long ago as 1905, when the British Carbon Lamp Association was formed to combat foreign competition. The pooling of patents and of the results of research followed and above all agreements regarding manufacture, supply and sales were entered into. In 1919, the formation of the Electric Lamp Manufacturers' Association, Limited, further crystallised the position. Even greater stabilisation occurred when the international body known as S.A. Phoebus was formed. Under the terms of this association, which was set up in 1925, the world market was divided into territorial zones, a common policy on sales was laid down, and the cross licensing of inventions was contemplated. As a result, when war broke out in 1939, the principal lamp manufacturers of the world, except those of Japan, were associated by a network of agreements. Although since then these agreements have naturally become ineffective, their place has been taken by an understanding between British manufacturers under which most of their provisions are maintained. The ramifications of this association are now, however, principally of importance because the Commission feels that many of to-day's conditions are heritages of its baleful influence.

Stating these conditions as briefly as possible, British electric lamp manufacturers can be divided into three groups : those who are members of the Electrical Lamp Manufacturers' Association ; those who are non-members, but are " controlled " by members ; and those who are " independent." The aggregate annual production of the industry is rather over 247 million filament lamps and five million discharge lamps. Of the former class, about 60 per cent. are produced by members of the Association, 13 per cent. by the " controlled " companies, and 27 per cent. by the " independent " manufacturers. Members of the Association also produce 62 per cent., and " independent " manufacturers 38 per cent., of the discharge lamps. These figures, therefore, do not disclose " the exclusive possession of a trade in some commodity," which is the usual definition of a monopoly, although they bring the industry within the " conditions " of the 1948 Act.

It must be admitted from the evidence produced that the Association is a powerful body and that its power is not diminished by the fact that two firms are between them responsible for over half the production of its members. Naturally, therefore, these firms play a considerable part in its activities. For instance, they supply not only their own requirements for bulbs and caps, but those of other members of the Association and to a large extent of the " controlled " companies and " independent " manufacturers as well. Further, they possess many patent rights, although it is conceded that the benefits of these have been made generally available. Finally, they perform the greater part of the research work of the industry, although, again, many of the resulting technical benefits have been passed on to the public in the form of reduced prices.

If, however, the evidence of the report is accepted this is not the whole story ; for members of the Association are permitted only to manufacture approved types of lamps and a uniform price which, in the case of the ordinary 60-watt lamp, is now lower than before the war, must be charged for these at every stage in their distribution. The advantages of competition among members are therefore, it is argued, practically eschewed. Moreover, each member is entitled only to a fixed percentage of the total trade ; and, if he sells more than his quota, must make a compensatory payment to those who are more unfortunate—or less energetic. On the other hand, the total number of lamps of all kinds sold by members is not restricted

* *The Monopolies and Restrictive Practices Commission. Report on the Supply of Electric Lamps.* London : H.M. Stationery Office. [Price 6*s.* net.]

but is free to grow—or to diminish—according to the demand. Competition, therefore, exists, if not to the extent that the Commission considers desirable. Moreover, the "independent" manufacturers buy a large proportion of their components from members of the Association and the present policy of the latter is, generally speaking, to maintain this supply at reasonable prices. The Commission, is, however, uncertain how long this halycon state of affairs will continue and therefore recommends that the sales quota system should be terminated.

It is also uneasy about the patent position on even more slender grounds; for while licences are now being granted well beyond the obligations required by law it is felt that this may be due more to the provisions of the Patent Act, 1949, than to a realisation of the error of their former ways. In any event, patents, at least as far as filament lamps are concerned, are not so important as they used to be. Again, therefore, there is some misgiving as to what might happen, and it is consequently considered that the position should be carefully watched. It is also regarded as important that the "independent" companies should continue to exist and that the "controlled" companies should still practise an independent price policy. One member of the Commission (and this is the only departure from unanimity in the report) regards this latter proposal as unrealistic; and suggests as an alternative that the Government should acquire the share capital of these companies at a fair valuation, while leaving their management in present hands.

Turning to the distributive side, it is pointed out that the two fundamental features of the system established by the Association are that its members must not supply any concern with lamps on wholesale terms unless that concern agrees not to sell non-Association lamps; while retailers who sign similar agreements are solaced by the award of an extra 5 per cent. discount. The Commission recommends that both these practices should cease for the reason that they stultify competition. Nevertheless, it is admitted that only 19,000 of the 35,000 lamp retailers in the country have signed the exclusive agreement and that actually competition from independent manufacturers is not ineffective. The practice of granting rebates to customers based on their total purchases of Association lamps is also deplored, partly because it is against the public interest and partly because the elaborate statistical machinery which must be used to implement it leads to a waste of effort and manpower.

Upon this necessarily concise, but nevertheless, we hope, unbiased summary of the Commission's conclusions two comments may be made: one is that their researches into past history have given them a somewhat exaggerated idea of the stranglehold imposed on the industry before the war by Phoebus and its associates, and of the exploitation of the consumer which resulted therefrom. Few such organisations are, however, as black as they are painted and if it were only for the contributions that it made to knowledge and for its successful attempts to avert a price war its existence may have been justified. This opinion is, however, at least by implication, rejected by the Commission, although it is admitted that the position is not so bad as it used to be. It is therefore the more unsatisfactory that so many of its recommendations seem to be based rather upon conditions as they were, or might be, than on what they really are.

The second point is perhaps even more important. Can the recommendations of the Commission be implemented and, if they can, what will be the results? Will the removal of the restrictions we have outlined result in the public being provided with a better quality article at a lower price? Is it possible that the same result could be obtained in a better way? It is upon the answers to these questions that the justification for the conclusions reached by the Commission must rely.

## CLEAVAGE FRACTURES OF SHIP PLATES.

The brittle behaviour of steel under certain conditions is not a new phenomenon, but it has caused perplexity since the earliest days of steel-making. The increased use of welding in recent years, however, has brought the matter into prominence, and the failures of American "Liberty" ships stimulated research into the behaviour of steel subjected to the stresses and conditions imposed on the hull of a ship at sea. Many new facts have been disclosed, and techniques for avoiding failure have been evolved, but a fundamental understanding of the problem has not yet been obtained. The toughness of steel, that is, its capacity to resist fracture in a brittle manner, cannot be determined from the usual physical tests, and it has been necessary to devise additional tests to reveal this characteristic. The amount of energy required to produce or extend a fracture may be taken as an index of the toughness, and, in this country, the standard usually adopted is the Izod value. In recent years, however, the Charpy V-notch test has come into favour; in this test, a beam specimen having an Izod notch is broken on a Charpy machine. By this means, it is possible to relate the toughness of steel at various temperatures to the energy absorbed, and the transition temperature range from the brittle to the ductile state may be determined. It is possible, too, to relate the appearance of the fracture, whether crystalline or fibrous, denoting brittleness or toughness, to the energy absorbed. There are many such tests, but unfortunately it is not possible to relate the results to each other, even on steel of a standard quality, nor to reconcile them completely with service results. It may be said, nevertheless, that it is possible to put steels in order of toughness by these methods. These are commercial tests, and therefore are carried out on small specimens, but attempts have been made to determine the factors influencing cleavage fractures in ship plates by testing large specimens.

The most important work of this nature was that carried out at the Engineering Experiment Station of the University of Illinois, under the ægis of the United States Office of Scientific Research and Development, and the Bureau of Ships, Navy Department.* This work was part of a programme sponsored by a Board appointed by the Secretary of the Navy "to investigate the design and methods of construction of welded steel merchant vessels" (afterwards superseded by the Ship Structure Committee of the National Research Council) to attempt to explain certain aspects of the failures in "Liberty" ships. Plates $\frac{3}{4}$ in. in thickness, having widths of 72 in., 48 in., 24 in. and 12 in. were tested, a 3,000,000-lb. tensile machine being used for the wider specimens. A stress raiser, with a width equal to one quarter of the breadth of the plate, and consisting of a $\frac{1}{2}$ in. slot with a jeweller's saw cut at each end, was cut in each plate, transversely to the direction of pull. Tests were carried out with the plates at different temperatures, and a variety of data was obtained. The distribution of the longitudinal strain across the plate was measured, and the energy absorbed to failure was estimated from the area under a curve showing total load and the average elongation of the plate on a standard gauge length equal to three quarters of the width of the plate. The fractures of the plates were examined to determine the proportion of the total section for which the failure was of the cleavage type and the part which was of the ductile type. It was found that, with the stress raiser used, the cleavage fracture, when it occurred, might take place instantaneously over the whole section, or intermittently, in "jumps." Factors which were considered to enter into the strength of the plates were the temperature of the steel, the type of fracture, the width of plate, and the type of steel. The relation between the temperature of the steel and the strength was somewhat erratic, but, in general terms, it was found that the strength of a wide plate with a severe stress raiser increased with increase in temperature in the transition range.

On the second criterion, it is not surprising to find that the strength of the plate increased with the proportion of the fracture that was of the shear type. When attempting to relate the strength of the plate to the width, the matter is obscured by the amount of cleavage in the fracture, but the broad result emerges that the strength decreased with the width of plate, and moreover, the effect would continue beyond a width of 72 in., the widest plate tested. Five kinds of steel were used in the tests, ranging from rimmed steel as rolled, to killed steel normalised; the chemical constituents of the steels varied. Three varieties of steel were used for the tests on the 72-in. plates, and it was found that the order of merit was: killed steel as rolled, killed steel normalised, and, lowest, rimmed steel as rolled. A similar result was obtained in the other plates. As regards energy absorption, it was found, as might be expected, that the capacity increased with the proportion of shear in the fracture, and this was many times greater under conditions which produced a shear fracture than under those which produced a cleavage fracture.

In addition to the tests on wide plates, Charpy V-notch impact tests were taken from each variety of steel. The transition-temperature range determined on this basis was broad, and, in average value, differed considerably from the values determined from the wide-plate specimens, where the range of the transition temperatures, as defined by energy absorption, percentage of shear in fracture, or elongation was narrow for the 72-in., 48-in. and 24-in. plates. However, the relative merits of the different steels fell into the same order as was obtained from the Charpy V-notch impact tests, except in the 12-in. plates, where the order was not the same. This partial correlation between the impact tests on the small specimens, and the tensile tests on the large specimens, is probably the most valuable result obtained by these elaborate, and no doubt costly, experiments. In addition, they demonstrated that the behaviour of the large plates was generally in line with what might have been expected. It does not follow from the experiments that service results must necessarily follow the same pattern, but they offer a valuable extrapolation from the commercial tests. It is worth noting that the manganese-carbon ratio in the killed steel tested in the wider plates was of the order of 2·5 or 3·0 to 1, a ratio which modern opinion, influenced by Barr and Honeyman, considers suitable for a reasonably tough steel; the ratio in the rimmed steel was 1·6 to 1, so that this steel is condemned on two counts. Several incidental results of interest were obtained; the most important arose through the failure of one of the pulling plates, to which the specimens were welded. This plate fractured with a complete cleavage, and an examination showed that the Charpy impact value was low, and that the sheared edge of the plate had incipient cracks and a greatly increased hardness, factors which might have been expected to reduce the strength and ductility of this strain aged plate. Summing up, therefore, it may be said that these experiments have provided data on the subject of brittle fracture of steel which can be fitted into the wider picture, though they do not, in themselves, add much to fundamental and scientific understanding of the phenomenon.

* *Cleavage Fractures of Ship Plates.* By Professor Wilbur M. Wilson, Robert A. Hechtman and Professor Walter H. Bruckner. Bulletin No. 388. University of Illinois Engineering Experiment Station, Urbana, Illinois, U.S.A. [Price 1 dol.]

## NOTES.

### Opening of Stephenson Building.

On Wednesday of this week, at Newcastle-upon-Tyne, His Royal Highness the Duke of Edinburgh, K.G., F.R.S., declared open the Stephenson Building, the new headquarters of the Mechanical and Marine Engineering Department of King's College, University of Durham. Further details regarding this building and its equipment will be found on page 681. Prior to the opening ceremony, which was performed in the heat-engines laboratory, Lord Eustace Percy, Vice-Chancellor of the University and Rector of King's College, delivered an address of welcome to His Royal Highness and conferred upon him the honorary degree of Doctor of Civil Law. The Duke, in reply, thanked the Vice-Chancellor and the University of Durham for the honour which, he said, would always be a reminder to him of the occasion. The great industrial prosperity which Great Britain had attained by the turn of the century was in no small degree due to the genius of such men as George Stephenson, but, since then, it had been largely destroyed by two major wars. There was, therefore, a pressing need for scientists and engineers able to develop new ways of applying technical knowledge and skill. The training grounds for such men were the universities and technical colleges and, in order that the men might give of their best, the training must be sound and thorough. Engineering science was particularly important in a highly industrialised and technically developed area like Tyneside, which had long been famed for its shipbuilders and engineers. He hoped that those who studied in the new building would go forth determined to maintain and, where possible, improve on the high standards set by their fathers. Praise and thanks were due to the Vice-Chancellor and those associated with him, whose foresight and determination had now borne fruit, to the Freemen and City Council of Newcastle-upon-Tyne, who had made the land available, and to all those who had contributed in their several capacities to achieve the final splendid result. In the certain knowledge that they had made wise provision for the future, he had great pleasure in declaring the Stephenson Building open. Professor A. F. Burstall, D.Sc., Professor of Mechanical and Marine Engineering, in reply, spoke of His Royal Highness as the University of Durham's youngest Doctor of Civil Law, and doubted whether the degree had ever before been conferred in such unusual surroundings. He thanked the Duke for the readiness with which he had accepted the invitation to open the new building and for the interest and enthusiasm which he had displayed during his tour of it earlier. As a serving officer in His Majesty's Navy, His Royal Highness was well acquainted with engineers and engineering. In some ways, said Professor Burstall, the ceremony reminded him of the launching of a ship, and he hoped that, some day, His Royal Highness might return to see how fared the "ship" that he had launched. As the concluding item of the ceremony, the architect of the building, Professor W. B. Edwards, presented the Duke with a souvenir album of photographs. Subsequently, His Royal Highness lunched at the Sutherland Dental School, Newcastle, and later, in his capacity as President of the British Association, paid a private visit to the Heaton Works of Messrs. C. A. Parsons and Company, Limited.

### Electric Wiring Regulations for Small Dwellings.

The well-known Wiring Regulations of the Institution of Electrical Engineers deliberately cover all safe methods of installation practice with a view to providing a defence against every contingency, including fire and shock. They are therefore necessarily diffuse, a quality which does not always make it easy for the inquirer to find the material he needs. To overcome this difficulty, the Post-War Planning Committee on Electricity Supply, Distribution and Installation proposed to the Council in 1944 that the Regulations should be divided into two parts consisting, respectively, of those dealing with basic safety and of a code of practical interpretations. While not accepting this proposal in its entirety the Council decided to include a statement of the principles on which specific requirements were based in the twelfth edition of the Regulations (published in May, 1950), and to supplement it with an abridged version containing the requirements necessary for simple family dwellings using a single-phase alternating-current supply. This abridgment has now been published and can be obtained from the Institution of Electrical engineers, Savoy-place, London, W.C.2, at a price of 2*s.* 6*d.*, including postage. While covering the requirements applicable to domestic installations, it omits matters which are not the concern of those engaged in work on the site, the assumption being that proper planning and ordering of materials have already been carried out and that the materials themselves comply with the full regulations. The abridgment, which is about one-third that of the complete edition, therefore provides a convenient means of reference to points likely to be met with on site. The numbering of the full regulations has, as far as possible, been retained and where the precise wording of these has been modified the change is indicated by the use of italics. The format is only $6\frac{5}{8}$ in. by $4\frac{1}{8}$ in., so that the book can be carried in the pocket.

### New Engineering Materials.

The evening discourse at the Royal Institution, Albemarle-street, London, W.1, on Friday, November 16, was one of particular interest to engineers. The lecturer, Dr. T. E. Allibone, F.R.S., head of research to Associated Electrical Industries, Limited, chose as his subject "New Materials in Engineering," and, although he gave away no secrets, the range of topics which he discussed was so wide, and his practical demonstrations were so well selected and efficiently carried out, that the lecture was of absorbing interest. The emphasis throughout was mainly on electrical engineering, since it is in this field that many of the most spectacular advances have been made. During recent years, said the lecturer, the synthetic polymer industry had expanded enormously; so much so that the bulk output of plastics now exceeded that of all the non-ferrous metals. Polythene, which was not produced before 1933, had revolutionised electrical communications since signals of all frequencies were attenuated only very slightly in polythene cables compared with cables containing cellulose. Synthetic rubbers resisted chemical attack more strongly than natural rubber, and silicones were more resistant to heat. The co-polymerisation of synthetic resins *in situ* eliminated voids in insulation, which freqently led to electrical breakdown, while a coating of synthetic polymers could prevent the ingress of moisture into insulation. The range of new synthetic materials included adhesives which had good insulating and bonding properties and which were being used experimentally to fix glass or porcelain to metal for a variety of purposes. Barium titanate and a number of related substances had dielectric constants about a thousand times greater than mica, owing to a small misfit in their crystalline lattice structure, and were useful for making very compact capacitors. The same structural feature was responsible for their being strongly piezo-electric. Semi-conducting elements, such as silicon, had long been known, but their production in pure form, or containing controlled traces of impurities, was comparatively recent and had opened the way to important developments. Silicon and germanium rectifiers and triode "valves" were likely to replace thermionic valves in many applications and result in lighter and less bulky equipment and economy in power consumption. Electronic conduction in materials which were almost insulators was now better understood, as was also the reason why a mixture of two metal oxides, each a good insulator, could have a low resistance. New photo-electric crystalline materials had been produced which were sensitive to X-rays or to infra-red rays. Basic research during the past 20 years had also produced magnetic materials with excellent properties, and the cost of these developments was likely to be amply repaid by the reduction of hysteresis losses in electrical machines. The very rapid magnetic saturation of some of the newer iron alloys under very small fields had opened up a new field of application of iron cores as "switches" without contacts, and a combination of new magnetic materials and new insulating materials had made possible the construction of small high-power motors which could run at high temperatures for long periods. A section of one such motor was shown which had run for 1,000 hours at 250 deg. C., without significant damage. New developments in metallurgy had also had important results, leading to better materials for turbine blades, metals with greater resistance to corrosion, metals, like zirconium, which did not absorb neutrons and were suitable for atomic "boilers," and metals with good cutting properties and high resistance to wear. Sintering of metal and non-metallic powders in an electric induction furnace had produced extremely hard metals and porous metals which could carry a lubricant for a bearing. The electric-arc furnace described over a century ago was now finding an important application for melting metals like titanium and zirconium in argon, to avoid their oxidation.

### The Printing, Packaging and Allied Trades Research Association.

The annual general meeting of the Printing, Packaging and Allied Trades Research Association (Patra) was held on November 22 at the Connaught Rooms and was followed by a luncheon and an exhibition illustrating the work of the various departments. Further progress has been made during the year on the suitability of rubber and thermoplastic printing plates for reducing the standing time of printing machines, by improving the impression; the tendency of the characters to spread sideways, it has been concluded, may be reduced by using materials of low resilience; the static hardness of rubbery materials is relatively unimportant in this connection. Trials are now being carried out on printing plates made of various materials of low resilience. On the packaging side, the investigations on the strength of containers continues, and 40 journey-shock recorders, manufactured in the Patra workshops, are now being used in service trials to determine the hazards to a package in journeys by full container load and by mixed goods traffic. Another type of recorder is under development to give more detailed information on the intensity and angle of the shock and the time at which it occurred. Other work carried out on packaging includes the construction of an instrument, adapted from the Hounsfield Tensometer, for measuring the initial tear strength of boards at loads up to two tons. A new research undertaken during the year, in connection with the accelerated deterioration of certain packaged goods which is known to be caused by light of certain wavelengths, is the measurement of transmission spectra of the common transparent packing materials, some of which extend farther into the ultra-violet region than others. The Council have decided to expand the inquiry departments and the information services. Among new activities to be undertaken on the printing side may be mentioned investigations on the applications of electronics and radioactive-tracer techniques to printing problems. Patra's research activities on packaging will be expanded to deal with adhesives, cutting and creasing boards, further investigation of the strength of packages and the penetration of packages by gases, liquids and heat.

### The British Council.

Under the terms of its Royal Charter, the purposes of the British Council are to promote "a wider knowledge of . . . the English language abroad" and to the development of "closer cultural relations between Our United Kingdom of Great Britain and Northern Ireland and other countries." "Cultural relations" is an indefinite term and to a large extent the Council has interpreted it as referring to literary and artistic matters. Science is not altogether neglected and both medicine and some aspects of agriculture are given considerable attention; engineering, however, fares badly. The report for the year ended March 31, 1951, contains a list of some 113 lectures delivered abroad during the year and the only one of these which might be described as being of an engineering nature is on "Industrial Atomic Energy," given by Dr. T. E. Allibone, F.R.S., in Greece and Turkey. There is, perhaps, no reason to grumble about this neglect of engineering, as presumably the Council attempts to choose subjects likely to interest a wide non-specialist audience. It would appear, however, that lectures on some aspects of British civil engineering might fall within this class. These overseas lectures, however, do not constitute one of the Council's major activities and although it would be difficult, or impossible, to present those in order of importance, the teaching of English must take a high place. It is doubtful if the "culture" of one country can be properly understood in another if the latter is entirely ignorant of the language of the former. From this point of view, it is satisfactory to learn that during the year 150 British teachers of English were working in educational institutions abroad and that several thousand native teachers of English were using the Council's facilities. It is probably in its work connected with the welfare of overseas students that the Council's activities have most direct effect in the engineering field. Students are met on arrival in this country, found accommodation, assisted in case of sickness and generally looked after. A large number of lecture courses are also organised by the Council for these foreign students and although, as with the lectures abroad, art and literature bulk largely, there are a number of engineering courses and study tours, particularly the latter. In the year under review these included tours for Chilean engineering students; Danish, Dutch and Norwegian shipbuilding students; and Swedish Diesel-engine students. A number of university posts abroad are subsidised by the Council and assistance is given in connection with the university interchange of lecturers.

PASSENGER TRANSPORT IN GLASGOW.

The report of a Committee, which was appointed in August, 1949, by the British Transport Commission to make recommendations regarding improvements or developments in the transport facilities in and around Glasgow, was published last week at the price of 7*s*. 6*d*. Copies can be obtained from the offices of the Commission in Edinburgh. The major problem which faced the Committee, it appears, was street congestion. It is considered, therefore, that first priority should be given to placing the railways in a position to attract a greater volume of traffic. Investigations showed that existing lines could cater for three times the present number of passengers; and it recommended that new halts be built and the steam services amplified to enable this to be done. As, however, more intensive suburban and inter-urban working is handicapped by steam operation, it is further recommended that an extensive electrification scheme, estimated to cost about 10,000,000*l*., should be undertaken in two stages. The first of these would involve some 153 route miles and the second 37 route miles, while at a later date a further 118 route miles should be converted. The scheme would include the provision of 11 new halts and of a new link between the King's Park and Circle lines west of Cathcart station. It is also regarded as desirable, if less urgent, that the existing main line stations at Queen Street High Level and Buchanan Street should be combined at the latter place, the site of the former being converted into a 'bus terminal. Proposals are further made for co-ordinating rail and 'bus facilities by establishing a series of traffic exchanges on the outskirts of the city. At these, passengers would transfer from the 'buses to the railway and vice versa, thus relieving congestion in the central area and reducing travelling time. Generally speaking, it is felt that railways should be preferred to buses for distances over five miles, though the latter form of transport should be retained as a feeder and where withdrawal would cause hardship. Railway and 'bus fares should be brought into line, and the interavailability of the tickets on the two systems should be increased. Several other recommendations are made on points of detail. The report as a whole provides a mass of interesting evidence which should be useful in reaching a solution of what is clearly a difficult problem.

THE BUILDING EXHIBITION.

The Building Exhibition, which closed at Olympia on Wednesday last, after having been open since Wednesday, November 14, was probably the most successful of the series ever to be held, as not only were the Grand and National Halls filled to capacity but it proved necessary to add the ground floor of the Empire Hall to the exhibition area. Furthermore, the number of visitors and the volume of trade inquiries were well beyond expectations. It was the third biennial exhibition to be held since the war and the twenty-fourth of a series founded in 1895. Attempts had been made to hold such an exhibition earlier than this, but on those occasions the title Building Exhibition was purely nominal, since most of the stands showed anything but building equipment. This year, the stands covered an area of approximately 300,000 sq. ft. and provided a very clear picture of the building industry and its allied trades. Perhaps the most outstanding feature was the quality of the stands; these, without exception, were of a very high order, particularly those exhibiting such products as bricks, tiles, glass and similar materials. The emphasis of the exhibition was on productivity and there was on view a wide selection of mechanical aids ranging from brick barrows which automatically pick up a load of bricks to mobile tower cranes and large hoists. Although the principles of woodworking machinery remain very much as heretofore, much progress has been made during recent years in tidying up the designs, and it was noted that the exhibits in this section were well finished, had a neat appearance and were built so that the guards, a very necessary adjunct to all such machines, formed an integral part of the design. As in former years, Government departments associated with the building industry took part in the exhibition. The Ministry of Works, for example, had two stands, one concerned with building research and housing and the other with their technical information services. Other Government departments represented included the Department of Scientific and Industrial Research, the Ministry of Fuel and Power and the Ministry of Housing and Local Government. The special feature this year was devoted to the craft of the stone mason and was designed to remind architects of the virtues of stone and to show the attractions of this craft as a career.

# LETTERS TO THE EDITOR.

## LOCKE, STEPHENSON AND BRUNEL.

TO THE EDITOR OF ENGINEERING.

SIR,—In the 172 volumes of ENGINEERING there are probably few in which no reference is made to Robert Stephenson and Isambard Kingdom Brunel, but none of them contains a finer tribute to the genius of Brunel than that of Mr. A. S. Quartermaine in his presidential address to the Institution of Civil Engineers, printed in your issues for November 9 and 16, on pages 599 and 633. Together with Joseph Locke, Stephenson and Brunel were regarded as the triumvirate of the engineering world and it was a remarkable thing that all three should pass away within about a year; Brunel died on September 15 and Stephenson on October 12, 1859, and Locke on September 18, 1860, all still under 56 years of age. As is well known, Locke and Brunel were buried in Kensal Green cemetery, and Stephenson's grave is next to that of Telford in the nave of Westminster Abbey, in the north aisle of which memorial windows were erected to them all.

Of the three windows, those of Stephenson and Locke were removed between 30 and 40 years ago, and that of Brunel a little over a year ago. Thanks, however, largely to the Newcomen Society and ENGINEERING, the Stephenson window was re-erected 18 years ago by the late Dean Foxley Norris; but the windows to Brunel and Locke, like that to Siemens, is still stored away out of sight, and every mention of the window to Locke is now omitted from the *Official Guide* to the Abbey.

In concluding his address, Mr. Quartermaine quoted from the presidential address of Locke in 1859, who, after referring to the recent deaths of his famous contemporaries said, "We . . . who feel that our Institution has reason to be proud of its association with such names as Brunel and Stephenson have a duty to perform and that duty is to honour their memory and emulate their example." No one will quarrel with these sentiments but may one not ask respectfully if the Institution has not a duty to perform in this matter of the memorials to their distinguished members? To a student of history, it is a very extraordinary thing for the Institution to acquiesce in the removal of memorials to their presidents, but still more extraordinary for the Institution apparently to care nothing about what becomes of them. Perhaps I ought to apologise for again taking up your space in calling attention to this matter, but what has been done in the past is little credit to anyone.

Yours faithfully
EDGAR C. SMITH,
Engineer Captain, R.N. (ret.).

Keepers Corner,
Horley, Surrey.
November 25, 1951.

## THE STANDARD OF LIVING.

TO THE EDITOR OF ENGINEERING.

SIR,—It seems to me a great pity that the otherwise admirable balance of your leading article on "The Standard of Living," on page 593, *ante*, should have been marred by the implication that all blame for the restrictive attitude of British labour belongs to the men themselves or their trade-union leaders. Primary responsibility for the existence of an unhealthy climate of opinion in any community ought surely to be attributed to those who have enjoyed the best and most frequent opportunities of forming it. Can anyone seriously dispute the fact that, in the industrial community, it is the managements of individual firms, rather than national or branch trade-union officials, who have at their disposal the most powerful means of convincing the workers that increased efficiency does, really, benefit us all?

Managements can, if they choose, keep in daily communication with their employees. They can, if they are really sincere in their desire to overcome prejudice, give specific and binding guarantees, such as that workers rendered redundant by new processes will be re-trained and re-employed in another capacity, or, failing that, that the total number of employees will be reduced by cutting down recruiting, not by dismissing existing personnel. Trade-union officials can do neither of these things, and it is therefore unrealistic as well as unjust to reproach them for failing to do what is not being seriously attempted by those who have infinitely better facilities for the job.

What a sad commentary it is upon the extent to which management has abdicated from its proper responsibilities in the field of human relations, that, when we are introduced to "a distinguished labour leader," we do not expect to meet the managing director of a large company!

Yours faithfully.
BJORN GUY.

18, Gardnor Mansions,
Church-row,
London, N.W.3.
November 18, 1951.

## THE SAMPLING OF SMALL COAL.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with great interest the article by Mr. E. T. G. Emery on "The Sampling of Small Coal," which appeared on page 452 in your issue of October 12. The first part of the paper is concerned with the accuracy of a sample of coal in relation to the variance of individual increments, where the sample has been obtained in the usual way by taking increments distributed evenly over the consignment. In the simplest possible case where successive increments are uncorrelated, the variance, $s^2$, of the sample value is obtained from the variance, $S^2$, of the individual increments by the relation $s^2 = \frac{S^2}{n}$. However, if there is a pattern in the ash distribution of the consignment, then successive increments will not be uncorrelated. Under such conditions the variance of the sample is less than $\frac{S^2}{n}$, whereas your correspondent implies that it will be greater than $\frac{S^2}{n}$. (It is this, of course, that makes it better to sample by taking increments evenly over the consignment, rather than at random.) In the article it was assumed that in equation (6) the term $2\Sigma m (n-q) C_{qm}$ is positive, whereas it will be negative except in a few special cases of no practical interest. It should be noted that $r_{qm}$ is not the intraclass correlation coefficient as stated, since in its derivation no allowance has been made for the mean.

In the second part of the article an attempt is made to deduce a law relating the variance of a single increment to its size. Equations (9) and (10) are intended to provide this relation, on the assumption that an increment is a "sample" of the sub-elements within it, where the "sample" consists of all these sub-elements. However, it can be shown that, under these conditions, the R.H.S. of equation (9) is necessarily zero. In fact, since the value for the increment is measured and not estimated, it cannot have a sampling error.

The subject of coal sampling has been treated by many different methods and, in an article to be published shortly in *Fuel*, a review of the various treatments together with a proposed solution of the problem is given by Mr. F. D. K. Liddell. In general, it would appear that no solution can be obtained by theoretical means without a large number of assumptions. Although these assumptions can sometimes apparently be justified by the results on a few coals, they have never been found to hold generally. This conclusion has been confirmed in the last 18 months in sampling trials carried out by the scientists of the National Coal Board.

Coal is not a simple substance which can be fitted easily to a theoretical model. Not only are coals inherently different in their "patchiness," but the method of handling and preparation, as well as the mixing of different seams, are all factors which affect the sampling accuracy to an unpredictable extent. The only satisfactory method of sampling is to use a simple quality-control technique to measure the accuracy actually obtained. This would require that the sample should be taken in two halves by putting alternate increments into different containers. Two half-samples would thus be obtained, each representative of the whole consignment. The mean value for the two half-samples would be returned as the ash content of the consignment and, after a number of similar consignments have been sampled, the mean accuracy obtained from the mean of the differences between half-samples.

A procedure such as the above requires no further work from the sampler and in many cases it will be found that the accuracy measured is greater than actually required, so that the amount of sampling may be reduced. This technique is suited to products which are being sampled regularly and needs modification when an isolated consignment is to be sampled. In such a case, at least five sub-samples will be needed in order to obtain any worth-while estimate of the sampling accuracy.

Yours faithfully,
R. C. Tomlinson.

Scientific Department,
National Coal Board,
Hobart House,
London, S.W.1.
November 19, 1951.

## INTERLINGUAL TECHNICAL DICTIONARIES.

To the Editor of Engineering.

Sir,—In your issue of November 16, on page 626, you made an interesting reference to Dr. J. E. Holmstrom's work, under the title "Interlingual Technical Dictionaries." In your review, you referred to a number of groups or fields of technical work, including electronics. With our world-wide export business, we also have felt the need for improved technical dictionaries, particularly beyond the three more usual European languages. We should like to point out that the spread of automatic control in industry has required a whole new terminology, which has received considerable attention in the United States and here, and also, to a lesser extent, in France and Germany; but it is still a problem to interpret the many new automatic control terms correctly into the languages of many other countries which, through rapidly increasing industrialisation, are beginning to have to make use of these new techniques and equipment.

Since the war, we have produced a catalogue covering standard measuring and control instruments, which has now been printed in French, Italian, German, Swedish and Danish. If the International Organisation for Standardisation, at Geneva, would be interested to receive copies of these catalogues, we should be happy to send them a set; and we should be pleased to contribute sets to institutional and other libraries concerned with this branch of technology, on request from the librarians.

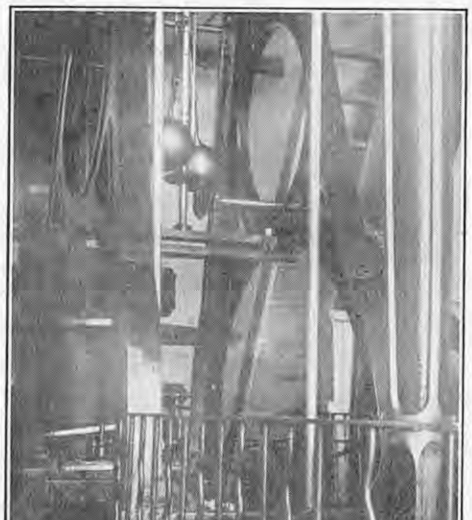
Yours faithfully,
For George Kent, Limited,
J. M. White,

Luton, Bedfordshire.
November 23, 1951.

## PINCHBECK MARSH PUMPING STATION.

To the Editor of Engineering.

Sir,—During the 1951 summer meeting of the Newcomen Society, a visit was paid to the beam engine and scoop wheel at Pinchbeck Marsh, near Spalding, Lincolnshire, possibly the only remaining plant of this kind that is still working. At the time of the Society's visit—May 31—the fate of the plant was in some doubt, but the interest shown in it, coupled with the fact that, they are advised, it is still serviceable, has decided the owners, the Deeping Fen, Spalding and Pinchbeck Internal Drainage Board, to preserve the engine and wheel in the original building, which is really the only way to preserve such historical exhibits if the effect of their environment is to be appreciated.




The buildings comprise a boiler house, engine room and wheel annexe or casing. Over the entrance to the engine room is a stone bearing the date 1833, and above it is an old fire plate of the Royal Exchange Assurance Company. The engine, illustrated herewith, has a single cylinder of about 25 in. bore and 4 ft. 6 in. stroke, and takes steam at 10 lb. to 30 lb. per square inch from a Galloway boiler. Its normal speed is 30 r.p.m. The boiler, of course, is not the original one, and is of much later date than the engine. Some years after it was erected, the engine was fitted with an early type of piston valve in which the steam is admitted at the centre, exhausting at the ends of the valve. This enables a cut-off of 10 per cent. to be used. The condenser can maintain a vacuum of $26\frac{1}{2}$ in. The engine has a Watt parallel motion. The beam centres are 14 ft. and the length of the connecting rod is 10 ft. 8 in. The flywheel is 19 ft. 6 in. in diameter, with six spokes and a rim constructed in six segments. A barring plate is attached to the engine-house wall.

The scoop wheel has a maximum diameter, over the floats, of 22 ft., and is staked on to its shaft with eight pairs of folding keys, fitted between corresponding flats on the shaft and inside the boss. It is driven through internal gearing, so that the engine and wheel rotate in the same direction. The scoop-wheel annulus has 126 teeth and the crankshaft pinion has 31, giving a ratio of 4·06 to 1; the teeth are 10 in. wide and of $3\frac{1}{4}$ in. circular pitch. There are 40 floats on the wheel, measuring 5 ft. 4 in. parallel to the axis and 2 ft. 3 in. wide. Bearing in mind the impossibility of housing in museums all the interesting examples of early engineering practice, I feel that the Drainage Board are to be commended for their decision to preserve this pumping plant on its original site.

Yours faithfully,
Ronald H. Clark, A.M.I.Mech.E.

Norwich.
November 14, 1951.

# OBITUARY.

## PROFESSOR A. L. MELLANBY.

We regret to record the death of Professor A. L. Mellanby, which occurred on Monday, November 26, at Westwood, Bridge of Weir, Renfrewshire, at the age of 80. He was well known for his work on the flow of steam in turbines, as a result of which he was able to separate the nozzle losses into their constituents and thus to evaluate performance. Engineers will be, perhaps, less generally aware that he was also an accomplished Latinist.

Alexander Lawson Mellanby was born at Hartlepool on July 3, 1871, and was educated at Barnard Castle School. At the age of 16 he was entered as an apprentice at the Central Marine Engine Works, West Hartlepool, and on the completion of his five years' service attended Armstrong College, Newcastle-on-Tyne, where he obtained the degree of Bachelor of Science and an 1851 Research Scholarship. He was subsequently engaged on research on multiple-expansion engines, both at McGill University, Montreal, and at Newcastle, until, in 1897, he became chief technical assistant at the West Hartlepool works of Messrs. T. Richardson and Sons, now Richardsons, Westgarth and Company. After a short time in this position, he was appointed chief lecturer in engineering at Battersea Polytechnic, London; and thereafter devoted himself mainly to educational work.

In 1899, he assisted Professor J. T. Nicolson in designing and supervising the erection of a laboratory and power station at the Manchester School of Technology; and on the completion of this work became lecturer in engineering at that institution. Four years later he was appointed Professor of Mechanical Engineering at the Royal Technical College, Glasgow, and in 1924, on the death of Professor J. G. Longbottom, was placed in full charge of both the civil and mechanical engineering departments. He retired from this position in 1936 with the title of Emeritus Professor and at the same time was awarded the honorary degree of Doctor of Laws by the University. In addition to his educational work, he had acted as consultant to many Clydeside shipbuilding firms and had taken an active part in the engineering life of Glasgow for many years.

Professor Mellanby was elected a member of the Institution of Mechanical Engineers in 1906. He had served on the Council of that body and had acted as its representative on the Joint Committee for National Certificates in Mechanical Engineering in Scotland. He was also a member of the Marine Oil Engine Committee of the Institutions of Mechanical Engineers and Naval Architects. He was elected a member of the Institution of Engineers and Shipbuilders in Scotland in 1905 and became an honorary member in 1941. In 1937 he delivered the fifth Andrew Laing Lecture before the North East Coast Institution of Engineers and Shipbuilders, taking as his subject "Land and Marine Steam Generators," while in 1940 he gave the Thomas Lowe Gray Lecture entitled "Fifty Years of Marine Engineering," before the Institution of Mechanical Engineers. He was the author of a number of papers on steam and oil fuel, and as a young man had collaborated with Unwin in writing a book on the elements of machine design.

# INTERNATIONAL CONFERENCE ON ABRASION AND WEAR.

As we mentioned on page 658, *ante*, an International Conference on Abrasion and Wear was held in Holland, at Delft, on November 14 and 15, by way of inaugurating the new buildings of the Rubber Stichting, the Dutch institute for research in rubber technology which corresponds with the British Rubber Producers' Research Association. We commence below a report of the proceedings; but, before dealing with the papers and discussions, it is desirable to include some particulars of the establishment in which the meetings were held. Some photographs of the new premises are reproduced in Figs. 1 to 5, on page 688.

### The Rubber Stichting, Delft.

The Dutch word *stichting*, literally translated, means "foundation," and it is as the "Rubber Foundation" that the establishment is referred to in such of its technical and descriptive literature as is published in English. The organisation was set up in 1936, but its development was naturally interrupted by the war and it was not until August 22, 1950, that the first pile was driven (by Mr. Mohamad Roem, the then High Commissioner for the Republic of Indonesia) on the present site at 178, Oostsingel, Delft. The primary purpose of the organisation, which is financed by the rubber-growers of Indonesia, is to stimulate the demand for natural rubber. To this end, two lines of policy are pursued; on the one hand, there is the function of undertaking scientific research and thus eventually creating new uses for rubber, and, on the other, propaganda and publicity, for which purpose a permanent exhibition formed an important part of the design of the new buildings. In a sense, the premises themselves are an exhibition of many of the uses to which rubber and rubber compounds can be applied, as they are used wherever possible in floorings, fittings, decoration, etc.

The arrangement of the buildings comprises a two-storey block, with one of its long sides facing the roadway, connected by the exhibition hall to the main block of offices, laboratories and workshops. The central portion of this main block, which is roughly square in plan, is a single-storey structure; but along the two sides at right angles to the Oostsingel a second floor has been added. From the main entrance, a short passage leads on the right to the administrative offices and another, on the left, to a large room which normally is the office of the Director-General, Dr. Ir. R. Houwink, but which is also used for meetings of the Governing Board, conferences of departmental heads, etc. Adjoining it is the accounts office. On the floor above, which is reached by double staircases that lead on to a landing from which the visitor can obtain a general view of the exhibition hall, there is a large lecture theatre over the Director-General's office and, on the other side of the building, a staff canteen.

At the far end of the exhibition hall, as viewed from the gallery at the top of the stairs, corridors lead right and left to the workshops, etc., and a door, facing the hall, provides direct access to the library. The exhibition hall is intended to be used largely for temporary exhibitions, and was so used during the Conference, scientific apparatus used in rubber research, and in tests of the abrasion and wear of other materials, being displayed there for the benefit of the delegates. There is, however, a permanent exhibition also, showing the various kinds of rubber, the various stages in its production, and many of the uses to which it is put; these are displayed partly in the main hall and partly in the corridors. There is also an interesting collection of portraits of pioneers in the discovery and commercial production of rubber, arranged on the walls of the corridors on the upper floor.

The laboratories include two for the study of latex, a mechanical laboratory and an adjoining room containing the heavier machines, laboratories for physical and organic chemistry, and an analytical laboratory. Among the other departments are instrument shops, a carpenters' shop, an engineering shop, and another devoted to glass-blowing, for the use of the various laboratories. There are, in all, about 80 rooms in the complete range of buildings. Rubber is extensively used in all of them. In the lecture hall, which accommodates about 150, the seats are upholstered with different types of rubber sponge, etc., the doors covering the blackboards (to be seen in Fig. 5, on page 688) are decorated with designs in moulded rubber, and the curtains consist of a "sandwich" of rubber between two layers of textile material. The insides of the doors are blacked, so that, as they are swung open, they provide, in effect, seven blackboards instead of the four that Fig. 5 suggests; seven, and not eight, because the back "board" on the right of the platform is a sheet of ground glass, illuminated from behind, so that a lecturer can write or draw upon it while the lantern is in use and the room is otherwise in darkness. Under these conditions, ordinary white chalk, because of its opacity, appears black on the ground glass. The lanternist is accommodated in an enclosed gallery above the entrance to the hall.

The equipment in the workshops and laboratories comprises all the machines necessary for the processing of rubber—calendars, extruding presses, etc.—some of which can be seen in Fig. 3; and an extensive range of testing equipment. This includes several types of abrading machine, among them one for wearing out rubber soles and heels of footwear by imitating the foot action of a pedestrian walking normally and turning corners; and another, constructed in the establishment, for abrading model motor-car tyres by running them on the inside of a large wheel, which can be lined with any desired form of road-surfacing material. During the Conference, as mentioned, the permanent equipment of the laboratories was supplemented, for the benefit of the delegates, by a special display of abrasion-testing apparatus as used by the various departments of the National Council for Industrial Research T.N.O. (which is the Dutch counterpart of the Department of Scientific and Industrial Research in Great Britain), together with some apparatus lent by other laboratories and individuals. A brief description of these loan exhibits will be appended in due course to our report of the Conference.

### The Conference.

The Conference proceedings opened with a short address of welcome by the Director-General, Dr. Ir. R. Houwink, who explained that, while there had been a formal opening ceremony on October 29, the Conference was also a part of the opening celebration. The subject of "Abrasion and Wear" had been chosen because it was considered to present the most pressing need for research within the sphere of the Rubber Stichting. In selecting speakers for the symposium, the organisers had sought deliberately to draw upon the experience of workers concerned with materials other than rubber, in the hope that fresh ideas would emerge from the interaction of different interests. Rubber was the best material in resistance to wear, but it could be improved, for there was much about it that was still obscure, and in the past the approach to the subject had not been very scientific. It was gratifying, Dr. Houwink continued, to note how international the gathering was; of the 152 participants, there were 26 from the United Kingdom, six from Belgium, five from France and the same number from Germany, three from the United States, and some from as far as Indonesia. In all, eleven countries were represented.

Dr. H. C. J. de Decker, the Director of Research of the Rubber Stichting, having outlined the general order of the proceedings (the whole of which, he explained, would be conducted in English, "the international technical language"), called on Dr. F. P. Bowden, of the University of Cambridge, to present the first paper, which was entitled "The Friction and Surface Damage of Non-Metallic Solids," and dealt with some recent work carried out at Cambridge.

### Friction and Surface Damage of Non-Metallic Solids.

Dr. Bowden remarked, at the outset, that the contact between two accurately finished surfaces resembled, in a degree, what might be obtained by inverting Switzerland and setting it down on Austria; even the best electro-polished aluminium surface, when examined by the electron microscope, revealed undulations of the order of 200 Angstrom units. A metal was plastically and elastically deformed at the few points of contact until the area of contact was sufficient to carry the load without further plastic flow. This deformation was usually sufficient to remove any protective oxide or the lubricant film, so that the two surfaces welded together at the isolated points of contact. The force of friction was that required to shear those junctions; and, the area of the junctions being proportional to the applied load, the force required to shear them was also proportional, giving rise to the constancy of the coefficient of friction. The materials in the vicinity of the junctions became work-hardened, so that fracture took place within the body of the material, the matter removed representing the "wear." Differences in the behaviour of various metals when in contact could be associated, in some respects, with their different elasticities; thus (as he demonstrated with polished specimens of the metals) steel lightly rubbed over a polished surface of silver did not "wring" to it, because of the high elasticity of silver, whereas steel would wring to indium, which had a low elasticity.

The behaviour of non-metals closely resembled that of metals, with certain important differences; for example, recent experiments with diamond showed a lack of constancy of the coefficient of friction with variations in load. This was attributed to the absence of plastic deformation, so that the area of contact was defined by the elastic considerations expounded by Hertz. In particular, the area of contact was proportional to the 2/3rds power of the applied load. When testing under ordinary atmospheric conditions, diamond on diamond gave a coefficient of friction of about 0·05, but, after heating in vacuum to 1,000 deg. C., the friction increased to 0·5. The admission of oxygen resulted in reduced friction. Thus adsorbed or chemisorbed layers accounted for the low friction of diamond. A sapphire behaved similarly. Rubber on rubber could produce a local temperature of 600 deg. C. Dr. Bowden then dealt with the frictional properties of plastics, and, by means of an inclined steel plane and miniature toy motor-cars fitted with tyres of different materials, gave an interesting demonstration of their differing frictional properties; a car with tyres of polytetrofluorethylene could not climb the slight incline, whereas a similar car with tyres of Perspex climbed it with ease.

(*To be continued.*)

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Sun Protectors for Leyland Export Vehicles.—A combined sun-visor and roof canopy has been introduced by Leyland Motors, Limited, Leyland, Lancashire, for fitting to the drivers' cabs of super-heavy duty vehicles destined for service in hot climates. Made from the blank of a standard roof panel, the canopy is, more or less, a duplication of the fixed roof over which it is mounted. It is made from a 16-gauge aluminium alloy and is held 4 in. above the fixed roof by two steel brackets bolted to the structure of the cab roof. The canopy follows the contour of the front of the cab above the windscreen and is then carried forward about 9 in. in front of the screen to form a full-width visor. To ensure the most effective air flow, the gap between the canopy and roof varies, being 2 in. at the front, 4 in. at the centre, and more pronounced still at the rear, to aid extraction.

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Exports of British Road Vehicles.—The Society of Motor Manufacturers and Traders have announced that the value of British cars exported during October broke all records, amounting to 11,400,000*l*. In volume, the shipment totalled more than 32,000 units, the largest since last May. Although the volume was slightly smaller than for May, the increased value is accounted for by the fact that more complete cars were exported during October and that a greater proportion of them was of the high-powered class. The value of commercial vehicles exported during October was also the largest since last May, a total of 10,840 units, worth nearly 6,000,000*l*., having been shipped. The figures for the export of agricultural tractors during October were the largest ever, both in actual numbers and value, just over 10,800 units, worth 4,400,000*l*., having been shipped. The previous highest figures were for July of this year, when 10,208 units, worth 3,964,000*l*., were dispatched.

# THE IRON AND STEEL INSTITUTE.

The autumn general meeting of the Iron and Steel Institute was held on Wednesday and Thursday, November 21 and 22, at the offices of the Institute, 4, Grosvenor-gardens, London, S.W.1. We gave on page 659, *ante*, a report of the preliminary business on the first morning and commence below a report of the technical proceedings.

### Graphite and Carbide in Cast Irons.

The first two papers considered after the conclusion of the formal business of the meeting dealt with "The Crystal Structure of Graphite in Cast Iron," by Dr. W. S. Owen and Dr. B. G. Street, and "The Carbide Phase in Iron-Carbon-Silicon Alloys," by Dr. W. S. Owen. Both papers described work carried out in the Department of Metallurgy of the University of Liverpool, and they were presented by Dr. Street, after which the papers were discussed jointly.

In the first paper the authors stated that they had studied the crystal structures of graphite extracted from an iron-carbon-silicon alloy prepared from high-purity materials and also graphites from a variety of commercial cast irons, by the X-ray powder method. In all cases, the structure was a mixture of the $\alpha$ and $\beta$ structures found in other graphites of different origin. In the $\alpha$-graphite structure the atoms were arranged in layers (within which they formed a regular pattern of hexagons) such that neighbouring layers were displaced and alternate layers lay directly beneath each other. In the $\beta$-graphite structure, the two layers were arranged in such a manner that the next layer was displaced by an equal amount in the opposite direction, the pattern being repeated at every fourth layer. Owing to the similarity of the structures, many of the diffraction lines coincided, and, in a mixed structure, only a few additional lines appeared. In the present investigation, the proportions of the $\alpha$ and $\beta$ structures present varied considerably in the different forms of graphite, and a correlation between the microscopic appearance and the crystal structure had been established. The parameters of the unit cells had been measured, and, as no variation from the accepted value for pure graphite had been found, it was concluded that the graphite occurring in iron-carbon-silicon alloys and in commercial cast irons was appreciably pure carbon.

In the second paper on "The Carbide Phase in Iron-Carbon-Silicon Alloys," Dr. Owen stated that the dimensions of the unit cell of the crystal structure of the carbide phase extracted from a plain-carbon steel, a commercial white iron, a high-purity vacuum-melted iron-carbon-silicon alloy, and a similar alloy melted in air, had been measured to a high degree of accuracy by a Debye-Scherrer powder X-ray method. No variation in the dimensions of the cell had been found. It was concluded that silicon in iron-carbon-silicon alloys did not enter the carbide phase, and, from this, it was deduced that the position commonly accepted for the peritecto-eutectic point in the metastable diagram of this ternary system was probably considerably in error.

Dr. R. V. Riley, who opened the discussion, stated that it would be appreciated, of course, that the work on the carbide phases and the formation of graphite in iron-carbon-silicon alloys was still going on, and that there were other publications pending on this subject. Some of the conclusions in the present two papers appeared to be rather sweeping. In the first paper, by Drs. Owen and Street, it was concluded that the crystal structure of any particular microscopic form of graphite was independent of the composition and method of manufacture of the iron. This conclusion appeared rather hasty in view of the limited number of specimens of cast iron which had been examined. The specimens of cast iron mentioned included none which contained alloying elements such as nickel, chromium, molybdenum, or even silicon above, presumably, 3 to 4 per cent. For years kish graphite had been found, on chemical analysis, to contain impurities. Very recent electron microscopic studies by the Belgian worker de Sy had shown that nodular graphite also was not homogeneous, but often had small inclusions in the centre of each nodule. The nature of these impurities could well be further investigated by X-rays, and then perhaps the rather broad statement in one of the conclusions that the pure graphite, the material extracted from the cast iron, did not contain any element other than carbon, might require to be modified.

Turning to the second paper, by Dr. Owen, it should be recognised that the statement that the solubility of silicon in the carbide phase was negligible must be applied only to irons in the very limited range covered by this research. The author, in private correspondence, had agreed to this qualification. It was probable that the position would be made clear upon the publication of the results of Dr. Owen's present researches, which had been submitted to the Institute, and possibly in his further researches in the United States.

Dr. A. Taylor said that he had read the paper by Drs. Owen and Street with great interest, in the hope that he would learn something of the mechanism of the formation of the spheroids in cast iron, but he had been a little disappointed to find that, with all the X-ray work carried out, they did not give any hint concerning how the spheroids or the flakes in cast iron were formed. The conclusion reached in the paper was that the graphite present in iron alloys did not contain any element other than carbon in appreciable quantities, and this seemed to be based on lattice-parameter measurements. This, of course, could refer only to elements which were actually in solution in between the planes, and did not in any way rule out the presence of foreign material in the way of a nucleus at the centre of each spheroid, which some workers believed to exist. It might be that stringent cleaning of the graphite would remove that nucleus, but the penetration would probably not be good enough to remove that small amount of nuclear material, and, in any case, X-ray methods would not be very sensitive for the detection of small amounts of nucleating constituents. It would be interesting to know whether chemical or spectrographic analyses were carried out to substantiate the statement that the impurities were negligible, because it would not be difficult to isolate a fair quantity of clean spheroids and then examine them spectrographically to see whether there was any nucleating constituent in them.

The second paper seemed to be based on the fact that the lattice parameter of $Fe_3C$ remained constant in the presence of silicon. In a paper by Groeber, published in 1937, the lattice parameters of the cementite had been measured and Groeber had found that they did not change however much the carbon content of the cast iron might be changed, and, moreover, in the presence of silicon. It seemed that the conclusions reached in Dr. Owen's paper bore out the earlier work.

Mr. H. Morrogh, dealing first with the paper by Dr. Owen and Dr. Street, said that he would like to underline the comments made by the previous contributors to the discussion with regard to the fourth conclusion, which was that "The graphite present in iron alloys does not contain any element, other than carbon, in appreciable quantities." He thought that the investigators might have been a little more justified if they had worded that conclusion to read "The graphite present in the extract from iron alloys does not contain any element other than carbon," but, even then, the statement would be open to considerable doubt. He had carried out experiments involving the chemical analysis of the extracts of graphite from cast irons of a wide range of composition, and it had been found that certain impurities were present, such as silicon. It could be argued, of course, that the method of extraction was not complete.

With regard to the paper by Dr. Owen on the carbide phase in iron-carbon-silicon alloys, he believed that his observations were probably quite correct, but that the conclusions which he had drawn were incorrect. Taking the eutectiferous iron-carbon-silicon alloys, with increasing silicon content up to about 2·5 per cent., the eutectic carbide phase appeared to behave as cementite. With silicon contents in excess of 2·5 per cent., there began to appear another phase which metallographically could be distinguished from cementite and appeared to be a carbide phase. With increasing silicon it increased in amount progressively, until with about 7 per cent. of silicon the original cementite was replaced by this other carbide phase. The highest silicon content examined by Dr. Owen was 3·14 per cent. The alloy of that composition would contain only a very small proportion of this second silico-carbide phase, and he submitted that the author's methods were not sufficiently sensitive to detect the presence of that phase.

Dr. B. G. Street, in a brief reply, stated that the X-ray work on the graphite referred, of course, to elements in solution in the graphite, not to foreign bodies. They had not tried to find why spheroids formed, but only whether any elements were in solution in the graphite, and the work of Dr. Taylor had emphasised their conclusions. With regard to the carbide phase, Dr. Owen had agreed with Dr. Riley and others that the results which he had reported applied only to alloys of the composition of those that he had examined, and he did not intend them to be extended to alloys having higher silicon contents, because they (Dr. Owen and Dr. Street) agreed that other carbides did form with higher silicon contents.

(*To be continued.*)

# FORTHCOMING EXHIBITIONS AND CONFERENCES.

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

International Cycle and Motor-Cycle Exhibition.—Saturday, December 1, to Monday, December 10, at Milan. Organised by the National Association of Cycle, Motor Cycle and Accessories Manufacturers, Via Macchi 32, Milan, Italy.

Smithfield Show and Agricultural Machinery Exhibition.—Monday, December 3, to Friday, December 7, at Earl's Court, London, S.W.5. Organised by the Smithfield Show Joint Committee, 148, Piccadilly, London, W.1. (Telephone: GROsvenor 4040.)

Symposium on Corrosion of Buried Metals.—Wednesday, December 12, at 4, Grosvenor-gardens, Westminster, London, S.W.1. Organised by the Iron and Steel Institute. Apply to the secretary of the Institute at the address given above. (Telephone: SLOane 0061.) See also page 190, *ante*.

Petroleum Industry Exhibition.—Monday, December 17, to Sunday, January 27, 1952, at the Royal Scottish Museum, Edinburgh. Organised by the Shell Petroleum Co., Ltd., St. Helen's-court, London, E.C.3 (Telephone: AVEnue 4312); and the Anglo-Iranian Oil Co., Ltd., Britannic House, Finsbury-circus, London, E.C.2 (Telephone: CENtral 7422). See also page 480, *ante*.

New Building Materials and Techniques Exhibition.—Friday and Saturday, January 18 and 19, 1952, at the Royal York Hotel, Toronto. *Agents:* Tides, Ltd., 1, Hanover-square, London, W.1. (Telephone: MAYfair 1101.)

International Radio and Electronics Exhibition of India.—Saturday, February 9, to Friday, February 29, 1952, at Bombay. For further information, apply to the secretary, Radio and Electronics Society of India, Fateh Manzil, Opera House, Bombay, India.

International Agricultural Machinery Exhibition.—Sunday, February 17, to Sunday, February 24, 1952, at Brussels. Apply to the secretary, Société de Mecanique et d'Industries Agricoles, S.A., 29, Rue de Spa, Brussels, Belgium.

Scottish Business Equipment and Management Exhibition.—Tuesday, February 26, to Friday, February 29, 1952, at the Waverley Market, Edinburgh. Organised by the Office Appliance and Business Equipment Trades Association, 11-13, Dowgate-hill, Cannon-street, London, E.C.4. (Telephone: CENtral 7771.)

German Industries Fairs, Hanover.—*Light Industries:* Wednesday, February 27, to Sunday, March 2, 1952, at Hanover. *Heavy Industries:* Sunday, April 27, to Tuesday, May 6, 1952, at Hanover. *Agents:* Schenkers, Ltd., 27, Chancery-lane, London, W.C.2. (Telephone: HOLborn 5595.)

International Agricultural Machinery Exhibition.—Tuesday, March 4, to Sunday, March 9, 1952, at the Parc des Expositions. Organised by the Union des Exposants des Machines et d'Outillages Agricoles, 38, Rue de Chateaudun, Paris 9e.

Vienna Spring Fair.—Sunday, March 9, to Sunday, March 16, 1952. *Agents:* British Austrian Chamber of

Commerce, 29, Dorset-square, London, N.W.1. (Telephone: PADdington 7646.)

Geneva International Motor Exhibition.—Thursday, March 20, to Sunday, March 30, 1952, at Geneva. For further information, apply to the secretary of the exhibition, 1, Place du Lac, Geneva, Switzerland.

Second United States International Trade Fair.—Saturday, March 22, to Sunday, April 6, 1952, at the Nay Pier, Chicago. Representative for the United Kingdom and Ireland: Mr. A. P. Wales, 16-22, Shelton-street, London, W.C.2. (Telephone: TEMple Bar 2972.)

Manchester Building Trades Exhibition.—Tuesday, March 25, to Saturday, April 5, 1952, at the City Hall, Deansgate, Manchester. Apply to Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester. (Telephone: Deansgate 6363), or to the London agent at 167, Oakhill-road, Putney, London, S.W.15. (Telephone: VANdyke 5635.)

First Supervising Electrical Engineers National Exhibition.—Friday and Saturday, March 28 and 29, 1952, at the Royal Horticultural Society's new hall, Greycoat-street, Westminster, London, S.W.1. For further information, apply to the conference secretary, Mr. P. A. Thorogood, 35, Gibbs-green, Edgware, Middlesex. See also page 266.

Exhibition of British Components, Valves and Test Gear for the Radio, Television, Electronic and Telecommunications Industries.—Monday to Wednesday, April 7 to 9, 1952, at Grosvenor House, Park-lane, London, W.1. Organised by the Radio and Electronic Component Manufacturers' Federation, 22, Surrey-street, Strand, London, W.C.2. (Telephone: TEMple Bar 6740.)

Swiss Industries Fair.—Saturday, April 19, to Tuesday, April 29, 1952, at Basle. Apply to the Division Economique, Swiss Legation, 18, Montague-place, London, W.1. (Telephone: PADdington 0701.)

Symposium on Diamond Drilling.—Monday, Tuesday and Wednesday, April 21, 22 and 23, 1952, at Johannesburg. Organised by the Chemical, Metallurgical and Mining Society of South Africa and the Diamond Research Laboratory. Apply to the director of the Laboratory, P.O. Box 916, Johannesburg.

Royal Sanitary Institute Health Congress.—Tuesday, April 22, to Friday, April 25, 1952, at Margate. Apply to the secretary, the Royal Sanitary Institute, 90, Buckingham Palace-road, Westminster, London, S.W.1. (Telephone: SLOane 5134.)

Television Convention.—Monday, April 28, to Saturday, May 3, 1952, at Savoy-place, Victoria-embankment, London, W.C.2. Organised by the Radio Section of the Institution of Electrical Engineers. Apply to the secretary of the Institution at the address given above. (Telephone: TEMple Bar 7676.) See also pages 265 and 371, *ante*.

British Industries Fair.—Monday, May 5, to Friday, May 16, 1952, at Earl's Court, London, S.W.5, and Olympia, London, W.14; and Castle Bromwich, Birmingham. Particulars from the director, British Industries Fair, Board of Trade, Lacon House, Theobald's-road, London, W.C.1. (Telephone: CHAncery 4411); or the general manager, British Industries Fair, 95, New-street, Birmingham, 2.

International Exhibition of Electrical Appliances.—Tuesday, May 13, to Tuesday, May 27, 1952, at Bologna. Apply to the Ente Autonomo Fiera di Bologna, via Farina 6, Bologna.

Swedish Industries Fair.—Saturday, May 17, to Sunday, May 25, 1952, at Gothenburg. *Agents*: John E. Buck and Co., 47, Brewer-street, London, W.1. (Telephone: GERrard 7576.)

German Exhibition of Chemical Apparatus.—Sunday, May 18, to Sunday, May 25, 1952, at Frankfurt-on-Main, Germany. Organisers: Dechema Deutsche Gesellschaft für Chemisches Apparatewesen E.V., Frankfurt.

Electrical Association for Women, 27th Annual Conference.—Monday, May 19, to Saturday, May 24, 1952, at Scarborough. Apply to the director, the Electrical Association for Women, 35, Grosvenor-place, London, S.W.1. (Telephone: SLOane 0401.)

Summary of Grey Ironfounders Productivity Team's Report.—The Council of Ironfoundry Associations, Crusader House, 14, Pall Mall, London, S.W.1, have issued an illustrated popular summary of the Grey Ironfounders Productivity Team's report and are offering free supplies of it to the ironfounding industry. The Council inform us that, so far, 588 firms have taken advantage of their offer and that 56,000 copies have been distributed to ironfoundry employees. Supplies of the popular summary are still available and ironfoundry managements are requested to make early application to the secretary of the Council, at the above address.

## LABOUR NOTES

Relations between trade unions and Governments in Britain were discussed in a paper read before the Industrial Co-partnership Association at a meeting in London on November 21, by Mr. E. P. Harries. He expressed some surprise that anyone should have questioned the willingness of the Trades Union Congress to co-operate with the new Government. That body could gain nothing from industrial or political opposition to a Government which must obviously be supported by many of the country's 16 million manual employees and their families. He suggested that the T.U.C. was, in fact, faced with the task of endeavouring to convert some eight million workpeople to a new way of thinking. A whole generation would probably have to pass, however, before the idea of class warfare and permanent opposition to the employers was abandoned by rank-and-file trade unionists.

Mr. Harries, who was at one time production officer to the T.U.C., considered that it was the duty of the trade unions concerned to co-operate with the managements of the nationalised industries. In his view, the trade-union movement, having persuaded a majority of the electorate to accept the principle of nationalisation, should understand that this was as yet only an experiment and still in its early stages. It seemed certain that little progress could be made unless a change took place in the attitude of the employees in these industries towards the employing Boards. Mr. Harries referred to the disappointment felt by some employers at the lack of response by the unions to suggestions put forward by "sincere enlightened managements," such as the British Institute of Management, for improvements and concessions on both sides of industry. The cautious inclinations of the workpeople was largely due to the attitude of the many old-fashioned employers who still remained in industry. An increase in effective joint consultation would do much to improve industrial relationships.

The Government's intention to submit a motion to the House of Commons for the setting up of a Select Committee on certain aspects of the nationalised industries was announced in the House, on November 22, by Mr. H. F. C. Crookshank, the Leader of the House. If appointed, the Committee would investigate the existing methods by which the House was informed of the affairs of the nationalised industries and report on any changes which might be desirable in the provisions laid down by Parliament. Mr. Crookshank informed the House that the establishment of this Committee would be irrespective of the wider review of the nationalised industries which the Government intended to undertake at a later date. A question was asked whether the Committee would receive evidence from the Ministers concerned with these industries as well as the chairmen of the nationalised Boards. Mr. Crookshank replied that it would be for the Committee to decide whom it wanted to hear.

A whole-day discussion on miners' wage claims, between the 24 members of the National Coal Board and the executive of the National Union of Mineworkers, took place in London on November 22. The union had asked for an increase of 23*s*. a week in the minimum rates for underground employees, 20*s*. a week for surfacemen, and 3*s*. a shift for those engaged at piecework rates. This was the second occasion on which the two sides had met to discuss the claim. It is understood that some preliminary assurances were called for by the Board that the union would co-operate fully in the taking of steps to improve colliery outputs. The Board also appears to have raised such questions as the acceptance of Italian workmen in the mines in the lower grades, holidays with pay, the adjustment of piece rates, and the introduction of wage ceilings. The probable effect of any wage increases on the price of coal was also considered during the negotiations between the two sides at this meeting.

The N.U.M. has desired for some time to secure the setting up of a new wage structure in the industry and a number of problems have arisen in this connection. In particular, it was hoped by both sides that, when piecework earnings were increased, existing anomalies between the various districts would be carefully avoided. At the same time, some members of the union's executive felt that the advantages enjoyed in certain areas could not be surrendered lightly. Strong opposition at the meeting was understood to exist, within the executive, to a suggestion by the National Coal Board that the miners should forgo a second week's paid holiday during 1952, in order to avoid the resulting loss in production. The principle of a second week's paid holiday was conceded by the Board some time ago. The joint meeting was eventually adjourned until November 28, to enable the union's executive to consider the Board's proposals separately.

After a separate meeting of the executive of the N.U.M. on Tuesday last, it was announced that a special delegate conference of the union would be summoned on December 7, at which the executive would recommend the delegates to accept certain proposals by the Board. These included an increase in the minimum rates for underground employees of 13*s*. 6*d*., bringing their new rate up to 7*l*. 0*s*. 6*d*. a week; and of 11*s*. 6*d*. for surface men, bringing their new rate up to 6*l*. 1*s*. 6*d*. a week. The wages of women and boys would also be advanced by similar amounts. These additional payments are based on an increase of 2*s*. 3*d*. a shift for underground employees and 1*s*. 11*d*. a shift for surface men. Piecework employees would receive an increase of 2*s*. 3*d*. a shift and it will be suggested to the conference that it should agree to these advances becoming operative from to-morrow.

Should agreement be reached regarding the new minimum rates, proportionate increases should follow automatically for the various grades of skilled miners, but there will be suggestions by the executive for the imposition of an upper limit on day-wage earnings and for restrictions on the revision of pieceworkers' price lists. As a result, the higher-paid employees may receive little benefit from the new wage concessions, and there may be some narrowing of differentials in particular districts. It is estimated that the cost of these wage improvements to the Board may amount to nearly 26*l*. million in a full year, and that the price of household coal may have to be advanced by 4*s*. a ton, owing to the many additions to the Board's expenses of production and marketing. These include additions to the wage bill, expenditure on the new supplementary pension scheme, higher railway-freight charges and the second week's annual holiday with pay.

The dispute concerning the Thames lightermen and tugmen took a fresh turn on Monday last, when another ban on overtime was put into force on the instructions of their trade union, the Watermen, Lightermen, Tugmen and Bargemen's Union. During the early days of this week, the men have worked strictly to rule and congestion at the Port of London has been growing rapidly in intensity owing to the delay in the loading and discharge of ships there. The dispute has had a somewhat complicated history and commenced in September, when the union started a work-to-rule policy and imposed a partial ban on overtime in an endeavour to secure certain wage improvements which had been rejected by the employers. At a later stage, normal working was resumed by the men in order to enable a committee appointed by the Ministry of Labour to investigate their pay grievances. Working to rule was re-started a few days later, when the committee presented its report rejecting the union's claims.

For their part in observing the ban on overtime, some 200 lightermen were suspended from duty for three days by the Dock Labour Board. The appeal of one of these men was dismissed last week by the relevant tribunal and the ban on overtime was reimposed by the union as from Monday last. The appeals of the remaining suspended men had still to be heard at the time of going to press. Most of the four thousand employees who were due to benefit from the union's claims for additional pay are taking part in the current protest action, and during the first two days of this week some 360 men were returned by their employers to the dock labour pool and reported to the Board with a view to other disciplinary action being taken against them.

The union appears to take the view that the working of overtime at the port is entirely voluntary but the employers contend that it has always been the practice for the lightermen and tugmen to work overtime when required. The Dock Labour Board have pointed out that the dock labour scheme, which has conferred many benefits on the men, rules that registered port employees are required to work overtime for such periods as are reasonable in each particular case. Interpretations of what is reasonable vary considerably. To many of the men it appears to mean that all overtime is unreasonable unless they are prepared to undertake it. Their union has ruled that, at the present stage in the dispute, the men may work only between 8 a.m. and 5 p.m. and claim that labour between these times is "reasonable."

Men who have been adversely reported on by their employers and returned to the dock's labour pool will receive only the guaranteed wage of 84*s*. a week while they remain under this disability, compared with their normal pay, which is stated to average between nine and ten pounds a week. Other tugmen and lightermen, who are obeying the overtime ban, but who have not been returned to the pool, will also be losing about four pounds a week.

# RESEARCH ON FRICTION AND WEAR.

Fig. 11.
GENERAL ARRANGEMENT FOR MEASURING CHANGES IN FILM THICKNESS.

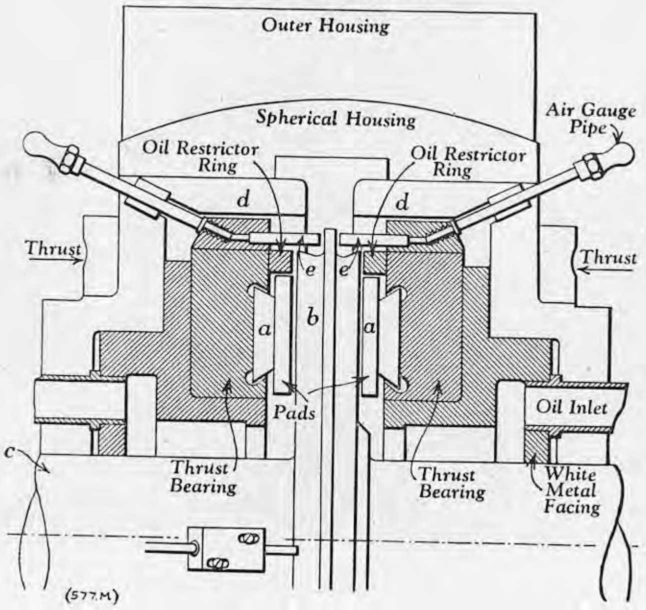
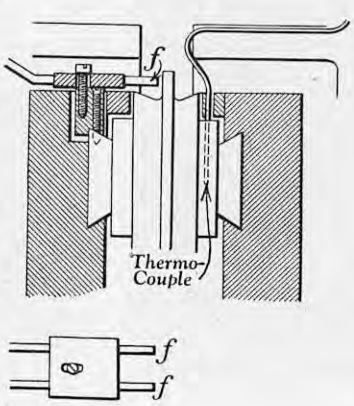



Fig. 12.
SCHEME FOR MEASURING TILT OF MICHELL PAD.



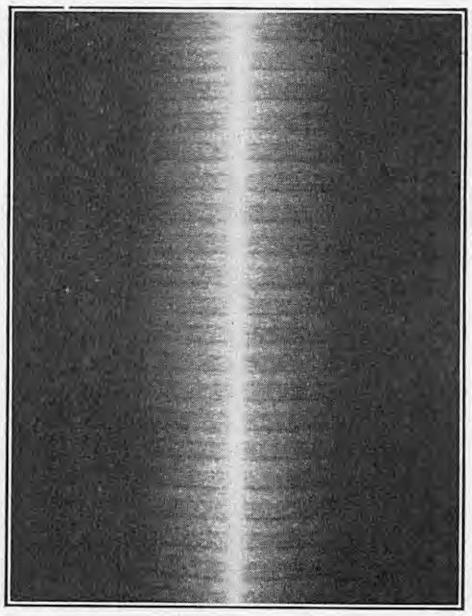



Fig. 15. Vortex Pattern in Eccentric Annulus; Inner Cylinder Rotating.

Fig. 13.
HYDRODYNAMIC PRESSURES IN THIN FLUID FILMS.

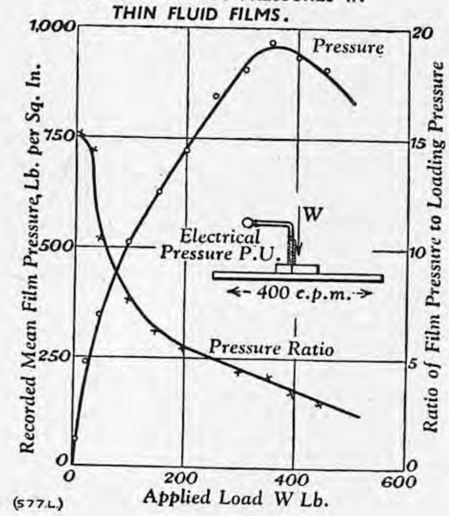



Fig. 14. THRUST BEARINGS: 3 TILTING PADS.

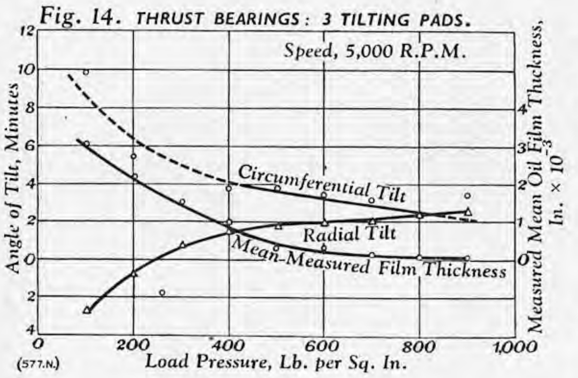



Fig. 17. BALL BEARING LIFE.

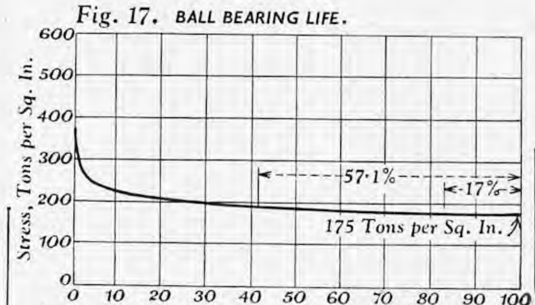
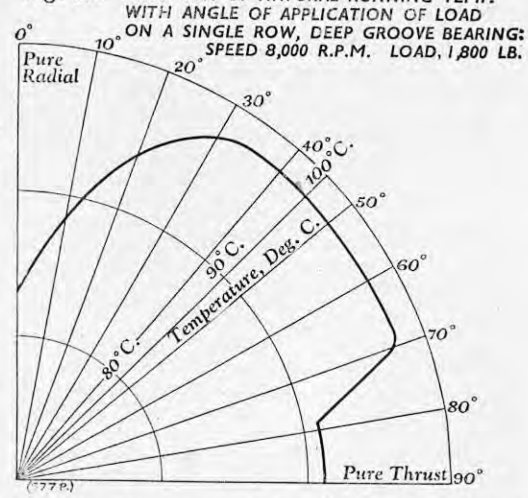



Fig. 16. VARIATION OF NATURAL RUNNING TEMP. WITH ANGLE OF APPLICATION OF LOAD ON A SINGLE ROW, DEEP GROOVE BEARING: SPEED 8,000 R.P.M. LOAD, 1,800 LB.




## RESEARCH ON FRICTION AND WEAR.*

By F. T. Barwell, B.Sc. (Eng.), Ph.D.

*(Concluded from page 651.)*

It is quite clear that the best way of minimising wear is to arrange for surfaces to be held apart by hydrodynamic forces and lubricant. The theory underlying this technique has its origin in the experiments of Beauchamp Tower† in 1885. The formulation, which is the basis of all thinking on the subject, was enunciated by Osborne Reynolds‡ in 1886. Reynolds' treatment is not applicable in a quantitative sense to everyday design because of certain simplifying assumptions that he made, the most obvious being lack of allowance for the quantity of lubricant which finds its way out at the sides of a bearing. Again, the effects of the changes in viscosity consequent on increase in temperature of the oil as it passes through the bearing are not allowed for; neither is the question of what happens on the unloaded side of a bearing fully understood. However, with the use of relaxation methods, as expounded by Christopherson,§ means are being developed to take such factors into account, and we may look forward to the day when the design of journal bearings can be placed on a more rational basis than it is at the moment.

Another vital question is the behaviour of a bearing under the action of a load that varies either in magnitude or in direction. Some work on this subject has been published, and rough rules as a guide to designers are beginning to emerge. One such guide, applicable where the applied load may be represented as a rotating vector, is presented by the formula

$$\frac{L}{L_1} = 1 - 2\left(\frac{N_2}{N_1}\right)$$

where L = load capacity; $L_1$ = load capacity of similar bearing under constant unidirectional load; $N_1$ = shaft speed; and $N_2$ = speed of rotation of load vector.

Another type of bearing which is not amenable to analysis on Reynolds' theory is the oscillating bearing, such as the top end of a marine Diesel engine. Here the movement of the bearing from rest through an angle of about 30 deg. to rest again does not provide an opportunity for the formation of the Reynolds wedge. There are, however, indications that quasi-hydrodynamic conditions may exist in these circumstances, and some researches on this complicated problem are at present being carried out for the British Shipbuilding Research Association on a specially-designed machine wherein friction and wear can be measured under a wide range of operating conditions. Some interesting results, particularly on the influence of grooving arrangements, are being obtained.

Similar considerations apply in the case of reciprocating motion, and an experiment shown in Fig. 13, herewith, provides direct evidence of the existence of hydrodynamic pressure during sliding. The pressure was measured in a gauge embodying electric resistance strain gauges, which was connected to a small hole drilled through the upper specimen. The causes of these pressures are not yet fully understood. Experiments are in progress to test the validity of some of the following hypotheses: that the hydrodynamic pressures arise from a thermal expansion of the oil passing through a parallel channel as postulated by Fogg*; that the rugosities of the surfaces may provide minute wedge action, as postulated by Salama†; that inertia terms arising from the oscillatory nature of the motion may cause sufficient pressure to separate the surface; and that there may exist, due to therma expansion or elastic deformation of apparatus, departures from the assumed form and position of the surfaces, sufficient to give rise to the Reynolds type of wedge.

The advent of the internal-combustion turbine has tended to focus attention on rotating machinery running at higher and higher speeds. In thrust bearings, the tilting pad is general for bearings at speeds of 3,000 r.p.m., providing engineers with an almost ideal method of transmitting thrust loading from rotary shafts to stationary supports. However, operation at high speed emphasises factors which may not be of importance in more conventional applications. For example, the centrifugal action may deprive pads of oil, and various oscillatory phenomena, as yet unexplained, have been noticed with this type of bearing. Some experiments are in progress which involve the use of air-gauging to measure the tilt of pads and to estimate film thickness. The experimental arrangement is shown in Figs. 11 and 12, herewith. To equalise thrust load on the shaft, two bearings *a a* are tested simultaneously, bearing on opposite sides of disc *b*, which is mounted on shaft *c*. The bearing rings are carried in sliding housings *d d*, which are, in turn,

* Paper read before the Institution of Engineers and Shipbuilders in Scotland at meetings in Aberdeen on November 2 and at Glasgow on November 6, 1951. Abridged.

† *Proc. I. Mech. E.*, vol. 36, page 58 (1885).

‡ *Phil. Trans. Roy Soc. A*, vol. 177, page 157 (1886).

§ *Proc. I. Mech. E.*, vol. 146, page 126 (1941).

* *Proc. I Mech. E.*, vol. 155, page 49 (1946).

† *Ibid.*, vol. 163, page 149 (1950).

# RESEARCH ON FRICTION AND WEAR.

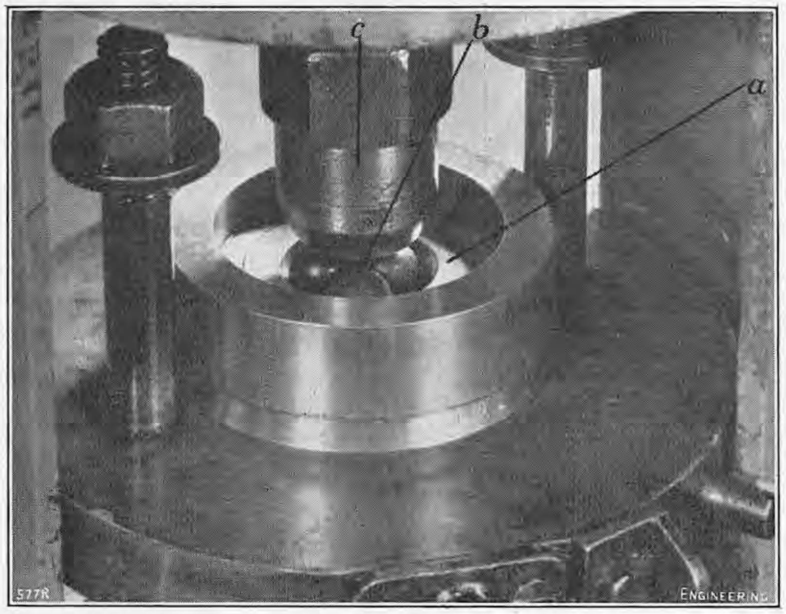



Fig. 18. Four-Ball Test Rig.

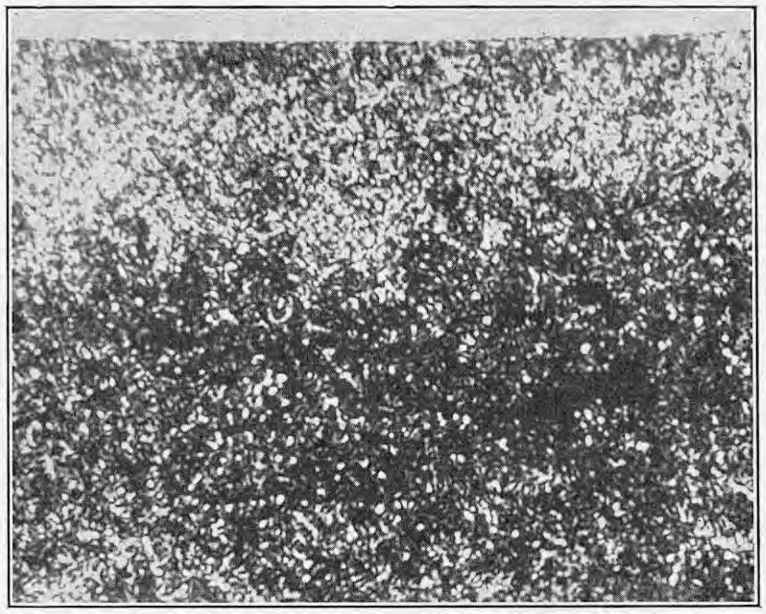


Fig. 19. Mechanical Troostite. × 700.

carried in a spherical housing. Thrust load is applied so as to force the sliding housings *d d* together. A rim on disc *b* serves as a reference face against which impinges air from nozzles *e e*. The air supply to the nozzles passes through apparatus for the accurate measurement of pressure, which is calibrated so that a change in the gap between the nozzle and the face of the rim is indicated as a variation in back pressure. It is thus possible to measure changes in the magnitude of the mean oil-film thickness. Similarly, nozzles *f f*, mounted directly on the tilting pads, enable the tilt of the pad to be measured.

From the results shown in Fig. 14, page 697, it will be noted that the pad tends to tilt both in the expected direction and also about the axis at right angles thereto. To overcome the risk that lubricant under the action of centrifugal forces might be thrown clear of the pads, a restrictor ring is arranged as shown in Fig. 11. This results in a bearing running fairly full of oil, with a consequent viscous shear loss. In this particular instance, the loss is 3·3 h.p. per bearing at 7,000 r.p.m. Indeed, one of the problems of high-speed bearings generally is that of viscous drag in the lubricant. Conventional oils are required to shear at such a high rate in a high-speed journal bearing, operated at, say, 50,000 r.p.m., that there is a surfeit of load-carrying capacity. Bearings are capable of supporting, without additional friction-drag, loads much in excess of those required, with the result that the coefficient of friction is excessive. The obvious step is to reduce drastically the viscosity of the oil, though this may lead to trouble at starting or under conditions of overload or misalignment. Such a thin oil should therefore be compounded with suitable boundary additives, in order that such difficulties may be overcome.

A further point of importance as speeds are increased is the possible breakdown of the laminar conditions postulated by Reynolds, upon which all bearing theory depends. Analogy with other problems of fluid flow leads one to anticipate that, at a certain critical Reynolds number, turbulence will set in. G. I. Taylor* has, however, shown that, in an annular space bounded by a stationary cylinder on the outside and a rotating cylinder on the inside, vortex conditions occur when a certain value of the appropriate non-dimensional parameter is exceeded. This has been confirmed experimentally in the Thorntonhall laboratories; Fig. 15, on page 697, shows the vortices occurring—visible by the fact that the outer cylinder was made of methyl methacrylate (Perspex). Taylor's theory was derived on the basis that the inner and outer cylinders were concentric. In the loaded bearing, however, the journal is eccentric with the bearing, which adds greatly to the difficulty of the mathematical approach. Therefore experiments were carried out in which the rotor was displaced relatively to the stator. This had no noticeable effect on conditions causing the formation of the vortices. It can be assumed, therefore, that Taylor's work can be applied directly to an eccentric bearing, the speed of which should not exceed

* *Proc. Roy. Soc. A*, vol. 157, page 546 (1936); and *Phil. Trans. A*, vol. 223, page 289 (1923).

HYDROSTATIC THRUST RINGS.

Fig. 20. SECTION X-X

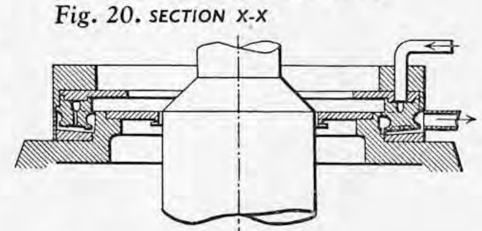
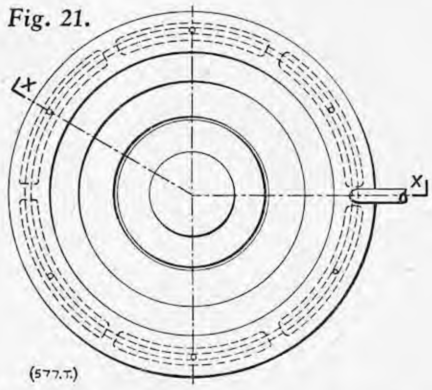


Fig. 21.




$1{,}000\left[\frac{77}{\mathrm{CD}}\right]^{\frac{3}{2}}\left(\frac{\nu}{\mathrm{D}}\right)$ r.p.m., if laminar-flow conditions are to be maintained; where $\nu$ = kinematic viscosity in centistokes, C = clearance in inches $\times 10^{-3}$, and D = diameter in inches.

Ball and roller bearings have been used for so long and so extensively that at first sight there appears to be little that is not known about them. However, the variations in length of life is the cause of considerable concern and the operation at high speeds presents problems somewhat novel in character. Heat generation at normal speeds is negligible, but at speeds of, say, 20,000 r.p.m., a generous supply of oil is needed to carry away the heat. However, if such oil is allowed to form a bath, the viscous drag at these speeds would be prohibitive; therefore, the best way of lubricating a bearing is to inject a quantity of oil, which might be something of the order of 8 pints per minute, in the form of a high-pressure jet, and to arrange for adequate drainage. The variation of heat generation with direction of application of load is shown in Fig. 16, page 697. The most critical component is the cage. For operation at high speeds, this should be machined from the solid, particular care being taken regarding the method of location. The most common form now adopted is located on the inner race, though it is estimated that the viscous friction between the cage and the race accounts for approximately 10 per cent. of the power dissipated in the bearing.

The reason for the greater variations in the lives of ball bearings is not wholly understood and it is general practice to rate the load-carrying capacity of bearings so that the life of 90 per cent. of the bearings will exceed the figure assumed as the desired life. It can be shown by Hertzian analysis* that the stress at contact for given ball and race is proportional to the cube root of the load applied. It is also known from the researches of Palmgren† and others that the life of an assembled bearing is inversely proportional to the cube of the load; therefore life is inversely proportional to the ninth power of the stress. In a diagram such as Fig. 17, page 697, in which life is plotted against stress if it is assumed that due to minor inclusions the local stress on the bearing material is increased by an amount X it will be seen that the life will be reduced by an amount Y. When X is 2 per cent., Y may be 17 per cent., and when X is 10 per cent., Y may be 50 per cent. This is one possible explanation. The other is that, while ball bearings are made to very fine tolerances, chance causes—for example, a ball at the maximum of the tolerance surrounded by balls at the minimum of the tolerance —would give rise to higher local stresses than one in which the diameters of the balls within the tolerance were more evenly distributed. These ideas are somewhat speculative and lack experimental confirmation of their validity. Simple experiments are in hand on the rig illustrated in Fig. 18, herewith. This is an adaptation of the Boerlage four-ball machine for testing extreme-pressure lubricants. Three balls are allowed to rotate in the outer race and are loaded by a fourth ball, which is carried in a chuck. The outer race is stationary and the upper ball is loaded vertically and rotated at 3,000 r.p.m. The arrangement is thus representative of an angular contact bearing under pure thrust loading, the fourth ball representing the inner race. Fig. 19, herewith, shows some metallurgical changes occurring in this ball under high surface stress. It will be noted that mechanical troostite is formed at some distance from the surface of the material, which is in accordance with the Hertzian analysis, which indicates that the maximum shear stress is so located. However, further tests with lower loads indicate that the appearance of surface cracks and pitting is not correlated with the formation of troostite; indeed, in the more lightly loaded bearings, pitting occurs with no evidence of troostite formation. It is possible, therefore, that the formation of troostite is dependent on high temperatures reached by the intensive loading used in the experiments, and need not be taken into account as a factor contributing to the failure of bearings under more normal conditions. However, at very high speeds, even where loads are light, it is possible that high temperatures will be generated in the material of contact. Experiments are now proceeding on similar lines, but with high speeds and low loads.

The tremendous advantage of hydrodynamic over boundary lubrication, as evidenced in bearing practice, leads one to consider devices whereby hydrodynamic

* *Theory of Elasticity*, by S. Timoshenko (1934).

† *Ball and Roller Bearing Engineering*, by A. Palmgren. Second edition (1946).

# BRIDGE DEMOLITION BY EXPLOSIVES.

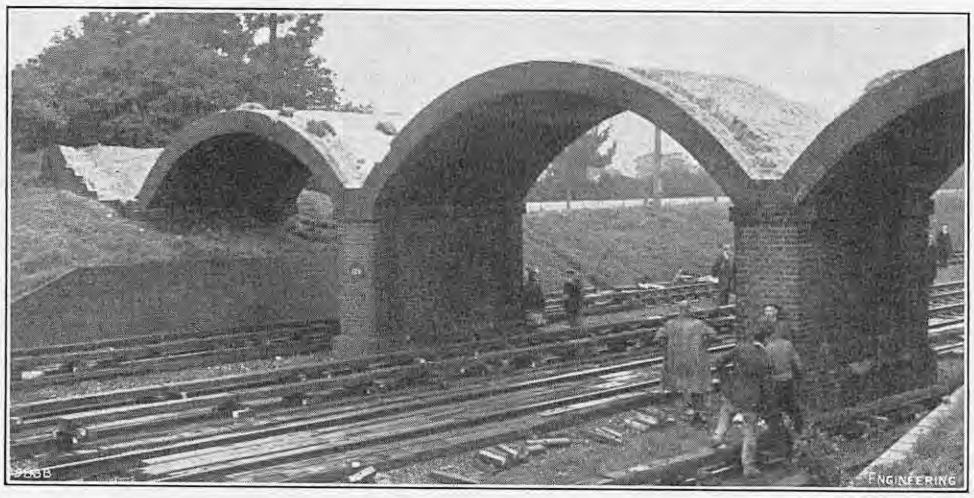


FIG. 1. BRIDGE PREPARED FOR DEMOLITION.

FIG. 2. EXPLOSION OF CHARGES.

conditions can be achieved artificially in circumstances where there is no inherent Reynolds wedge effect. Figs. 20 and 21, opposite, show an arrangement used to take the thrust reaction in the high-speed bearing testing machines at Thortonhall. Here hydrostatic pressure is provided by a pump which is connected to cavities in one of the bearing surfaces through restricted orifices. Sufficient flow of oil is provided under stable conditions to maintain pressure between the sliding surfaces and to keep them apart. If, however, one of the surfaces tilts relatively to the other, the flow from the cavities at the distant sidé will increase, but because of the action of the restriction, pressure on this side will diminish. Pressure will increase on the near side due to the restriction imposed by the reduced clearance. There will thus be brought into existence a couple tending to restore alignment. It is possible that the system might be applicable to bearings generally if the power required to drive the pump were compensated by reduction in friction, but the main application of the system is to cases where no friction is required at very low or zero velocities.

It will be gathered from the foregoing that our knowledge of frictional effects is by no means static. Powerful tools for research, such as radioactive tracer techniques, are becoming available, with the result that it is possible to look deeper and deeper into the complicated phenomena of friction. Provided that such work can be carried out against a background of engineering practice, so that the results may be rapidly applied in the form of improved designs or the use of new materials, the effort should be justified. It is probable that the outcome will not be the development of new lubricants or materials but the deepening of the understanding of the mode of operation of those already available, so that their selection may be based on sounder premises, and bearing design amended so as to enable them to be used to greater effect.

## BRIDGE DEMOLITION BY EXPLOSIVES.

THE use of explosives being the quickest method of demolishing a bridge, and causing the least interference with railway traffic, this method was adopted recently to demolish an occupation over-line bridge on the East Coast main line between Tempsford and St. Neots. The maintenance of the running lines in the vicinity of the bridge had been difficult for some time, owing to the presence of a clay formation, and it was impossible to lift the tracks any more due to the obstacle formed by the bridge. It was a three-arch brick structure, about 12 ft. wide, spanning four lines. The work was carried out by the Demolition and Construction Company, Limited, 3, St. James's-square, London, S.W.1, under the supervision and general direction of the railway district engineer, King's Cross.

Traffic conditions would only permit the full possession of the four lines for two hours on a Sunday morning. Therefore, to ensure the minimum amount of clearance after the explosion, the bridge was stripped down to the arch rings in advance, as shown in Fig. 1, and the arches were drilled for placing the charges. About 300 holes were prepared in the crown and haunches of the arches, and they were charged during the night with approximately 55 lb. of Polar ammonal gelignite. Then, 1,200 ft. of Cordtex fuse were laid, and at 8.5 a.m. on Sunday, September 23, the skeleton bridge was blown by electrical contact. Fig. 2 shows clearly the explosions bursting from the haunches and the centres of the arches.

The down slow line was restored to traffic at 8.50 a.m. and the up slow line at 9.50 a.m. The up and down fast lines were used for removing the debris, but were opened to normal traffic at 5.0 p.m. The track was not damaged, having been protected with a layer of sleepers, as can be seen in Fig. 1.

## REMOTE AND SUPERVISORY CONTROL OF ELECTRICAL SYSTEMS.*

By W. FORDHAM COOPER.

IT is common practice in power-station control rooms for each panel to be provided with a red and green light for indicating whether the switches are open or closed; and to have a mimic diagram giving single-line representation of the system and showing the position of each switch. With the development of armature instruments these control panels and diagrams have often been combined; and there has been a tendency to replace the semaphore indicators by lamps. To ensure that confidence in these systems is not misplaced, the equipment must fail to safety, i.e., every position indicator must give, and every handle must cause, either correct operation or no operation; every interlock must allow safe operation or prevent all operation; every indicator or interlock should also be linked with the moving parts of the circuit-breaker; and every important indication and operation should be self-checking.

On the basis of these requirements, early designs of semaphore indicators were not satisfactory, since they often failed to operate if the voltage was reduced; operators, therefore, had little faith in them. A more recent development has been the introduction of translucent semaphore discs with lamps behind them; the connections being such that if the disc is in the correct position the lamp is extinguished but is illuminated if the disc is in the wrong position. This has the advantages that some of the troubles due to inertia are overcome and that attention is immediately drawn to incorrect indication. Further, should the switch trip the change of conditions can be indicated by a flashing lamp or audible alarms. When the lamps burn out, however, the arrangement, if used alone, fails to meet the requirement that there shall either be a correct indication or none.

When it is desired to operate a circuit-breaker remotely, it is important to assume that the correct switch has been selected and that the operation has actually been performed. This can be effected by arranging that when any key on the switch panel is turned a lamp supplied from the switch-operating circuit is lighted. If this lamp is placed alongside the switch symbol on the mimic diagram it will perform the joint function of proving the circuit and ensuring that the operator is at the correct panel. If the "operate" button is then depressed the fact that the correct operation has been successfully carried out will be shown by the lights changing from red to green (or vice versa) and the lighting of the yellow light will indicate the change of conditions. Where an isolator is remotely operated, it is important that neither a red nor a green indication should be shown when it is in the half-open position. Similarly, the auxiliary contacts on an oil circuit-breaker should be linked as directly as possible to the cross arms and the diagram should show neither red nor green, unless the breaker is fully closed or open. Mimic diagrams should not be placed opposite windows or under skylights, as if they are it is difficult to see the lights on bright days. Trouble with lamps may arise from inadequate ventilation behind the board or diagrams. Where switchgear has draw-out or drop-down isolation, the absence of the switch should be recorded on the diagram.

When light-current channels are used for control or protection in parallel with power-supply lines, steps must be taken to protect the operators from induced high voltages or even acoustic shocks. It is also important to ensure that the transmission equipment itself is not damaged and the communication channel thus lost. The channel may be an insulated pilot cable with a multiply-earthed sheath to give electrostatic screening, while shunt reactors with the centre point earthed can be used at the terminals to ensure that the parallel longitudinal voltage produced in the conductors are suppressed and thus effective protection afforded against low-frequency interference and acoustic shock. Further protection can be given by spark gaps of various types, as well as air gaps or horn gaps. Whatever precautions are taken, however, it is impossible to give infallible protection. When telephones are used, therefore, an isolating transformer should be provided as a link between the pilot and the terminal apparatus. Every additional discharge path, however, provides an additional possible source of unreliability and the probability of damage must, therefore, be weighed against that of losing the channel of communi-

* Paper on "Electrical Control of Dangerous Machinery and Processes: Part 3. Remote and Supervisory Control," read before the Utilisation Section of the Institution of Electrical Engineers on Thursday, November 22, 1951. Abridged. A review of the first part of this paper appeared in ENGINEERING, vol. 162, page 494 (1946), and of the second part in vol. 171, page 171 (1951).

cation through defects. It is, in fact, evident that although some protection can be given to both equipment and operators, little can be done to reduce the vulnerability of the line. It is most important, therefore, that the equipment should fail to safety and that the circuits should be either "proved" before and after each operation or that some alternative safeguard should be arranged.

Where carrier-currents are used in connection with supervision, operation and selective protective gear, care is necessary to ensure that the channel of communication remains intact and neither initiates nor picks up spurious signals. The obvious method of securing continuity is to institute an overall check, which can automatically be provided by the telephone and by frequent meter readings. Where such fortuitous checks are not available some authorities favour the transmission of regular checking signals, although it is argued from recent Post Office experience that more faults arise from the equipment used for testing and monitoring than from normal use. It is therefore again necessary to balance the importance of continuity against that of knowing immediately when a circuit becomes defective.

Various self-checking devices have been adopted to ensure that danger shall not arise in remote supervisory systems from incorrect indications or operations. These include the insertion of characteristic resistances for the different operations in series with the control circuit and the measurement of the combined resistance of the two. As a result, indicator lamps are lighted on the switchboard and the control engineer does not open or close a switch or make use of an indication until he has obtained the correct check back signal. Alternatively, the substation automatic equipment can be arranged to dial back the instruction it receives. Systems of this type are, however, limited in scope and slow acting. Equipment has therefore been designed in which a pair of rotary selector switches are installed in both the sending and receiving stations. An impulse transmitted by one of the pair of switches at the sending station causes the associated switch at the receiving station to assume the corresponding position. As a result, the second switch at the receiving station is also turned to the same position and an impulse is re-transmitted to the second switch at the sending station. It is only when the rotary arm of this second switch has come to rest on the corresponding segment to that occupied by the first switch at the sending station that the operating key can be released and the executive signal transmitted. The primary danger with such a system is that a pulse may be lost or a spurious pulse picked up. The chance of this happening, however, is only 1 in $10^8$, a figure which is negligible in comparison with other sources of danger.

Alternatively, the signal can be checked by counting the pulses, in which case the apparatus comes to rest if a pulse is missed or is locked out if a spurious pulse is picked up. With such a system the chances of maloperation are not so remote as with a repeat back mechanism, but there is a valuable increase in the speed of operation. Another method, which will soon be in use, employs two alternative signals or units of communication, the resulting instruction resembling the Morse code. A sequence of $n$ impulses will then serve to make a selection between two final circuits, if a suitable interpreting system of relays is employed at the receiving station. Such a system can be made self-checking at every step, i.e., if the position of the last relay to be operated at the receiving station does not correspond with that of the last impulsing relay at the sending station the channel will be interrupted and the circuit locked out. The systems working on these two principles depend on the use of long and short pulses, which are interpreted by stepped relays, and it is uncertain whether they are as reliable as positive or negative direct-current signals or alternative frequencies on alternating-current signalling systems. If the check is not correct, the most recent practice is for the substation to register "failure to agree" by a special signal and to disconnect the faulty circuit, thus allowing the check at other points to proceed and the system to be operated.

In all the methods of signalling described, the possibility of error in details has been accepted and steps have been taken by checking and coding to reduce the possibility of these errors passing unheeded. The most profitable line of advance now seems to be to study the problem of encoding in the light of recent advances in fundamental communication theory. It is not, however, at all clear whether some systems span the complete operation and for important functions the final check should cover not only the communication channel, but the encoding apparatus and the switch-operating rods. Use might also be made of filter circuits to eliminate spurious impulses such as are produced, for example, by transients in power systems. There seems little doubt that the use of electronic valves in place of relays should be onsidered as a means of accelerating the transmission of information for large supervisory systems. The special weaknesses of electronic systems, in particular the difficulty of detecting leakage from high-impedance circuits and the possibility of sneak circuits from common supplies to groups of valves, will no doubt be overcome, but more operating experience as well as tests in research and development laboratories are desirable before they can be considered as alternatives to the well-established automatic telephone equipment.

On the face of it, any system of protection that can be operated by pilots can equally well be operated by carrier currents. Such a system would be largely free from troubles with capacitance current. In practice, such systems have not been employed, but a recent development has been the use of carrier technique for phase-comparison protection. In applying any method in which the signalling channel is provided by the power conductors to be protected, consideration must be given to the possibility of the fault itself interfering with the operation of the protective gear. In such circuit areas, both monitoring and coding may be desirable.

This analysis of a fairly wide range of equipment shows that a comparatively small number of fundamental principles is involved and that occasional failure of individual components or circuits must be expected. Such failures are, however, largely overcome either by closed-circuit checking or coding in such a way that incorrect operation will take place only on the simultaneous occurrence of failures, which are indeed usually fairly rare. As has already been shown, many mimic diagrams could be improved and the extent to which the protection spares the equipment an operation should be increased. The author has heard of only one doubtful case where checks may have failed and wrong operation occurred with telephone-type apparatus. On the other hand, experience with coded operating signals over pilot lines suggests that unless very great care is taken in devising them spurious signals may be interpreted by the relays as operating instructions. Induced currents, due to transient phenomena, may have a similar effect. Special precautions must also be taken where there are inflammable or explosive liquids, gases or vapours. As much of the equipment as possible should be placed in a safe area with only pilot connections to danger spots. The systems described are not absolutely safe, but if designed in accordance with the principles set out, they can be made as safe as any other part of the equipment and safer than any arrangement based on verbal messages.

## STANDARDISATION OF INTERNAL-COMBUSTION ENGINES FOR THE SERVICES.

To dispel any impression that an internal-combustion engine included in the "Inter-Services List of Standard General-Purpose Internal-Combustion Engines for Plant and Equipment" is officially deemed to be superior to those omitted, the Ministry of Supply have issued a notice setting out the reasons for drawing up this list. The main purpose, they emphasise, is to remove the complexities brought about by using an excessive number of different engine types in the Services; accordingly, the list is kept as short as practicable. The necessity for such a list became apparent during the 1939-45 war, when the three fighting Services, and the corresponding branches in the Ministries of Supply and Aircraft Production, were seriously hampered by the number of engine types and the diversity of spares and techniques, including special tools, required in all theatres of war. In 1945, an inter-Services committee was appointed to draw up outline specifications for standard ranges of engines from 1 h.p. to 2,000 h.p. for all general, as apart from particular, applications. They recommended the selection and, where possible the expansion into ranges, of suitable types of existing engines, and proposed an interim list of preferred engines as the basis of a standard list. Towards the end of 1950, a second committee was appointed to prepare a standard list based on the original interim list as revised from time to time by the Admiralty and Ministry of Supply. Completion of the standard list is expected in time for its adoption by the three Services this year and changes in it are not expected to be frequent. Features qualifying engines for inclusion are, in general: the number of engines of a given make, together with the quantity of spares, already held in the Services; the maximum use of common parts; a balanced covering of the field of probable requirements while keeping the number of types to a minimum; and the actual and potential productive capacity. Although the technical merits of an engine are given full consideration, these, unless accompanied by some or all of the features enumerated above, would not normally justify its inclusion in the list. It will be clear, therefore, that non-inclusion in the list of any particular engine implies no disparagement of its technical merits and it was neither contemplated, nor intended, that the list should be used as a guide for the selection of prime movers by non-Service customers.

## POWER-OPERATED CONTROLS FOR AIRCRAFT.*

By C. F. Joy, A.F.R.Ae.S.

(*Concluded from page 666.*)

Lag in response in a powered flying-control system is particularly important when using it with an automatic pilot. The well-trained human pilot can deal with a certain amount of lag in the flying controls, particularly when he knows the aircraft. Furthermore, he usually neglects small periodic oscillations which are smoothed out by the natural damping of the aircraft. The gyroscopes of the automatic pilot, however, cannot differentiate between a small oscillation and, say, the onset of a divergent disturbance; thus, a correcting signal will always be sent to the control surfaces. The effects of this signal may increase the damping or may make the oscillation divergent and produce instability. The criterion is the relationship of the time lag between a disturbance and the onset of the aircraft righting moment, to the natural periodic time of the aircraft. A small lag is probably acceptable; in any case, provided that it is linear with amplitude and not really excessive, the modern automatic pilot can provide correction by means of phase advance. Unfortunately, the automatic pilot cannot deal with a lag which is irregular and varying with amplitude, such as results from backlash and lost motion in any part of the system between the automatic-pilot servo and the control surface. With excessive lost motion and very low-amplitude inputs, the output can disappear altogether. This difficulty is not new, but it is aggravated by the powered control-surface actuator, and its effects are worse on modern high-speed aircraft, having short natural periods and requiring small control-surface angles when in automatic flight.

It is impossible, during the design and rig-testing stages, to be sure that the system is stable; it can only be checked by flight trials. The best way to ensure that the lost motion between the automatic-pilot servo and the control surface is a minimum is to provide the shortest possible length of control run from the automatic-pilot servo to the control-actuator input, and a short stiff inter-connection between the actuator output and the control surface. Such an arrangement is practicable for the elevator and rudder circuits; on the aileron circuit, however, the automatic-pilot servo can only be situated close to one aileron actuator and backlash in the aileron inter-connection signalling circuit must be accepted as inevitable.

The problem of installing an automatic pilot which will have sufficient power to control the aeroplane in automatic flight and, at the same time, will not have enough power to break the aeroplane in the event of a "runaway" type of failure, usually presents difficulties on a manually-controlled aeroplane. With power-operated controls, the problem becomes more complex. The normal input signal load is not likely to be more than 1 or 2 lb. per valve but, in order to prevent inadvertent operation, the fault detector requires a load of some 10 times that amount. It follows that the automatic-pilot servo power must be adequate to control the aeroplane, when resisted by the feel simulator, the most adverse circuit friction and the normal valve loads; at the same time, it must be capable of operating a fault detector. Its maximum power, however, must be such that, in the event of a runaway, it cannot break the aeroplane if these various contributions to "feel" are at their lowest value.

If manual flying controls are used as a stand-by, the simplest method of providing the pilot with "feel" is to feed back a proportion of the control-surface hinge moment. Proportional feed-back of feel is obviously confined to powered controls of the reversible type, where mass balances on the control surface are essential, and, probably, to aircraft cruising at relatively low subsonic speeds. With all-powered irreversible controls, some form of artificial feel is necessary. On aircraft fitted with automatic pilots, feel should vary with some function of speed, unless the danger of a runaway automatic pilot breaking the aeroplane is accepted or is dealt with in some other way. On modern aircraft with large speed ranges, even without powered controls, much effort is spent on beating the speed-square law, for example, by the use of spring tabs, aerodynamic servos, etc. It is suggested that no general requirement as to whether feel should vary with the speed V, $V^2$, or $V^3$ can be laid down and that each aircraft type should be considered on the basis of its operational functions. For example, a fighter must have light aileron controls at high indicated airspeeds, whereas a high-altitude bomber, in order to provide a steady bombing platform, should have a heavy rudder at relatively low airspeeds.

Broadly speaking, artificial-feel simulators may act by the direct force provided by dynamic pressure, or by a force provided by some auxiliary means controlled by dynamic pressure. An example of the first

* Lecture given before the Royal Aeronautical Society on Tuesday, October 9, 1951 Abridged.

# POWER-OPERATED CONTROLS FOR AIRCRAFT.

Fig. 8. DIRECT-TYPE FEEL SIMULATOR.

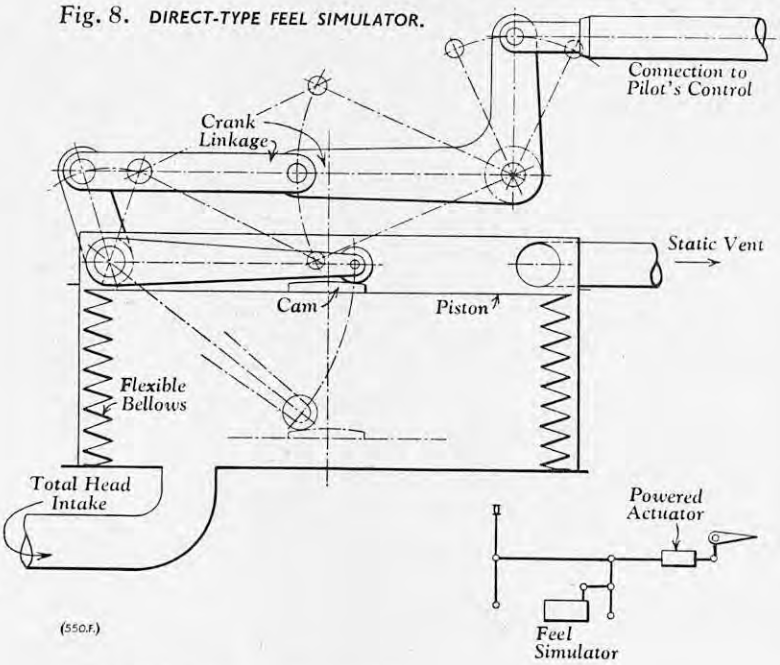



Fig. 9. POWERED-TYPE FEEL SIMULATOR.

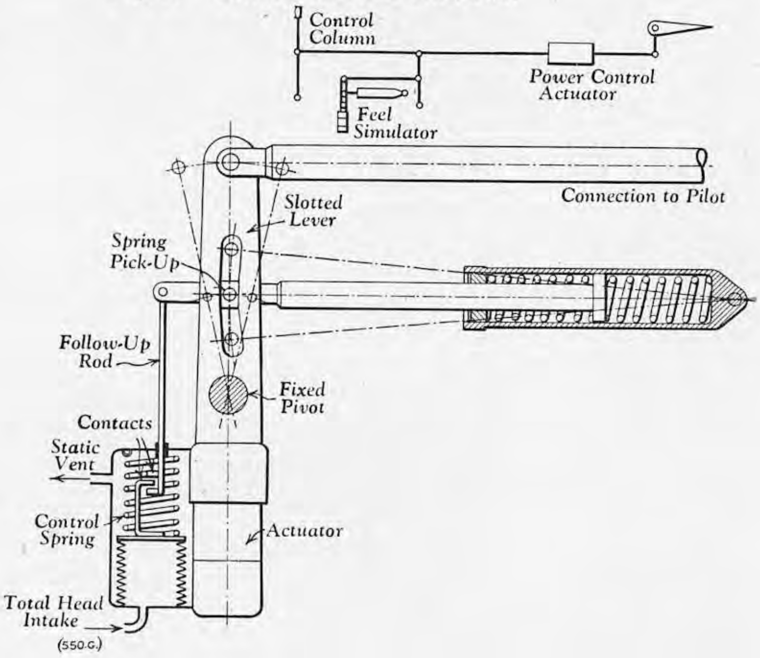



Fig. 10. SIMPLE BOB WEIGHT "g" RESTRICTOR.

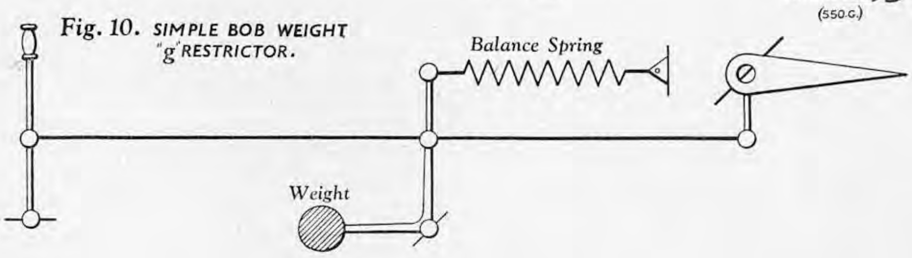



Fig. 11. BOB WEIGHT WITH DIFFERENTIAL-LEVER "g" RESTRICTOR.

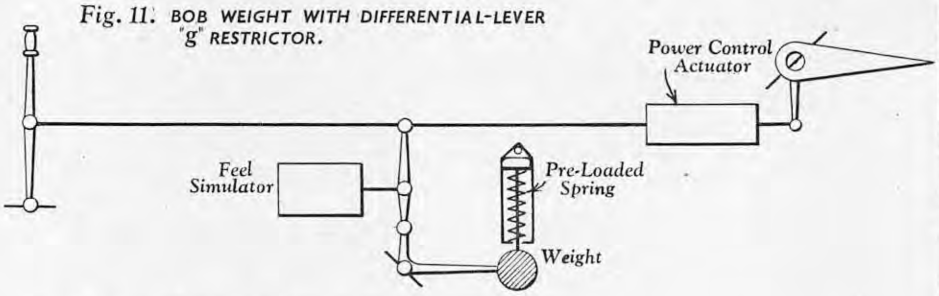
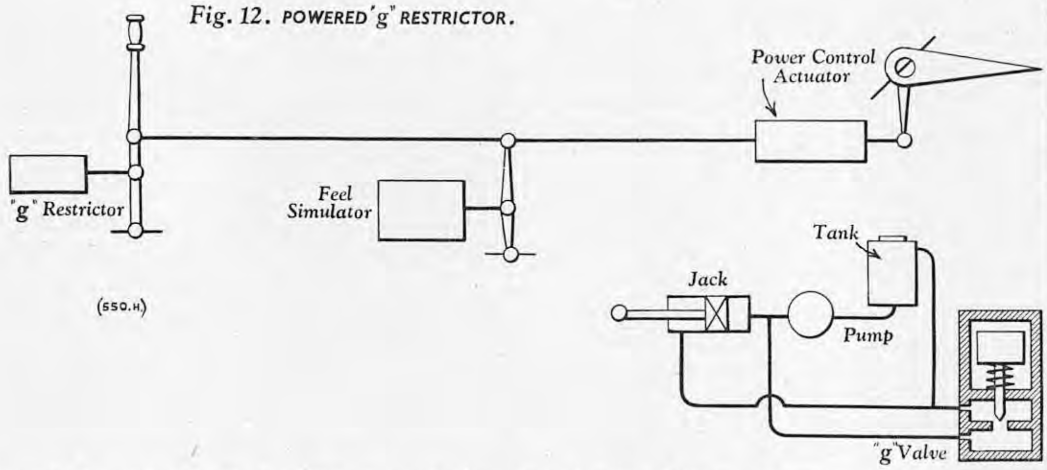



Fig. 12. POWERED "g" RESTRICTOR.




type is shown in Fig. 8, opposite; control-column displacements are resisted by dynamic pressure, transmitted through a bellows and cam, and the characteristics are modified by varying the area of the bellows and the cam shape. This scheme is undoubtedly the simplest, but the bellows may require a large space if the desired pilot's loads are high. The alternative, an example of which is shown in Fig. 9, is a spring-feel arrangement, with the relationship between the pilot's control displacement and spring displacement varied by an actuator which is controlled by dynamic pressure. Variations in forward speed result in movements of the diaphragm which controls power to the actuator by means of electrical contacts and a follow-up gear. Since the dynamic pressure is used only to make and break contacts, the bellows can be small. Its disadvantage is the employment of auxiliary power with the accompanying risk of failure. A compromise between the two schemes is to use dynamic pressure directly, through an irreversible mechanism, to modify the gear ratio between the controls and the spring (British Patent Application No. 28176/50). With this mechanism, if the controls are held in an untrimmed position, during a speed build-up, there is insufficient power to increase the pilot's loads to a value appropriate to the higher speed. However, the difference is likely to be small and is probably acceptable.

With high indicated airspeeds, and, in the case of large modern aircraft, relatively low ultimate load factors, a means of introducing manœuvring acceleration, or "$g$," into the artificial feel is probably desirable. Figs. 10, 11 and 12 show three methods of increasing control-column force with increasing acceleration; Fig. 10 by a simple bob-weight in the control run; Fig. 11 by combining the bob-weight with a feel simulator through a differential lever, and Fig. 12 by a powered $g$-restrictor.

The main disadvantage of the simple bob-weight is that the control-column force is a combination of the force due to the bob-weight and the force due to the forward-speed feel. Thus, at a given high value of acceleration, the control-column force will vary with the weight and the position of the centre of gravity. With the second method, the spring which balances the bob weight can be pre-loaded to any desired value of the acceleration, and until this value is reached, the normal feel is unaffected by acceleration. Above this pre-set value, $g$-feel replaces the normal feel and the latter cannot be felt on the control column. Thus, above this pre-set value, the stick force is independent of aircraft loading and centre-of-gravity position. In the last scheme, the spring can be set so that the $g$ control-column forces come in at any desired value. The control-column forces will, however, vary with weight and centre of gravity position. It has another disadvantage in that it uses auxiliary power, which inevitably increases its fallibility.

## IMPACT TEST FOR PLASTICS.

A DESCRIPTION of a single-blow falling-weight testing machine for determining the impact resistance of small notched specimens of polystyrene, cellulose acetate and other plastics is given in a paper, entitled "An Impact Test for Miniature Plastics Specimens," by Mr. H. W. Woodham, Mr. M. G. Wirick, and Mr. W. H. Markwood, printed in the October issue of the *Bulletin* of the American Society for Testing Materials. The test is carried out on injection-moulded notched specimens, $1\frac{1}{4}$ in. in length, and is intended for use in connection with experimental plastics when only small quantities of from 20 to 50 grammes of the moulding powder are available. Briefly, the machine consists of a steel cantilever, to the free end of which the end of the specimen is clamped. The specimen is fractured by a cylindrical striker freely falling a vertical distance of 2 ft., and attaining a velocity of approximately 11 ft. per second before coming in contact with the specimen. Attached underneath the steel beam, near the specimen clamp, is an Alnico bar magnet which dips vertically downwards into a hollow coil of wire, or solenoid, the terminals of which are connected to a cathode-ray oscillograph having a long-persistence screen. During a test, the energy required to break the test specimen is transferred to the cantilever beam, causing it to be deflected downwards. When the specimen is fractured, the beam is free to vibrate, and as it passes upwards through its normal central position from its point of maximum deflection (a travel of a few thousandths of an inch), its velocity is at a maximum. At this instant, the e.m.f. induced by the movement of the box magnet through the solenoid is recorded as a single trace on the oscillograph. The height of the trace is read visually, and this value can be converted to the approximate Izod figure by an empirically-derived correlation curve. As in Izod testing, at least five check determinations are recommended to obtain an average resistance value, although estimates can be made from single specimens.

# WORLD SUPPLY OF NON-FERROUS METALS.*

By R. Lewis Stubbs.

The present shortages of non-ferrous metals have led to much speculation about the future. A few experts believe that output cannot be increased to match the current expansion of the world's industrial capacity and that some metals will always be scarce; others are still more pessimistic and predict that the world resources of non-ferrous metals are rapidly being exhausted. In this paper I have tried to assemble the facts on which any forecast must be made. All the major non-ferrous metals are covered, namely, copper, zinc, lead, tin, aluminium and magnesium. Since our present shortage has led to a certain confusion of thought on the whole subject, I am going to begin analysing its extent and causes in order to clear the air. Authoritative figures of production and consumption in the free world have been issued by the Economic Co-operation Administration in Washington, and Table I gives these figures for 1948, 1949 and 1950. In Tables I and II figures for tin have been taken from the "Review of the World Tin Industry" for 1950-51, published by the International Tin Study Group, The Hague, Holland, and from their Statistical Bulletin for July and August, 1951. All the figures given here and later on are in metric tons. The production figures represent the total virgin metal output of the smelters or refiners; the consumption figures cover all virgin metal used by the fabricating industries and include the metal taken out of the fabricators' own stocks. The Economic Co-operation Administration statistics show deliveries for "Special account" the metal not being available for consumption, and these

Table I.—*World Production and Consumption of Copper, Zinc, Lead, Aluminium and Tin* 1948-50.

| Metal. | | 1948. | 1949. | 1950. |
|---|---|---|---|---|
| | | Thous. Metric tons. | | |
| Copper | Refinery production | 2,291 | 2,237 | 2,537 |
| | Consumption | 2,326 | 2,075 | 2,539 |
| | U.S. Special Account purchases | 13 | 163 | 208 |
| Zinc | Smelter production | 1,564 | 1,680 | 1,819 |
| | Consumption | 1,543 | 1,478 | 1,847 |
| | U.S. Special Account purchases | 54 | 103 | 116 |
| Lead | Smelter production | 1,365 | 1,510 | 1,674 |
| | Consumption | 1,327 | 1,185 | 1,560 |
| | U.S. Special Account purchases | 7 | 192 | 155 |
| Aluminium | Smelter production | 1,117 | 1,127 | 1,285 |
| | Consumption | 1,111 | 1,024 | 1,312 |
| | U.S. Special Account purchases | — | 11 | 20 |
| Tin | Smelter production | 160 | 171 | 175 |
| | Consumption | 136 | 117 | 149 |
| | U.S. Special Account purchases | 24 | 53 | 30* |

* Estimated

Table II.—*Summary of Three-Year Period,* 1948-50.

| Metal. | Total Production. | Total Consumption. | Excess or Deficit. | Total U.S. Special Account Purchases For Three Years. | Total Excess or Deficit. |
|---|---|---|---|---|---|
| | Thous. Metric Tons. | Thous. Metric Tons. | Thous. Metric Tons. | Thous. Metric Tons. | Thous. Metric Tons. |
| Copper | 7,065 | 6,940 | +125 | 384 | —295 |
| Zinc | 5,063 | 4,868 | + 97 | 273 | — 78 |
| Lead | 4,549 | 4,072 | +564 | 354 | +123 |
| Aluminium | 3,529 | 3,447 | + 82 | 31 | + 51 |
| Tin | 506 | 406 | +100 | 107 | — 7 |

are generally accepted by experts in America as the amount of metal "stockpiled" each year. They are shown separately in the tables and are not included in consumption. No figures for magnesium are given since production in recent years has been at a low level, the stocks accumulated after the war having been adequate for most requirements.

It will be seen that, in 1950, the consumption of copper, zinc and aluminium was in excess of production, the output of lead and tin having remained comfortably above consumption. Table II shows that it was the amounts of metal stockpiled by the U.S. Government in these years and earlier which really threw production and consumption out of balance. During the three years some 5 per cent. of the world's total copper and zinc production was stockpiled, 8 per cent. of that of lead and no less than 21 per cent. of

* Paper entitled "The World Supply of Non-Ferrous Metals, including the Light Metals," read at a meeting of the Institute of Metals, on Wednesday, October 17, at which a general discussion on "Metal Economics" was held. Abridged.

## WORLD SUPPLY OF NON-FERROUS METALS.

Fig. 1. WORLD PRODUCTION OF METALS BY WEIGHT.

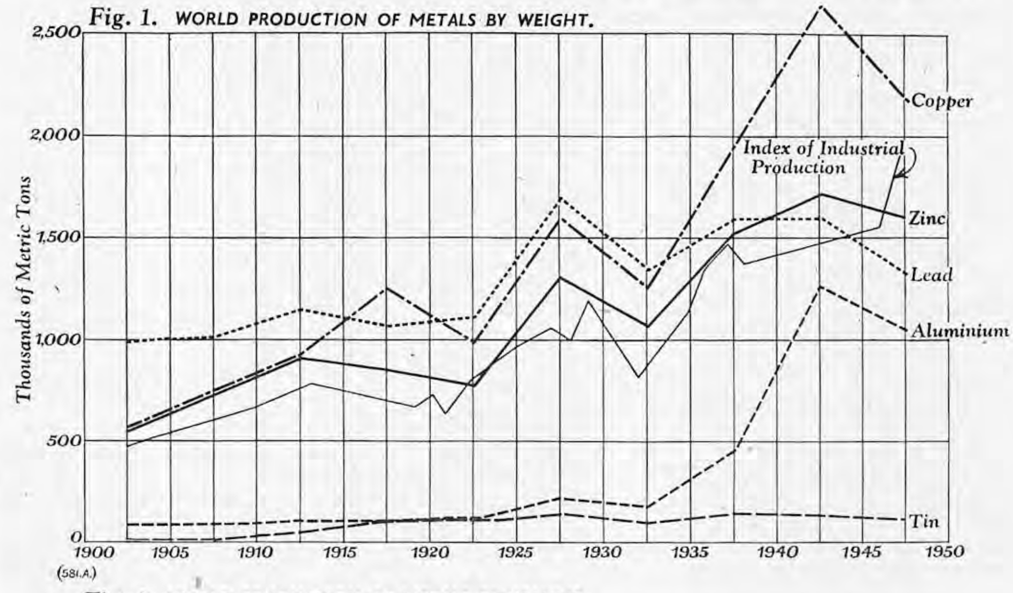
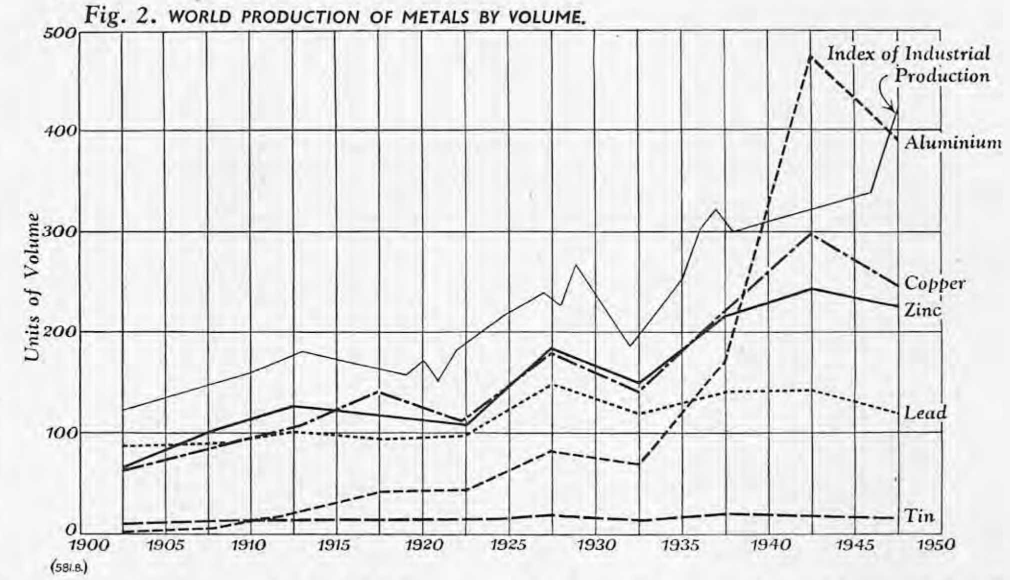



Fig. 2. WORLD PRODUCTION OF METALS BY VOLUME.




tin. In the case of copper the total deficit on paper is so great that it is hard to believe that the stocks could have been depleted to that extent, and perhaps the truth is that consumption has been over-estimated. In any case, what has happened is that stocks previously in the hands of the producers and consumers have been in effect transferred into the American stockpile. The mine production for the same three years, 1948-50, is also known, and Table III gives

Table III.—*World Mine and Smelter Production of Copper, Zinc and Lead,* 1948-50.

| Metal. | | 1948. | 1949. | 1950. |
|---|---|---|---|---|
| | | Thous. Metric Tons. | | |
| Copper | Mine production | 2,120 | 2,051 | 2,280 |
| | Metal content of scrap | 155 | 199 | 239 |
| | Combined total | 2,275 | 2,250 | 2,519 |
| | Smelter production | 2,291 | 2,237 | 2,537 |
| Zinc | Mine production | 1,542 | 1,593 | 1,764 |
| | Metal content of scrap | 64 | 83 | 130 |
| | Combined total | 1,606 | 1,676 | 1,894 |
| | Smelter production | 1,564 | 1,680 | 1,819 |
| Lead | Mine production | 1,282 | 1,347 | 1,466 |
| | Metal content of scrap | 68 | 137 | 143 |
| | Combined total | 1,350 | 1,484 | 1,609 |
| | Smelter production | 1,365 | 1,510 | 1,674 |

Table IV.—*Summary of Three-Year Period,* 1948-50.

| Metal. | Mine Production Plus Scrap for Smelting. | Smelter Production. | Excess or Deficit. |
|---|---|---|---|
| | Thous. Metric Tons. | Thous. Metric Tons. | Thous. Metric Tons. |
| Copper | 7,044 | 7,065 | — 23 |
| Zinc | 5,176 | 5,063 | +113 |
| Lead | 4,443 | 4,549 | —106 |

the figures for copper, zinc and lead, and also shows the metal content of the scrap used by the smelters to supplement the supplies of concentrates. The figures for scrap are only approximate, but help to complete the picture. They do not of course include scrap used by the secondary smelters or the fabricators. It will be observed that the supply of cupriferous material for copper production was adequate. A summary of the three-year period, 1948-50, is given in Table IV. From Table IV it would appear that, for zinc, mine production plus scrap exceeded smelter production by 113,000 tons. In fact, however, a part of the mine production was used to make zinc oxide and lithopone (namely, 142,000 tons in 1948, 113,000 tons in 1949 and 112,000 tons in 1950). Thus there was a deficit of 254,000 tons, which was partly made good by the release of 104,000 tons of concentrates from the U.S. stockpile, thus leaving a final deficit of only 150,000 tons for the three years. The deficit in lead was only about two-thirds as great.

It must be remembered that during the period in question the flow of zinc and lead concentrates was dislocated by a shortage of transport, with the result that large stocks of concentrates often accumulated at the mines; the total smelting capacity appears to have been adequate. Various opinions are held on the policy of stockpiling, but most people will agree that the present shortages are unreal since, if the American stockpiles were released now for general consumption—as one day they must be—the shortages would be made up for at least a year or two and perhaps longer. Nevertheless most of us would undoubtedly welcome a stockpile in the U.K. for use in case of war, provided no unreasonable sacrifice were entailed. Producers, on the other hand, must view stockpiles with a certain amount of apprehension lest they should at some time be used for other than strategic purposes. Recently sales from the United States Government stocks of tin (but not from the stockpile) were made to home consumers to bring down world prices. Again, copper from the United States stockpile was issued to consumers during a recent strike at producers' works. Since 1950, defence requirements have changed the

# WORLD SUPPLY OF NON-FERROUS METALS.

Fig. 3. BRITISH METAL PRICES, £ PER LONG TON, YEARLY AVERAGE SINCE 1913.

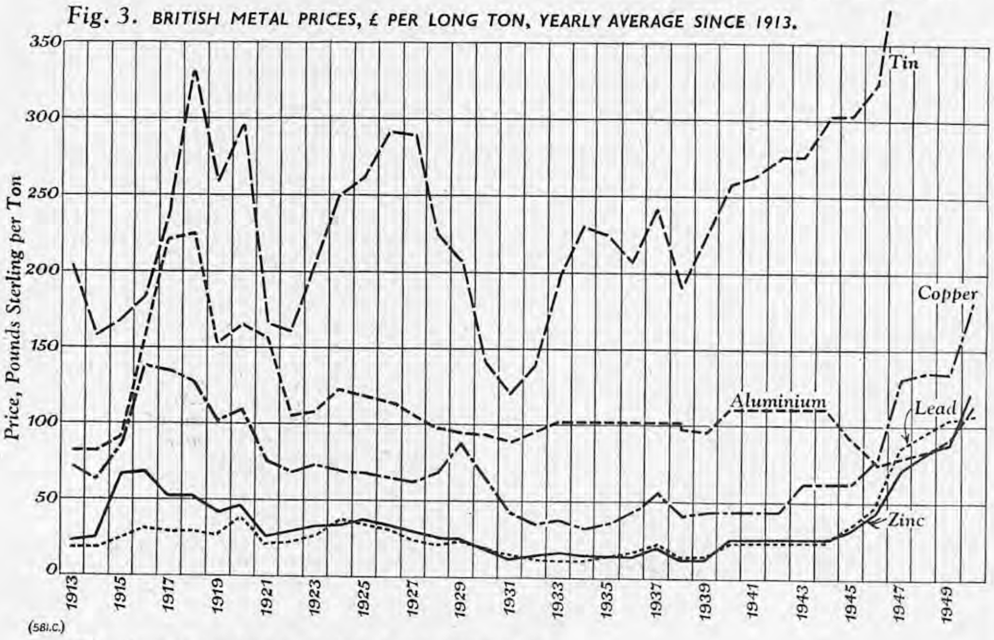
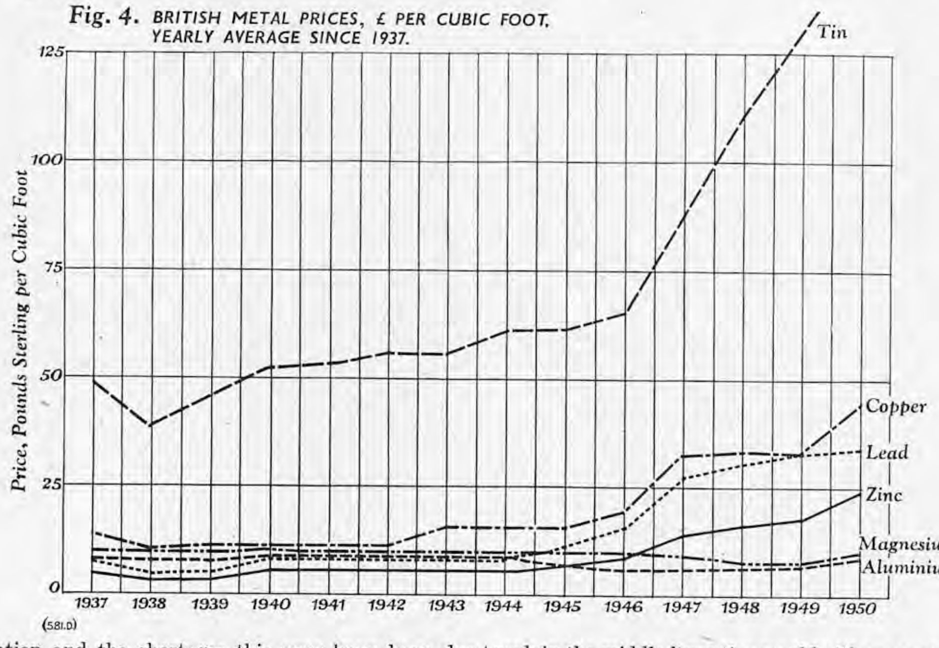



Fig. 4. BRITISH METAL PRICES, £ PER CUBIC FOOT, YEARLY AVERAGE SINCE 1937.




situation and the shortages this year have been due more to them than to stockpiling, for which purchases have been smaller. Later in the paper the prospects of production being increased in the immediate future to meet this expanded demand will be examined.

While, in a general way, it is possible to determine roughly the requirements for the next few years, it is not so easy to make any accurate forecast farther ahead. Recent years have been a period of exceptional demand while the ravages of war were being repaired; and we now seem to have entered a stage of accelerated industrial activity arising from the development of backward countries as well as from a general rise in the standard of living and an increase in world population. Until now, all metals have been equally plentiful for the consumer and the trends in consumption have been the result of advances in metallurgy and the techniques of fabrication, production and demand having been reasonably balanced in the long run. In the last few years, there have been significant changes in the relative consumption of the different metals which may be even more pronounced in the future and these changes, and the reasons for them, are examined below.

The graph, Fig. 1, opposite, indicates the world production of metals by weight over the past 50 years. The points plotted are yearly averages over the five-year periods beginning with 1900 to 1904. The index of world industrial production is also plotted on the same graph and shows how the production of metals has risen at roughly the same rate as industrial output. It will be seen that the production of copper and zinc is rising fairly persistently despite fluctuations. Allowance must of course be made for the exceptional rises in the last few years which are largely due to war and its aftermath. Zinc production in 1945-49 was about three times that of 1900-04 and copper production about four times. Lead, however, after rising to a peak in the middle 'twenties roughly 70 per cent. above the 1900-04 level, declined later and production in 1945-49 was only about one-third higher than in 1900-04. It has ceased to be the most used non-ferrous metal and now holds third place by weight. The most notable feature of the graph is the spectacular rise in aluminium during the second world war and its continuing high level, production in the last five years being about 140 times that in the first five years of the century.

A rather better comparison between aluminium and the other metals is obtained by measuring their production on a volume basis, since articles now made of aluminium are seldom of much greater bulk than the rival products of brass or zinc. The graph shown in Fig. 2, opposite, was obtained by dividing the figures in the first by the specific gravity of the metals. The growth in the popularity of aluminium has been due mainly to its comparative abundance and relative cheapness since the war, but the increased knowledge of its properties and the experience gained during the war have also helped to keep up the demand. Price has an important influence on the consumption of all metals though it is rather overshadowed just now by shortages; in the long run, it will again be a major factor in deciding how much of each metal is used. Between the wars, there seems to have been no significant relationship between price and output, the slow downward trend in price corresponding with the slow increase in the value of money as measured by the wholesale price indices.* This trend has been maintained through a period of slowly mounting output. Only in the case of tin were there major fluctuations which did not conform to this pattern. Except for aluminium, prices began to move upwards again with the outbreak of war and continued to do so until the middle of 1948. The falls that began then were soon arrested by the new demands which occurred after the start of the Korean war. The price of aluminium, however, with minor fluctuations, rose only slightly during and after the war and, after allowing for the fall in the value of money, is now much lower than ever before. Tin again did not conform to the pattern, purchases for the United States stockpile causing steep price rises which have been followed recently by falls resulting from the discontinuance of the stockpile purchases and the sale of metal from United States Government stocks. The variations in prices, in pounds sterling per ton, since 1913 are shown in the graph reproduced in Fig. 3, on this page. This shows that, between the wars, the relationship in the price of the different metals never changed significantly, but now things are very different.

Aluminium, the price of which has remained fairly stable for a long time, is now much cheaper than copper and zinc. While it is unlikely that the prices of copper and zinc have yet found their true post-war levels, it is still more unlikely that they will ever drop so much that they will compete as favourably with aluminium as they did before the war. Furthermore, as world production increases, the price gap between the old and the new metals might even widen. Thus, the average costs of copper, zinc and lead might be expected to rise as output mounts, since new production may come from lower-grade ores from which it will be more expensive to extract the metal. On the other hand, the raw materials for aluminium and magnesium are abundant and cheap, and the prospects for increasing the supply of electric power, the main component in the cost of production, are almost limitless in some parts of the world. Magnesium is another metal which is likely to be very important in the future, both for its properties and its comparatively low price. At present its price per pound in the United Kingdom is about twice that of aluminium, but its specific gravity is only 1·7 compared with 2·7, so its price per cubic foot is not much greater. Incidentally, the price of magnesium is now much higher here than a year ago, probably because of the sudden increase in demand as a result of the rise in rearmament, but in the United States its price is only 35 per cent. higher than that of aluminium. At the end of the war huge stocks were left over, so production virtually ceased and has only just started again. The significance of the low price of aluminium and magnesium when compared with the older metals on a volume basis is shown in Fig. 4, on this page, which illustrates the yearly average British metal prices, since 1938, in pounds sterling per cubic foot.

From all this it is clear that we are now faced with an entirely different pattern of consumption from that which prevailed between the wars, and that more and more non-ferrous metals are becoming available for general use. The indications are that, as consumption grows, aluminium and magnesium will take an increasing share of it, and thus the rise in the consumption of copper, zinc, lead and tin is likely to be less steep than the rise in industrial production throughout the world. This has already occurred in the United Kingdom, where industrial production from 1946 to 1950 rose some 40 per cent., but the consumption of various metals rose by very different percentages, namely, aluminium 56, zinc 13, copper 6, and lead 3; tin consumption actually fell. Hitherto, a certain conservatism has caused the older metals to be chosen for many purposes because they have always been so used. Now, however, aluminium is getting a tradition of its own which will tend to increase its use at the expense of the older metals, and the same applies in a lesser degree to magnesium. The fact is that there are perhaps many applications in which the older metals could be replaced by aluminium or magnesium, and the extent to which the switch over will take place will depend mainly on the price and availability of the older metals. These, however, may feel the pressure from aluminium rather less because the latter has a competition of its own with steel which may divert its supplies. Titanium, again, is another metal for which a great future is predicted, though it seems likely to compete more with steel than with the non-ferrous metals. Plastics already compete with metals in many respects and may make big inroads into the non-ferrous field.

*(To be continued.)*

* It is difficult to assess the change in the value of money at all accurately, but the following figures are based on the United Kingdom Wholesale Price Indices published by *The Economist*: 1913 Index = 100; 1920 Index = 283; 1930 Index = 125; and 1938 Index = 127.

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Gauge and Tool Makers' Association: Craftsmanship Competition.—The first competition in craftsmanship and draughtsmanship, held by the Gauge and Tool Makers' Association in May, was so successful that it has been decided to hold another in 1952, for apprentices and learners attached to member firms. Detailed particulars will be announced later.

## ANNUALS AND REFERENCE BOOKS.

*The Electrician Red Book: Electricity Undertakings of the World.* 61st edition, 1951-52.—In dealing with last year's edition of this useful annual, we pointed out that during its existence it had undergone many changes of form. This year another alteration has been made, the information being no longer given in the form of tables. Moreover, particulars now appear regarding the personnel and other details of Electricity Commissions, Boards and Authorities. As time goes on, it is felt, this type of information will become more important than systems operational data, since the latter will change less owing to the increasing tendency towards standardisation. For the rest, the arrangement follows that adopted for the first time last year and covers information regarding British generating stations according to Divisions, the organisation of the Area Boards with the towns served by the various district organisations, and particulars of the system of supply. Similar, although not such complete information, is given regarding the Channel Islands and Isle of Man, as well as of certain undertakings in the British Commonwealth and foreign countries. The latter is, however, by no means comprehensive, and is often meagre so that, on this score, the criticism might well be made that the new title is misleading. We note that the output of the generating stations is still given in megawatts. This is both incorrect and confusing. The *Red Book* is published by Benn Brothers, Limited, 154, Fleet-street, London, E.C.4, at the price of 30*s*., post paid.

## LAUNCHES AND TRIAL TRIPS.

S.S. "Beltinge."—Single-screw cargo vessel, built and engined by William Gray & Co., Ltd., West Hartlepool, for Constants (South Wales), Ltd., London, E.C.2. First vessel of an order for three. Main dimensions: 340 ft. overall by 46 ft. 6 in. by 24 ft. 3½ in. to upper deck; deadweight capacity, 4,628 tons on a mean draught of 20 ft. 6 in. Triple-expansion steam engine developing 1,250 i.h.p. at 75 r.p.m., and two oil-fired boilers. Service speed, 10½ knots. Trial, October 12.

M.S. "Croydon."—Single-screw collier, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the South Eastern Gas Board, Croydon, Surrey. Main dimensions: 264 ft. 6 in. between perpendiculars by 39 ft. 6 in. by 18 ft. 6 in.; deadweight capacity, 2,825 tons on a draught of 17 ft. 1 in.; gross tonnage, about 1,870. British Polar eight-cylinder marine Diesel engine, developing 1,150 b.h.p. at 225 r.p.m., constructed by British Polar Engines, Ltd., Glasgow, and installed by the shipbuilders. Speed, about 10¾ knots. Launch, November 1.

S.S. "Kingston Jacinth."—Single-screw trawler built by Cook, Welton and Gemmell, Ltd., Beverley Yorkshire, for the Kingston Steam Trawling Co., Ltd. Hull. Dimensions: 189 ft. by 32 ft. by 16 ft. 3 in.; gross tonnage, 750; fishroom capacity, 15,750 cub. ft. Triple-expansion steam engine to develop 1,100 i.h.p. at 130 r.p.m., and one multitubular oil-fired boiler, constructed and installed by Charles D. Holmes & Co., Ltd., Hull. Speed, 13 knots, loaded. Launch, November 3.

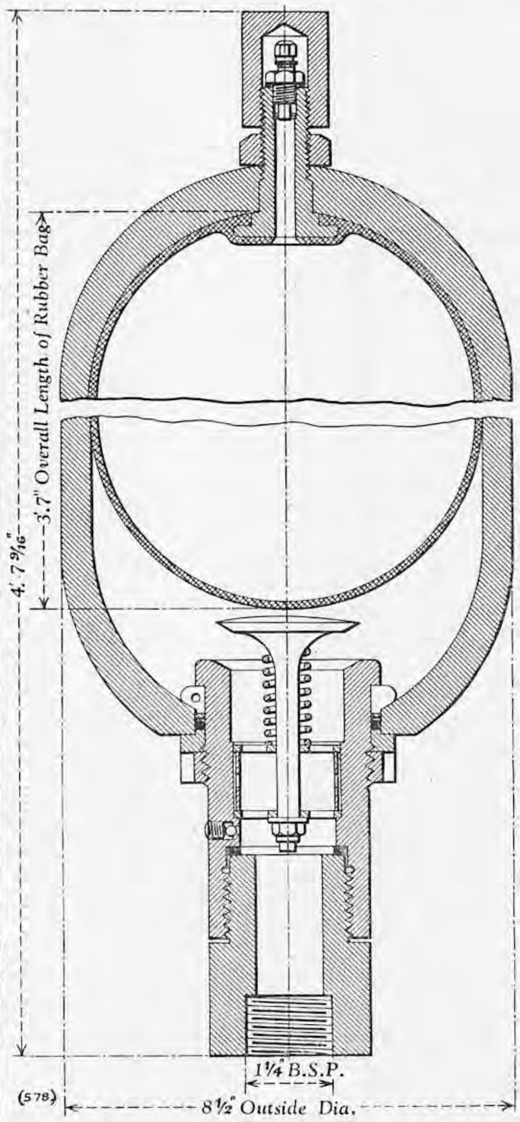
M.S. "Eskwood."—Single-screw cargo vessel, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the Constantine Shipping Co., Ltd., Middlesbrough. First of two similar vessels. Main dimensions: 214 ft. 6 in. between perpendiculars by 35 ft. 4 in. by 16 ft.; deadweight capacity, 1,675 tons on a draught of 15 ft. 8½ in.; gross tonnage, 1,273. Four-cylinder two-stroke trunk-piston direct-reversing Diesel engine, developing 640 b.h.p. at 250 r.p.m., constructed by British Polar Engines, Ltd., Glasgow, and installed by the shipbuilders. Speed, 10 knots. Trial trip, November 5.

M.S. "France Stove."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Belfast, for the Lorentzens Rederi Co., Oslo, Norway. Main dimensions: 580 ft. between perpendiculars by 78 ft. by 42 ft. 6 in. to upper deck; deadweight capacity, 24,000 tons on a draught of about 32 ft. Harland-B. and W. seven-cylinder two-stroke single-acting oil engine. Trial trip, November 10.

S.S. "Hackney."—Single-screw collier, built by S. P. Austin & Son, Ltd., Sunderland, for the British Electricity Authority, London, W.1. Last vessel of a series of three. Main dimensions: 260 ft. between perpendiculars by 39 ft. 6 in. by 18 ft. 6 in.; deadweight capacity, about 2,700 tons on a draught of 17 ft. 1 in. Direct-acting triple-expansion engine of North Eastern reheat type, developing 800 i.h.p. at 78 r.p.m., constructed and installed by George Clark (1938), Ltd., Sunderland, and one coal-burning three-furnace boiler. Service speed, 10½ knots. Launch, November 14.

## HYDRAULIC ACCUMULATOR.

The accompanying illustration shows in section the Greer-Mercier hydraulic accumulator, now being made under licence in this country by Messrs. Finney Presses, Limited, Berkley-street, Birmingham, 1, for industrial and marine-engineering applications. It is of the hydraulic-pneumatic type, in which a flexible bag inflated with air or nitrogen to a predetermined pressure is contained in a hydraulic pressure vessel. A pump compresses the gas in the inner bag, thus storing energy which is imparted to the fluid (water or oil) under pressure. The cylindrical outer casing is drawn from a single piece of alloy steel. Into the top of the synthetic-rubber bag is moulded a high-pressure air valve, secured to one end of the outer casing; the bag is designed so as to ensure that no severe stress concen-

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trations occur in the envelope as the gas expands when the system is on load. At the opposite end of the cylinder is the fluid port through which the accumulator is charged and discharged. It is designed to provide an unrestricted flow of oil, and is fitted with a spring-loaded poppet valve to prevent the flexible bag from being extruded through the outlet port as the hydraulic pressure is exhausted. The Greer-Mercier accumulator is suitable for pressures ranging from 500 lb. to 3,000 lb. per square inch and for operating in a temperature range of from − 40 deg. F. to 180 deg. F. At present the accumulator is available with a capacity of six gallons; it is intended, however, to extend the range to cover capacities from half a gallon to 10 gallons.

The F. B. Richards Equipment Fund, Leeds University.—To mark the retirement of Mr. F. B. Richards from the chairmanship of the Woodall-Duckham Group of Companies, after nineteen years of service in that capacity, the directors of The Woodall-Duckham Vertical Retort and Oven Construction Company (1920), Limited, 63-77, Brompton-road, London, S.W.3, have arranged to make a grant of 1,000*l*. per annum under a seven-year covenant to create an equipment fund for the Department of Coal Gas and Fuel Industries with Metallurgy at the University of Leeds. The capital from the fund will be utilised for the purchase of equipment for the department.

## BOOKS RECEIVED.

*Electrical Engineering Economics. Vol. II. Costs and Tariffs in Electricity Supply.* By D. J. Bolton. Second revised edition. Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 30*s*. net.]

*Passenger Transport in Glasgow and District.* Report of the Glasgow and District Transport Committee. British Transport Commission, 7, Castle-terrace, Edinburgh, and 55, Broadway, London, S.W.1. [Price 7*s*. 6*d*. net.]

*Productivity Report. Metal Finishing.* Report of a visit to the U.S.A. in 1950 of a specialist team representing the British metal-finishing industry. Anglo-American Council on Productivity, 21, Tothill-street, London, S.W.1. [Price 3*s*. 6*d*. post free.]

*The Earnings of Industry. The Truth about Prices and Profits.* 1951-52 edition. Compiled by Aims of Industry, Limited. Hollis and Carter, Limited, 25, Ashley-place, London, S.W.1. [Price 4*s*.]

*United States National Bureau of Standards.* Circular No. 512. *Methods of Measuring Humidity and Testing Hygrometers.* By Arnold Wexler and W. G. Brombacher. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 15 cents.]

*Annual Report (Technical) of the Central Board of Irrigation, India.* 1947. Parts I and II. Edited by N. D. Gulhati. The Secretary, Central Board of Irrigation, Kennedy House, Simla S.W., India.

*F.B.I. Register of British Manufacturers,* 1951-52. Kelly's Directories, Limited, 186, Strand, London, W.C.2, and Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 42*s*., post free.]

*The Monopolies and Restrictive Practices Commission. Report on the Supply of Electric Lamps.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 6*s*. net.]

*Department of Scientific and Industrial Research. Road Research.* Technical Paper No. 23. *Analysis of Plastic White Line Compositions made with Fluxed Rosin Binder.* By C. M. Gough and E. H. Green. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s*. net.]

*The Manufacture of Iron and Steel. Vol. II. Steel Production.* By G. Reginald Bashforth. Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 45*s*. net.]

*Surface Defects in Ingots and their Products.* (Recommended Definitions.) Prepared by the Ingot Surface Defects Sub-Committee (Steelmaking Division) of the British Iron and Steel Research Association. The Iron and Steel Institute, 4, Grosvenor-gardens, London, S.W.1. [Price 15*s*. to members, 25*s*. to non-members.]

*Typical Microstructures of Cast Iron.* The British Cast Iron Research Association, Alvechurch Birmingham. [Price 15*s*. to members, 21*s*. to non-members.]

*The Iron and Steel Trades in* 1951. *Special Review.* William Jacks and Company, Limited, Winchester House, Old Broad-street, London, E.C.2, and the Metal Exchange, London, E.C.3. [Price 5*s*.]

*A Practical Manual of Rubber Hardness Testing.* By A. L. Soden. Maclaren and Sons, Limited, Stafford House, Norfolk-street, London, W.C.2. [Price 6*s*. 6*d*., post free.]

*Model Steam Locomotives.* By Henry Greenly, revised by Ernest A. Steel. Cassell and Company, Limited, 37-38, St. Andrew's Hill, London, E.C.4. [Price 15*s*. net.]

*King's Manual of Gas Manufacture.* Section 2. Containing Chapter III. *Continuous Vertical Retorts.* Chapter IV. *Intermittent Vertical Retorts.* By T. A. Tomlinson. [Price 7*s*. 6*d*. net, postage 3*d*.] Section 3, containing Chapter V. (i) *Water Gas.* (ii) *Complete Gasification.* By Dr. F. J. Dent. [Price 7*s*. 6*d*. net, postage 3*d*.] Walter King, Limited, 11, Bolt-court, Fleet-street, London, E.C.4.

*Punched Cards. Their Applications to Science and Industry.* Edited by Robert S. Casey and James W. Perry. Reinhold Publishing Corporation, 330, West 42nd-street, New York 18, U.S.A. [Price 10 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 80*s*. net.]

*Bayernwerk Aktiengesellschaft. Bayerische Landeselektrizitäts-versorgung. Geschäftsbericht über das neunundzwanzigste Geschäftsjahr vom 21 Juni 1948 bis 30 September 1949. Geschäftsbericht über das dreizigste Geschäftsjahr vom 1 Oktober 1949 bis 30 September 1950.* Bayernwerk A.G., Bayerische Landeselektrizitatsversorgung, Munich, Germany.

*Les Barrages en Terre.* By Ch. Mallet and J. Pacquant. Editions Eyrolles, 61, Boulevard Saint-Germain, Paris (5e), France. [Price 2,500 francs.]

*Lecciones Elementales de Elasticidad con Aplicacion a la Tecnica de la Construccion.* By Professor Eduardo Torroja. Editorial Dossat, S.A., Plaza de Santa Ana 9, Madrid, Spain. [Price 150 pesetas.]

*Problems of Motor Vehicle Suspension.* By Alan Hodgson. Richard Berry and Son, Smethwick, Staffordshire. [Gratis].