# ENGINEERING IN THE FESTIVAL OF BRITAIN.*

## VIII.—EXHIBITION OF INDUSTRIAL POWER, GLASGOW.

THE Exhibition of Industrial Power in the Kelvin Hall, Glasgow, is Scotland's principal contribution to the Festival of Britain. It is not a trade exhibition, but an attempt to tell the story of Britain's contribution to heavy engineering. As heavy engineering is the "conquest of power", and coal and water are the two main sources of that power in Britain, the exhibits are fittingly arranged in two sequences dealing with these two sources. and the two unite in the Hall of Railways and Shipbuilding. The whole display occupies an area of some 20,000 sq. ft. The exhibition is to remain open until Saturday, August 18.

The coal sequence begins with coal mining and is followed by the Steel Hall, in which not only raw and finished materials, but machine tools, are shown, Steam and other types of engines are exhibited in the Power for Industry Hall, which comes next, while the generation, transmission and utilisation of electricity are dealt with in the Hall of Electricity. Similarly, the water sequence opens with the Hall of Hydro-Electricity, moves on through civil engineering, and ends with irrigation. Atomic energy is dealt with in a final hall.

The principal exhibit in the Hall of Power, which forms the entrance to the exhibition, is a black sculptured mural 105 ft. long, which is designed to show the latent possibilities of coal and to urge men to win this fuel and make it their servant. As a symbol of this source of power there is a "sun," which contains over 500 filament and mercury-vapour lamps giving an illumination of more than 750,000 candle power. Photo-flash equipment is provided to give the effect of sun spots from the centre to the surface of the sphere, while the lighting is so arranged that a moving shadow is formed, with the result that it appears that the "sun" is rotating. On the other side of the hall is a glass tunnel over which 20,000 gallons of water flow per minute and which encloses the stairway into the water sequence.

From the "sun" in the Hall of Power the visitor passes into the Hall of Coal, in which the progress from the primeval swamp to the modern mechanised mine is illustrated, in, among other ways, a mural legend, which shows how Britain, by being the first to bring together coal for fuel and smelting, iron for engines and machines and steam for motive power, inaugurated the Machine Age. The geological formation of coal is shown diagrammatically. A short descent can be made in a mine cage to a dark room showing the colliery conditions of two centuries ago. This is followed by a model mine, in which mechanical coal cutters and loaders are employed, while present-day organisation is illustrated by diagrams dealing in particular with rescue work and the rehabilitation of the injured. An "exploded" model shows the layout of a pit-head and the aids to safety exhibited include an automatic methane detector, which is set to operate in the presence of fire-damp in the atmosphere of a mine, a fire-damp recorder and flame safety lamps.

The visitor to the Kelvin Hall will find that the guide-catalogue gives a list of exhibits and the firms or trade associations who have lent them; at the South Bank the guide book and catalogue are separate publications. The historical exhibits in the Coal Hall include old picks, an original Davy lamp, and a model of the original Baird chain coal-cutter. Present-day mining machinery is represented by a number of cutters, loaders, conveyors, etc., which are described below.

Fig. 115, on this page, shows the Ace longwal coal cutter made by British Jeffrey-Diamond[1], Limited, Stennard Works, Wakefield, Yorkshire; at the exhibition there is also an Ace gummer, which is an automatic kerf cleaner. The Ace cutter, which is either electrically or pneumatically driven, is of unit construction, the principal units being the sliding jib and cutter chain, supplied in various lengths to suit the depth of undercut required; the cutting unit; the driving unit; and the haulage unit. The three latter units are spigot-faced and are held together by high-tensile steel bolts. The haulage unit provides a variable slow speed for cutting and a reversing fast speed for "flitting"; the maximum rope pull is normally 12,000 lb., an automatic feed and safety device coming into play whenever the predetermined rope pull is exceeded. The rope drum takes 25 yards of $\frac{5}{8}$-in. diameter wire rope. In the case of the compressed-air machine, the driving unit incorporates two rotors, which are a pair of double-helical gears, housed in a cylinder or casing with a patented form of contour designed to give a quieter and more gentle release of air from the rotors and to maintain the full power of the turbine even with moist air. The velocity of the exhaust air is considerably lowered and the tendency to freezing is reduced. The power of the turbine is 60 h.p. In the case of an electrically-driven machine a 60-h.p. motor (one-hour rating) is used; it runs at 1,475 r.p.m. on a three-phase 50-cycle supply. The starting torque is $2\frac{1}{2}$ times the full-load torque.

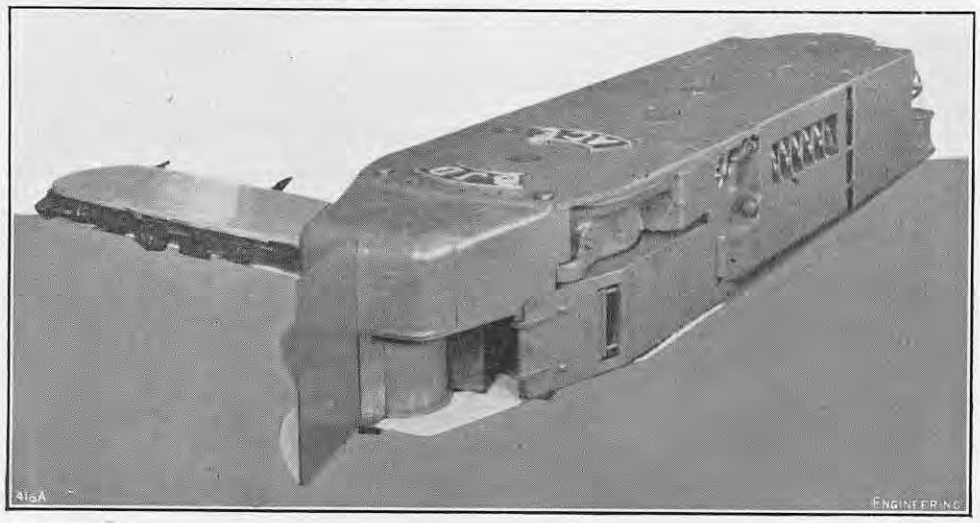


FIG. 115. "ACE" LONGWALL COAL CUTTER; BRITISH JEFFREY-DIAMOND, LIMITED.

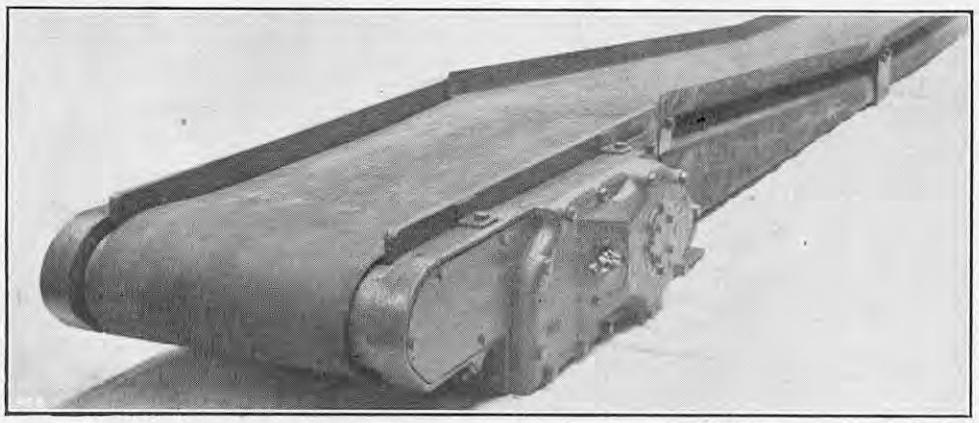


FIG. 116. 26-IN. TOP-LOADING FACE CONVEYOR; BRITISH JEFFREY-DIAMOND, LIMITED.

The cutting unit is arranged to allow ample clearance space for the cuttings, thus enabling the machine to cut freely without close shovelling. The jib can be locked in any of three positions, namely, at either side for cutting right or left hand, or in line with the machine for flitting or other manœuvring. The machine can be arranged for floor-level or dead floor-level undercutting, or for overcutting. In the latter case, two types of turret head are available: a low type to cut at a height of $11\frac{1}{2}$ in. from the floor level, and a high type to cut at a height which is variable from 18 in. to 25 in. The Ace gummer, which is fitted to the coal cutter, is applicable to all seam conditions; the cuttings brought out by the chain are immediately swept clear and discharged in a neat pile. Cogging and timbering are not interfered with—face timbers can, in fact, be set within 12 in. of the cutter chain—and the cuttings are not deflected to such an extent as to encroach unduly on the conveyor track.

The British Jeffrey-Diamond face belt conveyor in the Kelvin Hall is the R/9/1 model, which is 17 in. high to the coal line, and is available with belts from 20 in. to 26 in. wide; the minimum belt speed is 170 ft. per minute. The driving unit is either a 15-h.p. three-phase motor, or a 15-h.p. Spiro compressed-air turbine with a high starting torque. The drive head, which is shown in Fig. 116, herewith, forms the delivery end of the conveyor, and the motor or turbine is an integral part of it. The conveyor can be arranged on a left-hand or right-hand face without any structural alteration; gate side packs can be kept closer to the face than is possible with a gear-head having the power unit mounted at the side; the whole gear is compact for moving over and stelling; and there is not the same tendency to distortion when the gear is stelled as there is with a drive head which has the power unit mounted separately alongside. The intermediate structures for this conveyor are of the semi-troughed type, either open or with a fully-covered bottom belt. A standard tail end or a self-cleaning tail end can be used.

The Python conveyor which has been lent by Messrs. Hugh Wood and Company, Limited, Gateshead-on-Tyne, 11, is illustrated in Fig. 117, on page 34, which shows its flexibility. It is made in three forms: two light types and a heavy type. It can be used with advantage where any of the following methods of work are being undertaken: on coal-plough and slicer-machine faces; on coal cutting and filling faces, including power-loader and cutter-loader faces; on pneumatic-pick and hand-got faces; and on faces where, in special circumstances, the coal is shot off the solid. The construction of the conveyor sections permits them to conform closely to the contour of the coal face during the loading period, and they are also capable of operating in undulating conditions. The con-

* Previous articles in this series, on the Dome of Discovery, the Royal Festival Hall, the temporary bridges, the "Skylon," civil-engineering work, and exhibits at the South Bank Exhibition, appeared in the previous volume of ENGINEERING (vol. 171), in the issues of April 13 and 20, May 4, 11 and 18, and June 1, 8, 15, 22 and 29, 1951.

# EXHIBITS AT THE EXHIBITION OF INDUSTRIAL POWER, GLASGOW.

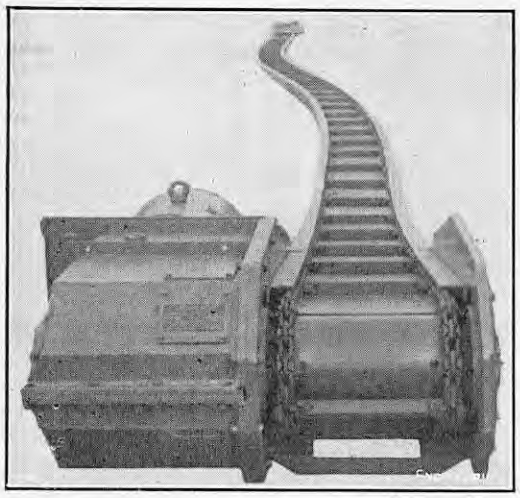


FIG. 117. "PYTHON" 30-IN. CONVEYOR; MESSRS. HUGH WOOD AND COMPANY, LIMITED.

veyor can be pushed bodily forward towards the face—an operation which can be performed while the conveyor is working—and it can be maintained close to the working face. As the illustration shows, it is not essential for the conveyor to be maintained in a straight line; indeed, on coal-plough faces it is the usual practice to move up to the face only that portion of the conveyor over which the plough has already travelled and loaded the coal. Thus, the supports can be adjusted early, which is a most important consideration. The drive head incorporates a motor, gearbox, and sprocket arrangement which drives the conveyor chains. Where more than one power unit is used on a conveyor, the drive from the motors is taken through fluid couplings to equalise the load, but where a single power unit is used a fluid coupling or a flexible bobbin coupling can be fitted.

A 26-in. gate tail-end (Fig. 118, herewith) and a 30-in. fixed tail end (Fig. 119) have been provided by Messrs. Richard Sutcliffe, Limited, Horbury, Wakefield. The gate tail-end has been designed for easy and quick extension in extending gate roads. It has a telescopic section which enables the return box and hopper section to be drawn back 4 ft. 6 in. When this section has been pulled out to its limit, a 3-ft. section and/or a 6-ft. section of fully-troughed framework can be inserted between the last stool and the tail-end. The low construction of the tail-end enables the feed from the face conveyors to be made directly to the belt without undue packing up of the face gear-heads. The unit can be quickly dismantled into three parts for ease of handling. The hopper section is 9 ft. in length and is split into one 6-ft. unit and one 3-ft. unit; the latter can be removed if a short hopper section is required. The overall length of the tail-end is 11 ft. 8 in.; the width is $8\frac{3}{4}$ in. wider than the belt; and the height is $19\frac{1}{8}$ in. over the hopper section.

Fig. 119 shows Messrs. Sutcliffe's 30-in. fixed tail-end with a low-type hopper incorporating impact idlers. It has been designed for use at the coal face in thick seams and on trunk conveyors in tandem, either in line or at an angle. The impact section, of three rollers immediately in advance of the tail-end box, forms a cushion for the belt and prevents falling material from damaging it. The hopper plates, 13 ft. $1\frac{1}{2}$ in. long, in two sections, ensure that the material has come to rest centrally before it is carried along the run of the conveyor. The tail-end box houses a 12-in. diameter return drum, and two D-links are fitted to the rear of the tail-end for attaching chain tensioners. The overall length of the tail end is 15 ft. 6 in., and the height from the covering over the hopper to floor level is 2 ft. 8 in. for a 30-in. belt.

The A. B. Meco-Moore cutter-loader, made by Messrs. Anderson, Boyes and Company, Limited, Motherwell, Scotland, and the Mining Engineering Company, Limited, Worcester, which is illustrated in Fig. 120, opposite, is, like the other exhibits, a well-established item of mining equipment. It is designed for simultaneous cutting and loading on longwall faces in both directions. The machine comprises a cutting portion and a loading portion, coupled by a strong hinge connection. The cutting portion consists of an Anderson Boyes longwall coal cutter arranged with both undercutting and overcutting jibs, and incorporating twin 60-h.p. motors arranged side by side in one housing. One of the motors drives the coal-cutting section of the machine, and the other the loading portion and the shearing jib. Both motors drive into the gear-head of the machine, where one drive is arranged through gearing to the coupling shaft of the loader. The drive from the second motor is geared through to the top and bottom horizontal cutting chains. These chains may be engaged or disengaged by means of control spindles passing to the haulage end of the machine.

The loading end, manufactured by the Mining Engineering Company, Limited, consists of a projecting frame within which is mounted an endless rubber belt fitted with steel slats, each slat being attached, at its ends, by means of lugs, to driving chains which engage with sprockets on the driving shaft. In front of, and in line with, the loader frame is a loading bar which is separately driven and fitted with picks in double-helical formation. As the bar rotates, these picks pass through slots provided in the loading edge of the loading frame, and the loading bar lifts the bottom coal and transfers it to the loader belt. It also helps to break up the bottom coal into suitable sizes for loading. As the machine is designed to work in either direction, the loading bar arrangement is duplicated on the other side of the loader frame. A gummer of the single-worm type is fitted to the side of the delivery end of the loading structure, its function being to remove the gummings produced by the bottom cutting chain and to discharge them on to the face conveyor. The shearing jib, which is of triangular form, is mounted on the face end of the loader structure and is fitted at the apex with a gearbox which transmits power to the cutting chain through a detachable shaft. The shearing-jib assembly is mounted on a swivel joint attached to a rigid angle plate bolted to the loader structure; this simple and efficient device enables the shearing jib, complete with gearbox, to be turned fully round for shearing in the opposite direction. The machine weighs 10 tons.

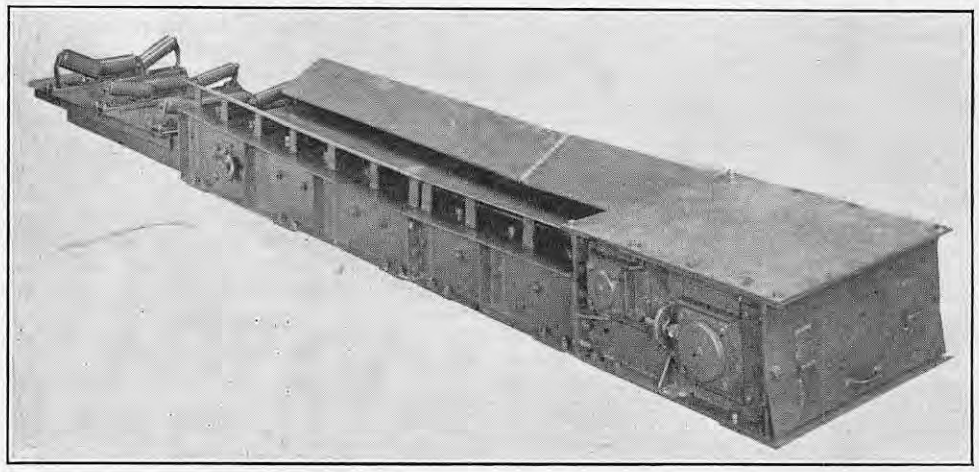


FIG. 118. 26-IN. GATE TAIL-END; MESSRS. RICHARD SUTCLIFFE, LIMITED.

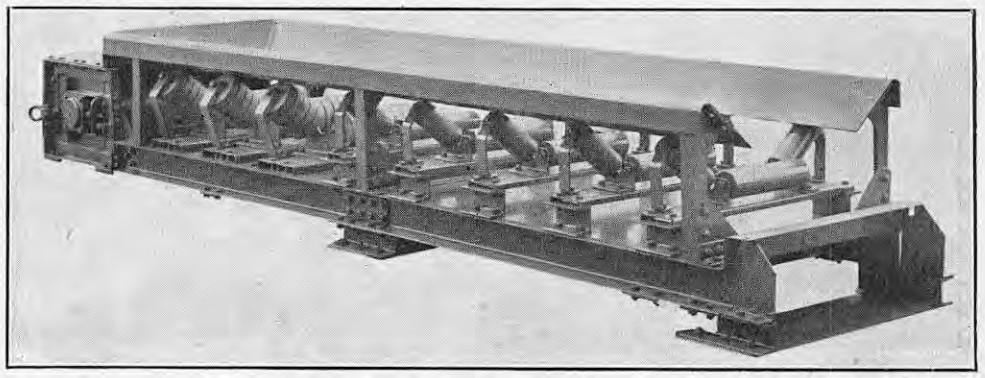


FIG. 119. 30-IN. FIXED TAIL-END; MESSRS. RICHARD SUTCLIFFE, LIMITED.

Messrs. Mavor and Coulson, Limited, Bridgeton, Glasgow, S.E., have lent a Samson loader, illustrated in Fig. 121, opposite, which is shown in conjunction with a troughed-belt conveyor. Normally, the loader is only $24\frac{1}{2}$ in. high to the deck of its conveyor, though its height can be altered for filling shuttle cars, tubs or mine cars. It can handle up to 4 tons a minute. Two gathering arms pull the coal or stone on to a flexible conveyor. The to-and-fro movement of the machine while loading is controlled by plate clutches. The loader is driven by an alternating-current motor, or a compressed-air turbine, as required. The motor is spigoted directly to the transmission gearcase, which is a steel casting stiffened by internal webs. To save height, the shafts are arranged side by side, instead of one above the other. The top halves of the bearing housings are removable, to allow the shafts to be lifted out complete with their bearings and gearing. The surface of the ramp is flat and smooth, so that none of the material can catch on it, and the crank discs, which move the mid-points of the arms, are sunk flush with the surface. The upper end of each of these arms slides in a Meehanite pivoted block. The receiving end of the conveyor is well below the surface of the ramp, forming a hopper which holds the material swept to it by the arms.

The crawler treads are 10 in. wide, and carry the loader steadily on the straight and round corners, on the level and up or down steep gradients. When turning sharply or slewing the jib suddenly, neither the loader nor the jib has any tendency to shake or "dance." Oil from a pump is admitted by piston control valves to jacks for raising the head, raising the jib, or slewing the jib. During loading, the gathering-head valve is held out by a catch, so that the head keeps on the floor by its own weight and follows the changes in floor level. When loading, the machine thrusts straight into the heap.

# EXHIBITS AT THE EXHIBITION OF INDUSTRIAL POWER, GLASGOW.

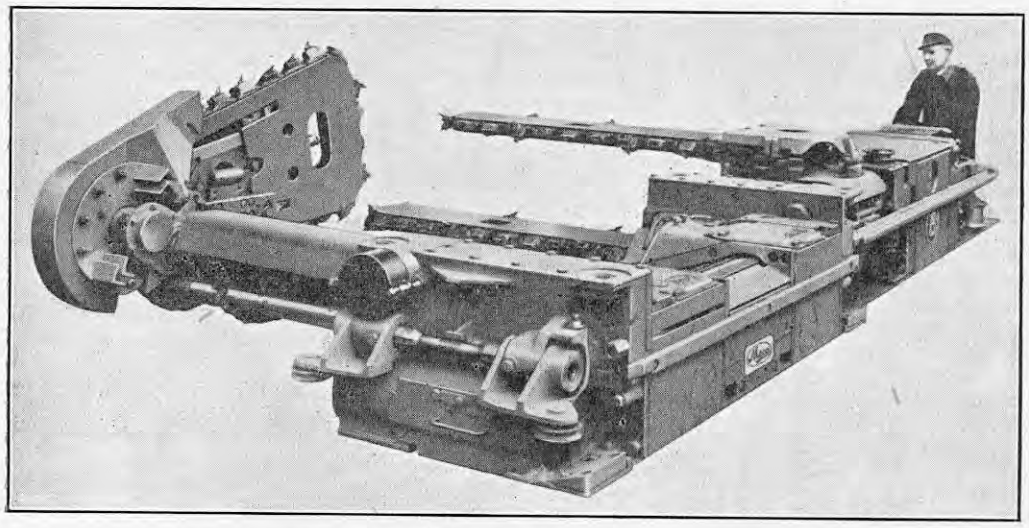


FIG. 120. "MECO-MOORE" CUTTER-LOADER; THE MINING ENGINEERING COMPANY, LIMITED, AND MESSRS. ANDERSON, BOYES AND COMPANY, LIMITED.

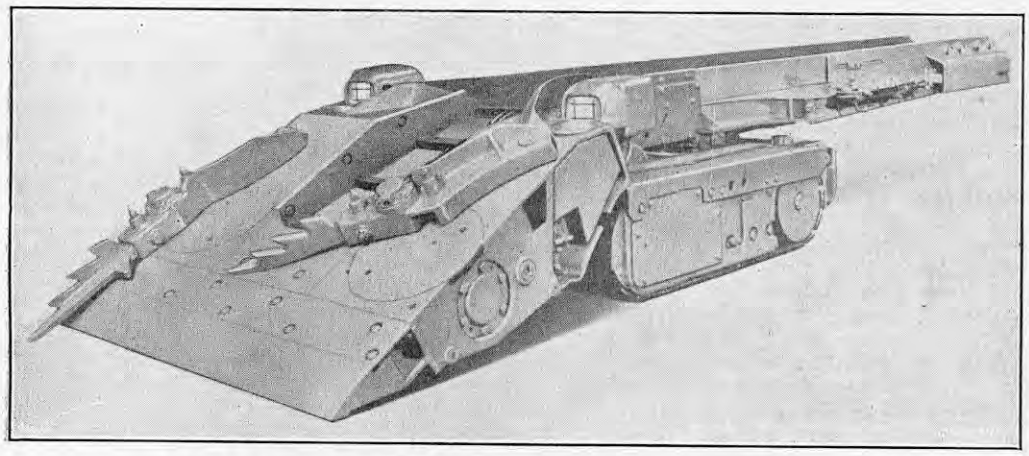


FIG. 121. "SAMSON" COAL LOADER; MESSRS. MAVOR AND COULSON, LIMITED.

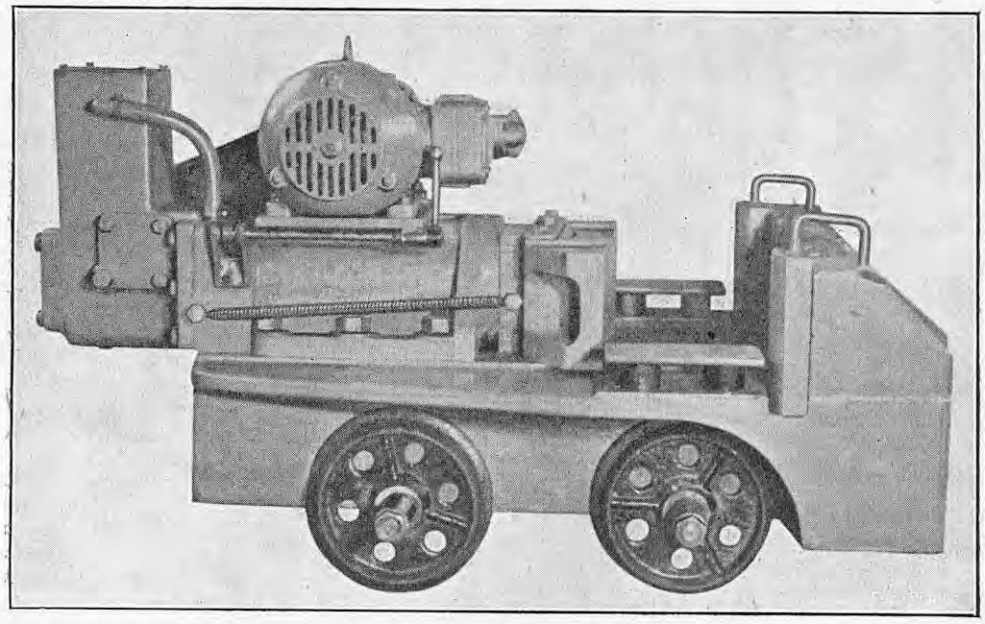
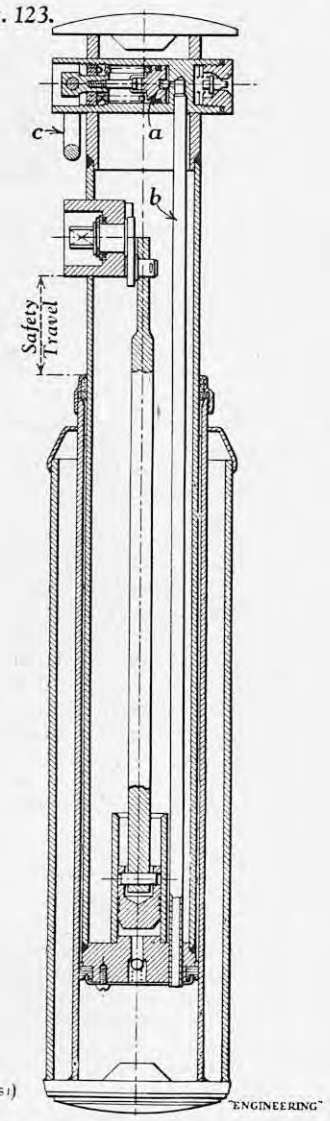


FIG. 122. HYDRAULIC PRESS FOR COLLIERY ROOF SUPPORTS; FINLAY CONVEYOR COMPANY, LIMITED.

The mobile hydraulic press shown in Fig. 122, herewith, is made by the Finlay Conveyor Company, Limited, Newport, Monmouthshire, for cold-bending steel sections, up to 60 lb. per yard, for roof supports. It is driven by a 3-h.p. flameproof motor. The press unit itself, which is also used on a number of different mountings, consists of a stationary crosshead, against which the section is bent; a hydraulic ram with return springs; a hydraulic cylinder; and the motor, oil cistern and pump. The machine is used for the reconditioning of colliery-roof supports.

Dowty Mining Equipment, Limited, Arle Court, Cheltenham, have supplied a number of hydraulic pit props for the Festival exhibitions. The design is illustrated in Fig. 123, herewith. In a paper read before the Institution of Mining Engineers last year, Mr. M. Fountain-Barber described the development of this prop. It comprises two concentric tubes: the outer pressure cylinder, within which slides the reservoir tube. The lower end of the latter is closed by a piston head which carries a bearing ring and a sealing gland. The pressure cylinder is enclosed in a further protective cylinder. A small pump is accommodated within the reservoir and is actuated by means of a connecting rod and a crank with a square external boss on which is fitted a removable handle. Actuation of the pump transfers oil from the reservoir to the pressure cylinder to extend the prop and set it at an initial load of 5 tons. Fluid pressure in the pressure cylinder is communicated to a "yield" valve *a* in the head of the prop by means of a pipe *b*, and when the roof weight exceeds 20 tons this valve relieves pressure by passing a small quantity of oil to the reservoir, thus permitting the prop to shorten. Resistance is maintained at 20 tons and yielding continues intermittently until the prop is withdrawn. When it is required to withdraw the prop, the release link *c* is pulled. This allows oil in the pressure cylinder to escape back to the reservoir and the prop to shorten. When necessary, this can be done from a safe distance by means of a light cable or chain. In effect, the prop is a compact self-contained hydraulic jack with the additional feature that it yields under a load of 20 tons. It is manufactured in various lengths from the smallest prop—18 in. when closed and with an extension of 5½ in.—up to the longest of 88 in. when extended, with a yield travel of 18 in. The prop can be set easily, quickly (before bed separation occurs), safely, and tight to the roof. When set, it offers a uniform resistance of 20 tons while accommodating convergence; also, all the props on the face offer identical resistance, thus preventing the break-up of the roof.

*Fig. 123.*




(*To be continued.*)

# RECOVERY OF SULPHUR FROM FLUE GASES.

By W. FRANCIS and G. H. LEPPER.

OWING to the serious shortage of sulphur and sulphuric acid now confronting the numerous industries which require these materials—a state of affairs that may get worse instead of better as far as present sources of supply are concerned—urgent consideration is now being given to various possible ways of meeting this situation and providing for the future needs of the country. Among such, the recovery of the large quantities of sulphur contained in the flue gases discharged into the atmosphere by power-station boiler houses and other large coal-burning or coking installations seems to offer promising prospects of eventually supplying a substantial proportion of the requirements. The present coal consumption of power stations alone is over 30 million tons per annum and the quantity is increasing by about 5 per cent. each year. The average sulphur content of the coal now being burnt is probably not less than 1·25 per cent. and may be even higher.

At least 92 per cent. of the sulphur oxides contained in flue gases can be removed by the non-effluent type of gas-washing plant which was installed at Fulham power station to comply with the conditions laid down when authority was given for the construction of a power station on that site. The gas-washing plant was closed down early in the war when it was suspected that the white plumes from the chimneys served as beacons for enemy aircraft. There are several known processes for recovering practically the whole of the sulphur contained in the sludge from the gas-washing plant and plans for the installation of a recovery plant at Fulham to produce sulphuric acid and cement clinker were in hand in 1938. Owing to the situation which arose after Munich, however, the idea was dropped.

Of the several processes for recovering saleable products from flue gases the four which appear to have the best prospects for immediate application on a commercial scale are, firstly, the production of ammonium sulphate by double decomposition. The calcium sulphate in the sludge resulting from washing flue gases with lime or chalk is converted to ammonium sulphate by digesting it with a solution of ammonium carbonate which is produced in large quantities as a by-product of the gas and coke-oven industries or, synthetically, for use with natural calcium sulphate (anhydrite) as in the I.C.I. plant at Billingham. Its application to flue-gas washing plants, using the strong ammoniacal liquor derived from coke ovens, is covered by British Patent No. 457,278 (H. Lessing) but the process, depending as it does on the existence of an adequate supply of the ammoniacal liquor in the vicinity of the gas-washing plant to obviate transport charges, would only be commercially applicable where boiler house and gasworks or coke-oven plant were reasonably close together.

Secondly, there is a process for the recovery of solid sulphur, liquid sulphur dioxide or sulphuric acid and cement. This process also uses lime or chalk (preferably the former) as the alkali, the calcium appearing in the cement in combination with silica. The calcium sulphate and sulphite contained in the sludge are roasted in a kiln with coal ash, clay or a mixture of both; the sludge then gives off sulphur dioxide in sufficient concentration to permit its conversion into elemental sulphur by passing it over hot coke. Alternatively, it can be converted directly into sulphuric acid by contact with a suitable catalyst. Decomposition of the calcium salts in the kiln is facilitated by the presence of alumina and silica which may be derived from the coal ash or clay. The silica and alumina combine with the residual quicklime to form Portland-cement clinker. If the quantities of calcium, aluminium and silicon are adjusted appropriately and the correct quantity of carbon is present, a good cement clinker is formed at temperatures of about 1,250 deg. C., the sulphur present appearing as sulphur dioxide. The proportions of the ingredients in the sludge can be readily adjusted to lie within the necessary limits, the clinker produced having properties of the standard laid down in the B.S. Specification for Portland cement, except as regards sulphur content which is somewhat too high. This excess of sulphur would not be sufficient to prevent the clinker from being saleable for various uses; indeed, the product would comply with Continental standards for Portland cement. Alternatively, it could be blended with cement clinker derived from limestone or chalk.

Both in England and Germany this process, using natural calcium sulphate as the source of calcium and sulphur, has been operated on a large scale for a number of years and it is to be applied more extensively here for the production of sulphuric acid and cement from native deposits of anhydrite. For producing these by-products from a gas-washing plant it should be economically sound to install small rotary cement kilns and recovery plant at power stations burning 1,000 tons of coal a day and upwards. At smaller power stations, down to those consuming not less than, say, 100 tons a day, a type of kiln more flexible than the rotary and less costly to operate would be desirable. A sintering process which was developed in Germany before the war would be suitable. Each unit of this type produces upwards of 10 tons of cement clinker a day, and it is practicable to connect a battery of them to a sulphur-recovery plant and thus obtain a high degree of flexibility to meet varying load conditions. Some of the earlier shaft kilns—such as the Dietzsch or Aalborg—could also be used economically for small plants.

Thirdly, the recovery of ammonium sulphate and sulphur is a direct process in which solutions of ammonium carbonate are used as the scrubbing medium. The methods have been developed to the pilot-plant stage. In one of these (British Patent No. 545,767, W. Francis) the end products are ammonium sulphate (more than 95 per cent.) and solid sulphur (less than 5 per cent.). The only addition to the gas-washing plant is that required for purifying and recovering the ammonium sulphate. Both the capital costs and operating expenses of such a process might well be below that of installations in which lime is used as the alkali; and its efficiency should be high. If exploited on a commercial scale this direct process, like the indirect process previously described for producing ammonium sulphate, in which lime is the alkali employed, would only be applicable at boiler houses situated close to coking plants or gasworks where sufficient quantities of the strong ammoniacal liquor were available.

In the fourth process sodium carbonate is used as the scrubbing medium to produce sodium sulphite and sulphate; the relative yield of each is controlled by the amount of oxidation that occurs during scrubbing. The products are allowed to accumulate in the system, little or no heat being required for the recovery of the crystalline salts from the purge of the gas-washing system. The recovered sodium salts can be used for industrial purposes, as in the paper-pulp industry, or they can be heated with chalk or waste calcium carbonate to regenerate the sodium carbonate used for scrubbing, with production of calcium sulphide. This sulphide is decomposed, as in the old Leblanc soda process, with carbon dioxide and water to produce hydrogen sulphide, which can then be converted into sulphur, sulphur dioxide or sulphuric acid by known processes. The precipitated chalk produced during this process is used again in the roasting operation, so that all the alkalis employed can be recovered for further use and it is only necessary to make up the losses inherent in such chemical engineering processes. The only saleable product is sulphur or some useful compound containing that element. The scrubbing plant required is much smaller than that needed when using lime or chalk and is simpler to operate as there is no possibility of scale formation, all the products formed being soluble in water.

Costing on the basis of 1937 prices for a sulphuric acid-cement plant in association with a non-effluent gas-washing installation of the Fulham type, capable of dealing with the gases from a boiler house burning 1,000 tons of coal a day, indicated that, whereas the gas-washing plant without recovery of by-products represented (in capital, operating and maintenance charges) an addition of nearly 3*s.* a ton to the cost of the coal consumed, this debit could be transformed into a credit of nearly 5½*d.* a ton by recovering sulphuric acid and cement and eliminating the cost of removing the sludge from the power station. Allowing for the increased present-day cost of the plant and the higher operating and maintenance charges, and taking into account the rise in the prices obtainable for the sulphuric acid and cement, such an installation should show appreciably better results than those indicated by these calculations.

A preliminary estimate of the post-war cost of recovering sulphuric acid from a large power station burning 2,000 tons of coal a day, with an average sulphur content of 1·5 per cent., shows that this would be approximately 7*l.* a ton, without credits for the value of the cement clinker produced or for the reduction in pollution of the atmosphere which would be effected. If the cement clinker be valued at 2*l.* a ton, the net cost of producing sulphuric acid would be approximately 5*l.* a ton. If full credit were allowed for the inevitable cost of the removal of grit from flue gases by electrostatic means, the cost of sulphuric acid would be materially lower. Moreover, the total capital cost involved would not be greater than for the equivalent-sized anhydrite sulphuric-acid plant and, indeed, should be less, since the collecting tanks used in the flue-gas washing could be used for mixing the cement-forming ingredients and no provision need be made for the storage of large stocks of anhydrite in the factory, or for the expensive grinding equipment for pulverising raw material.

Although there are obvious advantages in having the by-products recovery plant directly adjoining the gas washer, limitations of space at power stations may sometimes make it desirable to transport the gas-washer solids to a more convenient site for treatment. In such cases, and also where a number of small boiler houses have to be dealt with, a central recovery plant might be established, but in that event it would be desirable to dry the washer solids at the power station to reduce transport costs. Hitherto, gas washing at large boiler houses has been considered by the authorities almost entirely from the point of view of reducing atmospheric pollution. Important as it undoubtedly is to eliminate the sulphur oxides which do such extensive damage to buildings, injure vegetation and assist the formation of dirty fog, the country's urgent need of sulphur and sulphuric acid is to-day, and seems likely to be in the future, a compelling reason why the bulk of the hundreds of thousands of tons of sulphur now being discharged into the air each year by power stations and other large coal-burning and coking plants should no longer be allowed to go to waste. In 1950 our imports of sulphur from the United States amounted to more than 438,000 tons, and, according to the official trade returns, were valued at nearly 4·4*l.* millions. The cost had to be paid in dollars; only a few hundred tons were obtained from other oversea sources. We also imported nearly 200,000 tons of pyrites, valued at more than 853,000*l.*

Owing to the increased demand for sulphur throughout the world, particularly in the American home market, we shall be fortunate if we receive 375,000 tons of sulphur from the United States this year—a drop of about 15 per cent. from last year's imports from that source. Taking sulphur and pyrites together, about 5·25*l.* millions were spent last year on imports of these materials. At least half this sum could be knocked off what must again be an adverse balance of overseas trade in the course of a few years by the steady pursuit of a long-term programme of installing gas-washing and recovery plants at power stations. Several such installations could be put in yearly at major power stations without undue strain on capital resources, manufacturing capacity or man-power if the project were given the necessary degree of priority by the Government. As a beginning, and to give the process a thorough trial, a recovery plant might be put in instead of grit-arresting equipment at one or two of the new power stations now being built, and if the results proved satisfactory a gradual programme of application to existing major power-station boiler houses could be put into effect. The requisite technical ability to design and install the

# PRINTING MACHINERY AT DÜSSELDORF.

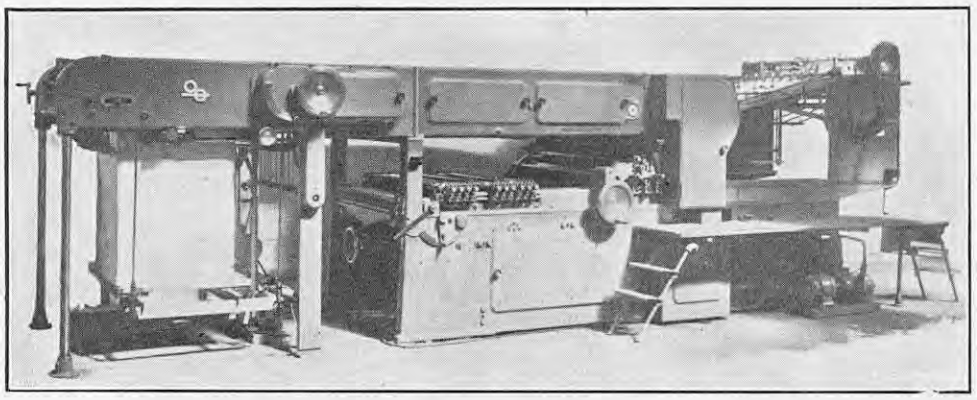


FIG. 1. TWO-REVOLUTION PRINTING PRESS; KOENIG UND BAUER, A.-G.

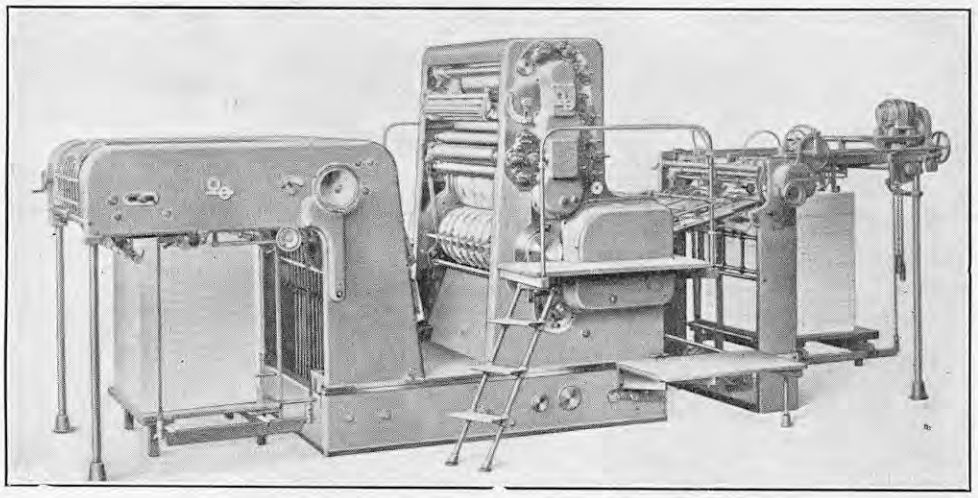


FIG. 2. SHEET-FEED ROTARY PRINTING PRESS; KOENIG UND BAUER, A.-G.

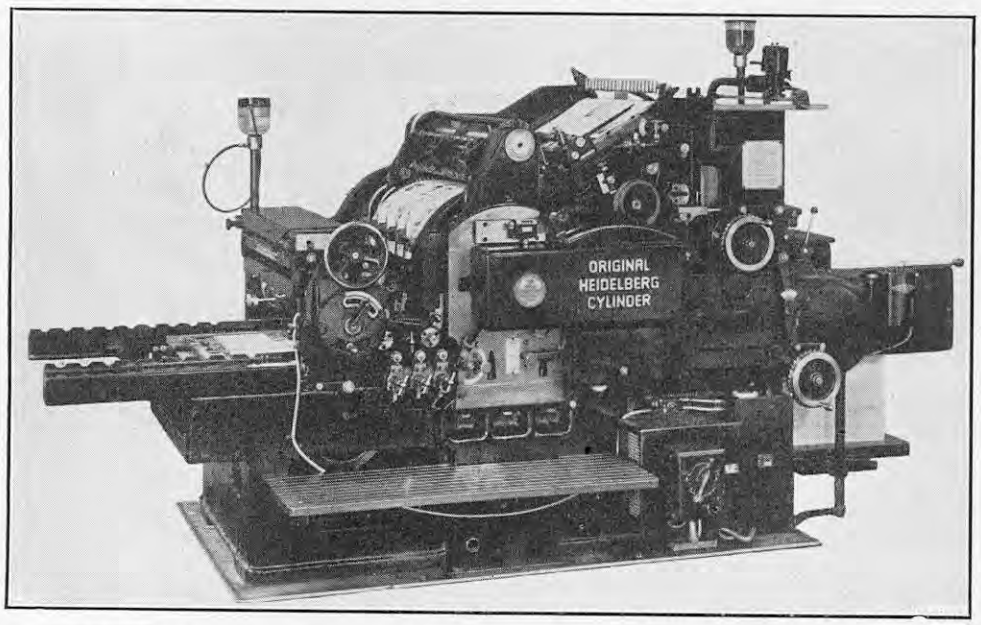



FIG. 3. CYLINDER PRINTING MACHINE; SCHNELLPRESSENFABRIK HEIDELBERG.

plant certainly exists, and if manufacturers in this country are too busy with rearmament and other high-priority activities to supply the equipment it could be obtained from the Continent. The capital cost of such installations at present prices cannot be small, but there is good reason to believe that it would not be greater, and might even be less, than that of plants of equivalent output of the kind which are to be used for mining and treating anhydrite.

INSTITUTE OF PHYSICS RADIOLOGY EXHIBITION.—In connection with the summer meeting of the Industrial Radiology Group of the Institute of Physics, an exhibition will be held at the Institute's headquarters, 47, Belgrave-square, London, S.W.1, on Monday, July 23, from 2 p.m. to 5.30 p.m.; on Tuesday, July 24, from 10 a.m. to 6 p.m.; and on Wednesday, July 25, from 10 a.m. to 4.30 p.m. The exhibition, admission to which will be free, will include sections on gamma-ray sources and containers, protection, stereography, tracer-autoradiography and microradiography, the history of X-ray tubes, and applications of radiography. Further particulars may be obtained from the secretary of the Institute at the address given above, or from Mr. B. N. Clack, Radiochemical Centre, Amersham, Buckinghamshire.

# PRINTING AND ALLIED MACHINERY AT THE DÜSSELDORF EXHIBITION.

By DAVID EYRE, A.M.I.Mech.E.

THE International Printing and Paper Fair (Drupa), which was held in Düsseldorf, Germany, from May 26 to June 10, was a break-away section of the Leipzig Fair and dealt with all aspects of paper and printing. The exhibition was ideally situated on the eastern bank of the Rhine, in and adjoining a public park known as the Hofgarten, and was housed in 17 halls. The scope of the exhibition was very comprehensive, there being shown composing machines, printing machines, paper and board converting or processing machinery, as well as numerous items of auxiliary equipment. The total number of exhibitors was about 480, of which 50 or 60 were foreign. Mr. H. H. A. Sternberg, chairman of Schnellpressenfabrik A.-G. Heidelberg, was president of Drupa.

A printing machine designed in 1811 by Koenig und Bauer A.-G., Würzburg (represented in this country by Mr. K. S. Paul, c/o Messrs. Neill Malcolm and Company, Limited, 55, Bishopsgate, London, E.C.2) was shown in the entrance hall leading to the printing section of the exhibition. This machine was built for *The Times*, which was thus the first newspaper in the world to install a mechanical printing press. On November 29, 1814, the first edition printed on the first machine to be driven entirely by power was issued. The machine was demonstrated at Düsseldorf and is of interest to-day as it incorporates numerous mechanisms that are still accepted in principle in modern practice. One such mechanism is a reciprocating device which consists of a double-sided rack engaged by a pinion mounted on the end of a shaft driven through a universal coupling, the latter serving to anchor the shaft at that end. The pinion end of the shaft is held laterally in a vertical slide, and is driven continuously at a constant speed, so that when the pinion reaches the end of the upper side of the rack, a guiding cam lowers it so that the under side of the rack is engaged, so reversing the direction of travel of the rack.

In 1817, Friedrick Koenig invented the first two-revolution printing press, but it appears that the design was not readily accepted. Indeed, it was not until 1884 that the factory returned to this type of machine; it has been developed continuously since that year, the latest type being the Sturmvogel Fn., which is shown in Fig. 1, on this page. On this machine, the cylinder is driven directly from the main driving shaft, independently of the type bed, so that it revolves at a constant speed throughout the impression. Furthermore, there is no play in the cylinder gearing, whether the cylinder is under pressure or raised for the return stroke of the type bed. The lifting device for the cylinder is controlled by twin cams and all principal gears have helical teeth to ensure smooth running. By the addition of a cylindrical printing unit, two colours can be printed at one impression, and by using the Beckmann process of curved plates, four colours can be printed at one impression.

An interesting letterpress machine, also exhibited by Koenig und Bauer, was their Pax BR VIII, which is illustrated in Fig. 2, herewith. This is a sheet-feed rotary press which prints sheets 32½ in. by 46½ in. and has a maximum output of 6,000 sheets an hour. A flat-bed machine of this size would be limited to approximately 2,400 sheets an hour. Owing to the higher costs of the curved stereotype plates that are necessary for the rotary machine, however, it is only more economical for runs in excess of 20,000 sheets. A factor in its favour is the relatively slower printing speed, i.e., the speed at which the ink is deposited on the paper. For a cycle of one sheet there is very little idle time, since the circumference of the impression and stereotype cylinders is little more than the length of the sheet; the diameter is, in fact, smaller than that of the cylinder of an equivalent two-revolution press. Furthermore, there is no idle time as there is on a flat-bed machine due to the return traverse of the table. These factors mean that for equivalent output speeds the rotary press has approximately

# PRINTING-TRADE MACHINERY AT DÜSSELDORF EXHIBITION.

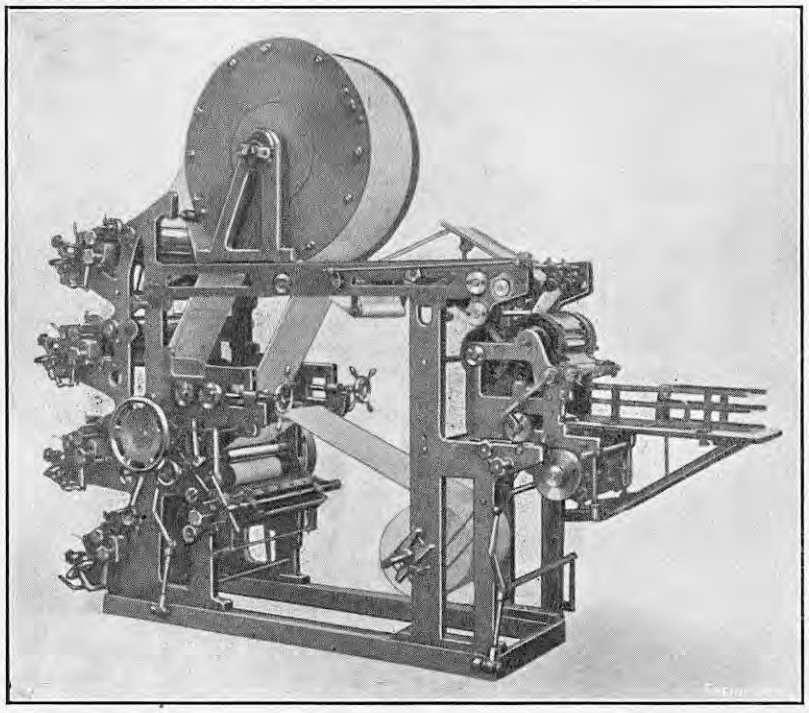


FIG. 4. PAPER-SERVIETTE MACHINE; ROBERT GIEBELER.

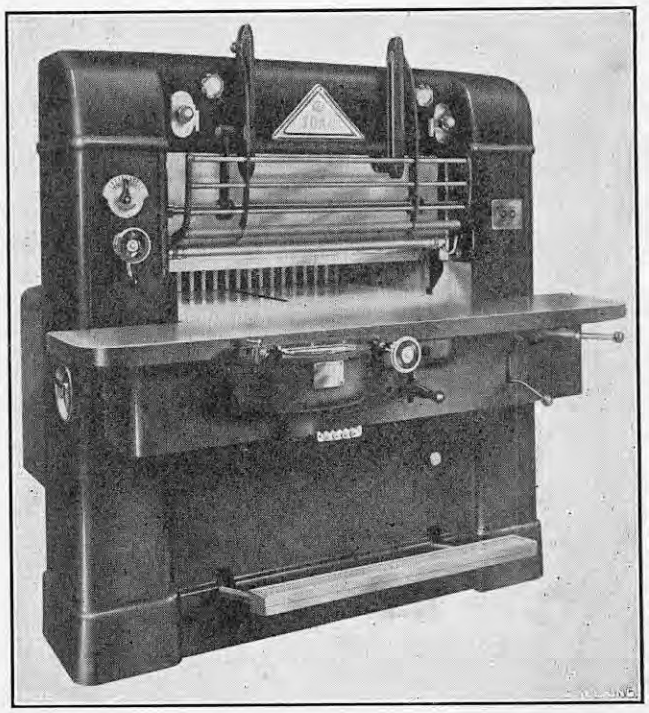


FIG. 5. 42-IN. GUILLOTINE; SOAG MACHINERY COMPANY.

twice the time available for ink deposition. The stereotype cylinder has a large number of helical grooves machined on its surface to accommodate clamps, thus enabling the plates to be moved exactly as required. This simplifies locating the plates in relation to the sheet to be printed.

The feed table, like the delivery table, is open on three sides to facilitate loading and unloading of the press. The feeder is of the stream-feed type, and is designed so that should a sheet be misplaced in the grippers, or two sheets be fed simultaneously, the feed stops and the press speed is reduced to a rate equivalent to 1,000 impressions an hour to clear the sheets already printed. In addition, the ink flow is stopped and the impression released by the lifting of the printing cylinder.

The sheet is passed from the feed table to the impression cylinder by individually-sprung swing grippers. These grippers overlap the cylinder grippers so that, for a short distance, the sheet is clamped simultaneously by both sets of grippers. The printed sheet is passed to the delivery pile by means of a chain conveyor. The Pax BR VIII press, it is claimed, combines the clarity of letterpress printing with the advantages of rotary gravure and offset presses.

Prominent among the exhibitors of printing machines were Schnellpressenfabrik A.G. Heidelberg, who are represented in this country by the Heidelberg Automatic Platen Company, Limited, Eyot Works, St. Peter's-square, London, W.6. They exhibited their two "original" platen machines and their "original" cylinder machine. The three classes of machines are stated to be the only machines built on assembly lines. The production rates at present are: 500 a month for the smaller platen machine, 60 a month for the larger platen machine, and 50 a month for the cylinder machine.

Though Heidelberg are perhaps best known for their platen machines, it is probably not generally known that they built cylinder presses before the Heidelberg automatic platen was invented. Shortly before the recent war, a return was made to a cylinder press. This machine, which is shown in Fig. 3, page 37, is of unique design as it is a one-revolution press, most letterpress printing machines being of either the stop-cylinder or two-revolution type. To obtain the one-revolution cycle, the bed has an accelerated return stroke, so that the working, or impression, stroke takes 63 per cent. of the cylinder cycle and the return, or idle, stroke 37 per cent. The single-revolution principle necessitates a cylinder approximately twice the diameter of the orthodox two-revolution machine, a fact that has assisted the designers for it has resulted in a massive cylinder weighing, together with its bearing blocks, one ton. This cylinder revolves continuously at uniform speed and is mounted in fixed bearings, so that, unlike other types of machines, the cylinder is not lowered for the impression. The type bed has a pair of racks mounted on it, one on each side, which engage, on the impression stroke, with a pair of gear segments on the cylinder, so that it is the cylinder that propels the bed during the working stroke. The return stroke is effected by means of a crankshaft and connecting rod, the latter having a pinion gear mounted on its gudgeon pin and engaging permanently with two racks, one on the machine frame and the other on the underside of the type bed. The rotation of the crankshaft is accelerated on the return stroke by a link mechanism. Thus, the bed is returned during the idle or blank section of the cylinder.

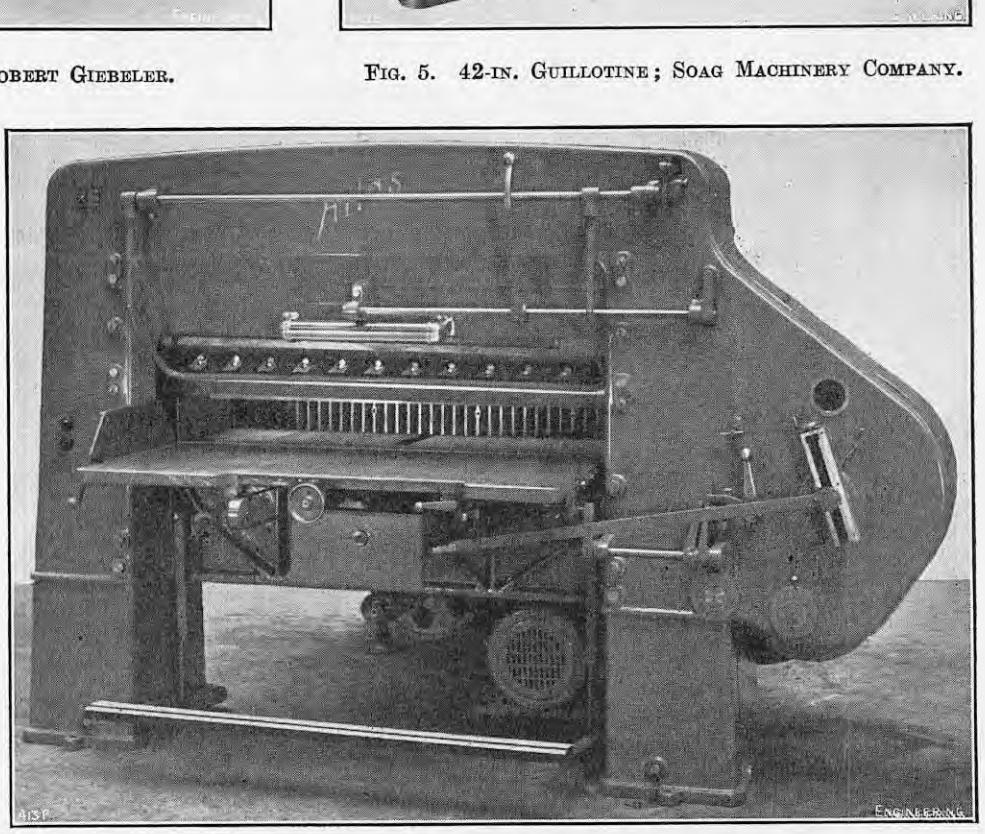


FIG. 6. 52-IN. GUILLOTINE; ATLAS-WERKE A.-G.

The one-shot pressure lubrication system on this machine is worthy of note. There are about 50 points, requiring daily attention, which are linked with a hand pump that meters oil to them at a pressure of 420 lb. per square inch. The system is airtight and dustproof. A single-lever control on the machine simplifies its operation and safeguards it against abuse. In the stop position, the motor is at rest and the flywheel brake is applied Movement of the lever to the first station releases the brake and starts the motor. The second station brings the paper feed into operation, and finally the third position engages the impression and releases the ink supply. Thus, all operations are performed in the correct sequence. Should the paper feed fail to pass a sheet to the cylinder, the press is stopped automatically. Another Heidelberg feature is automatic washing of the inking rollers while the machine is running, an operation that is performed in one minute. The conventional procedure is to

remove the inking rollers from the machine for washing.

Robert Giebeler, of Langenfeld, near Cologne, whose agents are Messrs. Engelmann and Buckham, Limited, Anstey Mill Lane Works, Alton, Hampshire, produce machines for rotary printing of paper and for converting paper into a variety of articles. The range is too numerous to mention here, but one of their machines that may be noted is used for the manufacture of serviettes; it is illustrated in Fig. 4, opposite. The paper is fed into the machine from a reel, and passes through as many as five printing units, after which it is embossed, folded longitudinally, cut to length, folded cross-wise and delivered on to a horizontal table ready for packing. All the printing units are rotary, four aniline and one gravure. They are arranged so that the printed surface of the paper is untouched by guide or register rollers until it has passed over the drying cylinder, thus avoiding the risk of smearing. To obviate the use of inter-colour registering rollers (to register the various colours in a print design), the printing cylinders are mounted on splined shafts sliding through helical gears, so that lateral movement of the driven gear rotates the printing-cylinder shaft without moving the printing cylinder laterally. To complete the register, however, end adjustment of the printing cylinder is also provided.

To prevent the ink, which is quick drying in serviette work, from acting as an adhesive when the machine is stopped, an independent drive is provided for the inking rollers, so that they continue to rotate while the web of paper is stationary. This necessitates a mechanism which withdraws the printing cylinders from the paper; a device is therefore coupled to all the aniline printing units and linked to the clutch-operating lever, so that one control lever starts the web of paper and engages the impression. The cross-cutting and folding unit consists of two pairs of knives and a folding mechanism mounted on cylinders geared together, so that each pair of knives produces a scissors action when they engage at each revolution. The set of these knives ensures a right-angle cut on the paper, and the length of paper cut is variable. The cross fold is obtained by grippers mounted on a cylinder receiving the paper, which is inserted by a thin spring-steel blade mounted on the mating cylinder. These grippers then pass the finished article to the delivery table. The position of the cross fold of the serviette in relation to the cross cut can be adjusted so that it is exactly mid-way, or it may be up to one inch off centre. The machine, which is of unusually compact design, consists of individual units mounted on a common frame. The machine will produce up to 12,000 serviettes an hour.

One of the few British firms to exhibit was the Soag Machinery Company, Juxon-street, London, S.E.11, who showed a machine for the manufacture of paper cups (used by bakers and pastrycooks for making cakes), a 42-in paper guillotine, and a machine for making drinking cups. The guillotine which is shown in Fig. 5, opposite, has several features which were not apparent on other machines at the exhibition, not the least being the better finish. The overall design presents a cleaner and more pleasing appearance, since mechanisms which, on German machines, are mounted externally, are built into the interior of the Soag machine. In order to ensure interchangeability of components, jigs are extensively used in the production of the machine. The knife mechanism is actuated by toggles which help to keep the load on the flywheel constant, since the thrust increases as the knife progresses through the paper pile. An unusual feature of the knife assembly is the provision of two handwheels with calibrated scales for levelling the knife after regrinding. The rate of operation is 40 cuts per minute. A friction clamp is used to hold the paper pile while cutting, the pressure being set by means of a handwheel and calibrated dial.

The back gauge of the guillotine is power-operated and is also provided with a micrometer handwheel adjustment, which is a useful feature in conjunction with the semi-automatic advance of the back gauge, as allowance can be readily made for slight variations in the pitch of printed matter. The author observed that nearly all the German guillotines shown at the exhibition had tables about 6 in. lower than the table of the Soag guillotine. Ideas of table height appear to vary in the two countries, for it is common practice here to build up the height of a machine having a low table. The table of the Soag guillotine is cantilever-mounted, so that it is unaffected by any possible settling of the floor. The majority of accidents on guillotines are due to overrun of the knife, a fault that is stated to be overcome on this guillotine by the provision of an interlock that disengages the knife drive when the knife brake fails to function.

The Polyform Series PDS Machine marketed by the Soag Machinery Company produces a simple and cheap paper drinking cup of the pleated type from a single web of paper. The discs, or blanks, are cut from the web by a thin serrated blade made of strip steel fixed to the outer contour of the pleat-forming tool. The web is held between clamps for this operation, in such a way that the cutting edge of the blade does not make contact with any metal parts of the tool. When the pleats have been formed, the cup is retained in one of four similar tools mounted on a turret indexed by means of a Geneva mechanism. The first index brings the pleated cup to the edge-rolling station, where a spinning tool rolls the rim of the cup so locking the pleats firmly in position. The second index delivers the cup to a delivery conveyor which stacks the cup ready for packaging. The operation of this machine is fully automatic, its optimum speed being 60 cups a minute.

Another guillotine examined at Drupa was the Atlas A-132-Z 52-in. machine made by Atlas-Werke A.G., Bremen, and illustrated in Fig. 6, opposite. It is of robust design employing orthodox principles. The knife, which operates on the well-established swinging motion, is held in position by bolts inserted through slots in the knife holder. These slots are arranged slantwise, so that excessive pressure will not move the knife. Knife setting is effected by two levers conveniently mounted on the machine. The paper clamp is operated by tension springs, the length of which ensures approximately constant pressure on the paper, regardless of height of the pile. In normal use, the clamp is provided with ribs, but these can be covered to avoid marking the work being cut. The back gauge is reversible, one side being ribbed, the other plain. As the back gauge is symmetrical, the setting of the measuring tape is unaffected. The ribs on the back gauge are staggered in relation to the ribs on the clamp so that paper can be cut down to a remaining strip of $\frac{7}{8}$ in. The back gauge is power operated in both directions and can be advanced automatically for repetition work. The knife is driven through a friction clutch, which can be disengaged at any part of the stroke, disengagement of the clutch automatically engaging a brake.

To describe all the machines shown at the exhibition would, of course, be impracticable; the few that have been chosen for this article, however, were among the most interesting. The exhibition was apparently a great success, particularly as regards the export trade of Germany, and it seems likely that it will be held again in three or five years' time.

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SOUTH LONDON TRAMWAY CONVERSION.—The fourth, and smallest, of the nine stages required to complete the conversion of the South London tram routes to oil 'bus operation came into operation on the night of July 10-11. The London Transport Executive announce that the 68 and 70 tram routes and the 68A 'bus route have been replaced by three new 'bus routes; namely, the 188, between Greenwich Church and Chalk Farm Station, the 70, between Greenwich Church and Waterloo or London Bridge Station, and the 70A, between Deptford and the Embankment. The 4 'bus route, from Finsbury Park Station to Bermondsey, have been extended to Surrey Docks Station, and the 196 'bus route, from Tufnell Park to Waterloo, has been extended to Norwood Junction. In all, 33 trams have been replaced by 38 'buses, bringing the number of trams withdrawn to date, to 313, and the number of 'buses put into service, to 384. Prior to the commencement of the conversion, there were 102 route miles (202 track miles) of tram lines in the districts affected. Including the changes now announced, the lengths abandoned will amount to 36½ route miles (73 track miles), leaving 65½ route miles (129 track miles) still in use. Tram tracks in eleven South London main roads will no longer be required.

# THE JOINT ENGINEERING CONFERENCE, LONDON.

(*Continued from page* 9.)

Two sessions of the Joint Engineering Conference, organised by the Institutions of Civil, Mechanical and Electrical Engineers were held on the afternoon of Friday, June 8, one at the Institution of Mechanical Engineers, where a paper on "Technical Advances in the Gas Industry during One Hundred Years," by Mr. F. M. Birks, C.B.E., M.I.Mech.E., was presented, and the other at the Institution of Electrical Engineers, where Sir Noel Ashbridge, B.Sc. (Eng.), M.I.C.E., M.I.E.E., gave a paper on "The British Television Service."

## TECHNICAL ADVANCES IN THE GAS INDUSTRY.

At the Institution of Mechanical Engineers the chair was occupied by Mr. P. L. Jones, M.C., Wh.Ex., M.I.Mech.E. To illustrate the work of British pioneers in building up the industry, Mr. Birks referred, in his paper, to William Murdoch, who, in 1792, had examined the distillation products of coal and other substances, and had later taken credit for the first application of gas to useful purposes. Continuing, Mr. Birks stated that the gas industry as a public service had come into being with the formation of the Chartered Gas Light and Coke Company in 1812. In those days, technical knowledge was meagre and old musket barrels were used for the early gas pipes, giving rise to the expression "barrel piping." The world's first gasworks, at Westminster, was being used, in 1851, for making two types of gas, namely, gas of maximum candle-power obtained from cannel coal and used to supply the Houses of Parliament, the Royal Palaces, and the purlieus of Westminster, and gas of normal candle-power made from "Newcastle" coal. This, with similar supplies from two other works, was used to supply the remainder of the district served by the Chartered Gas Light and Coke Company.

During the greater part of the Nineteenth Century, charging of gas retorts was manual, so that the retorts were limited to two or three tiers. This limitation in height of the retort setting, and consequently the restricted amount of gas per unit of ground space, did not affect most works which had ample area. At the St. Pancras works of the Imperial Company, however, the demand for gas increased so rapidly in about 1860 that D. Methven, the engineer of this station, was only able to meet his requirements with the limited site available by building settings of ten retorts in five tiers. The top two tiers of retorts were charged from a movable stage. During the two decades 1870-1890, direct firing of retort settings had been superseded by producer-gas firing, with or without the addition of recuperators for preheating the secondary air by heat exchange from the waste gases.

The period 1900-10 had seen the successful development of the Glover-West and the Woodall-Duckham systems of continuous vertical retorts. High gas output per unit of space and improved amenities owing to the elimination of hot-coke discharge and low fuel consumption had made continuous vertical retorts so popular that they were responsible for about one-half of the gas output of the industry. Moreover, at present the fuel consumption of continuous vertical retorts was only about one-sixth of the coke produced, and about 1,050 lb. of waste-heat steam were made available per ton of fuel. This was sufficient to supply all the process and power requirements of the works. A ton of Durham coal yielded 74 therms of gas, 20 therms of tar, and 165 therms of saleable coke, the total products for sale having 86 per cent. of the thermal value of the coal. The gas industry differed from any other public-utility undertaking as it had to market several different but interdependent fuels and chemical materials and the manufacturing costs of its main product, gas, was markedly influenced by the revenue received from the residuals of the carbonisation process.

## DISCUSSION.

Mr. C. H. Chester, who opened the discussion, said that the author could not be expected to consider deeply the question of refractories as used in

retort settings and coke ovens. The great reduction in thermal losses in the period under review, however, had been due, in part, to improved methods of heating and design and, in part, to the closer control of operating conditions, but a contribution had also been made by the improvements in refractories, which had resulted in better heat transmission. On the twin questions of gas purification and by-product recovery, much could be said. The possible contribution which the gas industry could make to the supply of home-produced motor fuel was hampered by economic considerations. The refining of by-products, however, had progressed very rapidly during the last few years, particularly under the impetus of war.

Captain (E) W. Gregson said that the paper showed that, by 1851, the gas industry was already established in this country, but at that time its output was used almost entirely for purposes of illumination. He believed that the first road to be publicly lighted had been Pall Mall, and it was a matter of interest that some of the original flares were still in existence outside some of the clubs in that thoroughfare. The gas industry was essentially a British industry and the two main systems of carbonising, the horizontal retort and the continuous vertical retort, were both essentially British developments. The use of the gas turbine for waste-heat recovery had considerable potentialities when applied to gasworks practice and a combination in which a gas turbine was employed for electricity generation and the remainder of the waste heat used for steam generation seemed to be an extremely attractive proposition for the average gasworks in this country.

Mr. J. H. Dyde said that when Mr. Birks had mentioned that, by 1851, the method of constructing gasholders was fairly well established and a sound engineering accomplishment, so much so that the essential parts of many of these holders had lasted to the present day, this was a fitting tribute to the former engineers in the industry. The introduction of the electrostatic "de-tarrer" in recent years, to eliminate tar "fog," was an interesting development. The tar fog was precipitated by subjection to a corona discharge from wire electrodes at 30,000 volts.

Dr. J. Burns stated that the author had drawn attention to the comparative heat balances relating to carbonisation in 1851 and in 1951. These showed that the industry had succeeded in extracting from coal exactly 39 therms per ton more in 1951 than in 1851. Both tons of coal had been credited with 300 therms, but, whether the coal of to-day had the same number of therms as the coal of 1851, he was not quite sure. The next speaker, Mr. H. Kerr, said that the modern continuous vertical retort was capable of dealing with any type of gas-making coal of either high or low swelling properties. This kind of plant had the added advantage over the static types of plant that it could be built in a residential area without detriment to the surrounding amenities. In the past, gasworks had been a source of derision, but the architectural design and layout of the modern plant were such that it could be successfully harmonised into any surroundings. The last speaker, Mr. K. H. Tuson, said that he was glad to hear that dry coke-quenching plants were being started up again. To a layman, it seemed a shocking waste of heat to see the volumes of steam emerging from a wet-quenching tower. He believed that some 25 per cent. of the heat used to fire a coke oven might be dissipated in this way, as opposed to 8 per cent. for a dry coke-quenching plant.

After a brief general reply by Mr. Birks, a vote of thanks was accorded to him for his paper, on the motion of the chairman, and the session terminated.

## THE BRITISH TELEVISION SERVICE.

THE meeting at the Institution of Electrical Engineers on the afternoon of Friday, June 8, was presided over by Sir Harry Railing, and a paper on "The British Television Service" was presented by Sir Noel Ashbridge. The author said that experimental work at the start of the century had led to the development of low-definition television with mechanical scanning and ultimately to the introduction by the British Broadcasting Corporation of 30-line transmission on medium frequency in 1926. The development of cameras with electronic scanning made it possible to use much improved definition. As a result the 405-line television service on "very high frequency" came into operation in 1936. This service was closed down in 1939, but was re-opened in 1945, using pre-war standards.

Outlining the improvements which had been made since that time, Sir Noel described the cameras, control apparatus and film-scanning equipment used, as well as the system of television recording employed and the studio lighting and outside broadcast apparatus. Details of the transmitters and masts and aerials employed were also given. As regards long term developments, a few years ago it appeared quite possible that the next step forward in television would be increased definition for monochrome pictures obtained by increasing the number of lines. At the present time, however, the picture quality with the 405-line system was so good that the attractiveness of this step had decreased. On the other hand, all the disadvantages of a large number of lines in cost, spectrum space and liability to distortion had become increasingly evident. The objections to stereoscopic transmission were serious. It would increase the channel space required and the cost of the receiver; and add to the complication in the studio. Colour transmission offered the most attractive large scale development in television for the future. It was now possible to transmit a satisfying picture of adequate detail in colour within the same spectrum space as a picture of apparently similar detail in monochrome.

### DISCUSSION.

In opening the discussion, Sir Stanley Angwin suggested that further references to published work on camera and control equipment would be useful. For example, the adoption of the Emitron and super-Emitron for the British system was mentioned, but there did not appear to be any reference to later work on the Image Orthicon. The circuiting and control mechanism necessitated very high standards and fine limits of tolerance. It was also essential to obtain a reasonable life while keeping the cost of production within economic limits. These problems would be intensified when higher definition was required and colour reproduction was added. The general advantages of standardisation were as applicable to television as to other engineering projects. The particular advantages of standardisation lay in the desirability of minimising the possibilities of interference and providing for the interchange of programmes. The most controversial question was the number of lines to be used. An increase in the number of lines above 405 might, however, be prohibitive economically and involve some degradation of the picture. If chaos was to be avoided European agreement on the frequency bands to be used, the allocation of stations within those bands, and the allocation of specific frequencies to all stations within a country and to those in adjacent countries, was necessary.

Sir Archibald Gill said that a debt of gratitude was due to Baird for the way in which he had inspired interest in television in this country. The great step forward in the development of television had been the introduction of the modulated-beam cathode-ray tube. He thought that all those who knew the facts were convinced of the wisdom of the decision to continue to use the 405-line system and the author had dispelled to some extent the myth that the number of lines was a measure of the quality of the picture. It was stated in the paper that plant for a 50-kW medium-wave station would cost about 100,000*l.* and for a 50-kW television station about 200,000*l.* The costs of the equivalent short-wave radio equipment were considerably less, thus emphasising the expense of broadcasting equipment. The same difference in cost between audio-frequency transmission and television transmission occurred in the line.

Mr. I. Shoenberg said they had started research on television at Electrical and Musical Industries, Limited, in 1931 by investigating the possibilities of electronic reception. It was soon found that the hard cathode-ray tube was a practicable proposition; and a tube with sufficiently good electron-optical focus for high-definition pictures was made. A short-wave sound transmitter, designed by the Marconi Company, was modified and used as a transmitter. The success of the Emitron had recently re-opened the question of the number of lines to use. The answer was determined not by mechanical considerations, but by the band width permitted by the valves and circuits then available. Finally, the 405-line system was chosen, but it was some indication of the doubts that were felt on the subject, as well as on the abandonment of the mechanical system, that the Television Advisory Committee took the precaution of arranging for a simultaneous trial of a mechanical system operating on 240 lines. At the beginning of 1935, it had been possible to submit to the Television Committee a detailed specification for a high-definition television system operating on 405 lines, which was later embodied without any important modifications in the Alexandra Palace transmitter.

Mr. G. M. Wright thought there was room for considerable improvement in the aerial which was used by the general viewer for the reception of the television programme. Emphasis must be laid on the necessity of research into metnods of producing the highest power possible in the upper frequency band, which could be modulated linearly over the band required by television. It was disturbing to learn that 300 kW would be dissipated in lighting at the Lime Grove studios and it seemed that more study of this branch of the art was required.

Dr. D. C. Espley pointed out that the slight degradation of the picture quality in transmitting the programme over the radio link, mentioned in the paper, was due to the fact that a temporary system was being used under conditions which necessitated the employment of very narrow and high-attenuation filters on the ultra-high frequency side. This had now been altered.

Mr. C. E. Strong said that, though the author had given reasons for not using a wider band than three megacycles, the London-Birmingham cable had been designed to cope with a wider band if the need arose. Low-power modulation could be less complex than high-power modulation, at least, if the inter-stage coupling circuits could be first twin inductively-coupled circuits. There was a great difference in simplicity between a high-power sound modulator and a high-power vision modulator and it was also necessary to take into account new developments, such as reverse feed-back. If the vision stations were amplitude-modulated and the sound equipment frequency-modulated, it would make diplexing easier, while if ultra high-frequency broadcasting used frequency modulation, there would be a case for having the same system on sound as on television.

Sir Noel Ashbridge, in reply, said that all the studio apparatus in use at Alexandra Palace had been in operation since 1936. At the moment, the design of this apparatus was lagging somewhat, but they hoped to catch up when equipment specially designed for studio operation was installed at Lime Grove. Ultimately, there was no doubt that standardisation would have to come, but not at the moment. With the sort of aerials that viewers used, it was doubtful whether polarisation would make any difference, unless they were almost on the edge of a service area. The view of the Corporation was that a good service required a field strength of at least 0·5 millivolt per metre. About 11 per cent. of the sets in the country were, however, working at under 100 microvolts per metre, which meant that many of them were taking service from the wrong transmitter. It was certain that people would not, over the years, be satisfied with this. They had recently been thinking about the question of direct relaying, since the ten-station scheme could not last for ever and it would be necessary to squeeze more stations on to the five channels or break out into another band.

*(To be continued.)*

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STRANDINGS OF M.V. "CAMEO" AND S.S. "PYROPE."—The formal investigations into the strandings of the Glasgow motorship Cameo and of the Glasgow steamer Pyrope have been fixed for hearing at the Judiciary Building, at the foot of Saltmarket-street, Glasgow, on Wednesday, July 25, at 10 a.m., and Thursday, July 26, at 2 p.m., respectively.

# THE INTERNATIONAL CONFERENCE OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

(*Continued from page* 12.)

THE second paper presented at the opening technical session, on June 26, of the International Conference of Naval Architects and Marine Engineers, was that on "The B.S.R.A. Resistance Experiments on the 'Lucy Ashton.' Part I.—Full Scale Measurements." A summary of the printed paper is given below; but Sir Maurice Denny, in presenting the paper to the meeting, did not use the printed text which had been circulated. Instead, he summarised the course of events leading to the trials, indicated the general lines on which they had been planned, and drew attention to various points of particular interest in the equipment used, the problems to be solved, and the results obtained.

### RESISTANCE MEASUREMENTS ON THE "LUCY ASHTON."

Sir Maurice Denny's paper dealt with the full-scale research on the Lucy Ashton. Some results were included because of their interest and importance (in particular, the resistance curves for four conditions of the hull) and to show the methods adopted; but in general the paper was descriptive of the ship, the method of propulsion, the modifications made to the hull, the instrumentation, etc. It was explained that a second paper would deal with the correlation of the full-scale trials with the tests of models in experiment tanks, and that further results obtained would be the subject of a subsequent paper, or papers. The trial results described in the paper related to resistance tests with the seams sharp and the hull coated with red-oxide paint; with sharp seams and bituminous aluminium paint; with faired seams and red-oxide paint; and faired seams in conjunction with bituminous aluminium paint. The fairing consisted of a wedge of plastic composition 3 in. wide. When the vessel was docked after the first trial with this filler in place, it was found that about 25 per cent. of the fairing was missing, so that the improvement attributable to it could not be ascertained exactly; it was thought, however, to amount to between 3 and 4 per cent., and probably nearer to 3 per cent. The four Rolls Royce Derwent V engines used for propulsion each had a thrust of 3,600 lb. at 14,500 r.p.m., giving a total propulsive force of just over 6 tons; $5\frac{1}{2}$ tons gave the ship a speed of about 15 knots. The consumption of fuel (a special-quality aviation kerosine) was about 1 lb. per hour per pound of thrust, at full load; and the thrust could be measured to an accuracy of about $\pm$ 5 lb. on each engine. This margin represented an error of about one-sixth of 1 per cent. at full speed. The speed through the water could be measured by the Pitometer logs to an accuracy of one-tenth of 1 per cent. at 10 knots. It was found that the ship could be handled and manœuvred on the measured mile with the same facility as any other vessel with conventional means of propulsion. The trials emphasised the importance of the condition of the hull surface, and of the sensitivity of full-scale ship resistance to small roughnesses; trials run with the naked hull coated with bituminous aluminium paint (which gave a smoother surface than red-oxide paint) after the ship had been laid up for 40 days showed that the total resistance had increased by about $3\frac{1}{2}$ per cent. The dimensions of the Lucy Ashton were: length between perpendiculars, 190 ft. 6 in.; breadth moulded, 21 ft. 0 in.; and depth moulded, 7 ft. 2 in. At a mean draught of 5 ft. 4 in., measured over the 4-in. bar keel, the displacement in salt water was 390 tons in level trim. The block coefficient was then 0·685; the prismatic coefficient, 0·705; the midship area coefficient, 0·972; and the wetted surface, including rudder and bar keel, 4,488 sq. ft.

Sir Maurice added that, since the paper was written, certain further results had become available. The programme of tests had included—but only if time and opportunity offered—some work on the increase of resistance due to fouling. This work had no relevance to the main purposes of the trials, but it was thought that data might be obtained which would be of value to shipowners and also to shipbuilders who had experience, on the trials of sister ships, of wide discrepancies in the power required, which could only be ascribed to fouling. Some discrimination must be observed in interpreting the final results because the water temperature was not constant over the period, rising from 43 deg. F. at the end of March, to 59 deg. F. in early June. At the latter date, the hull showed a fine growth of short "grass," while, on the bottom of the ship, there was a general but light scattering of tiny limpets. By this time, at what might be a normal service speed, the total resistance had increased by about 28 per cent. This figure was larger than would be expected from the results given in the paper, obtained during the months of December and January, and suggested that water temperature had a large effect on fouling. A fair mean for the increase in surface friction would be about 0·6 per cent. per day; and Sir Maurice recalled that before the Institution of Naval Architects, many years ago, his father, Sir Archibald Denny, had suggested a figure of $\frac{1}{2}$ per cent. per day increase in surface friction at standard temperature as a good working basis.

### DISCUSSION.

Sir Charles S. Lillicrap, K.C.B., who opened the discussion, recalled that 82 years had passed since a committee appointed by the British Association for the Advancement of Science rendered a report "On the state of existing knowledge on the stability, propulsion and seagoing qualities of ships and the application which it may be desirable to make to Her Majesty's Government on these subjects." One recommendation in that report was that the resistance of a full-size ship should be determined by towing it at sea. Trials of at least two ships were proposed, considerably different both in size and proportions, and with different conditions of smoothness of surface. The Committee realised that great care would be necessary to ensure satisfactory results, and enumerated the precautions necessary. William Froude was a member of the committee and signed the report, subject to an explanation regarding ship resistance. He described his theory of ship resistance and expounded the Law of Comparison. While agreeing that a dynamometric determination of the resistance of a full-size ship was necessary, he considered that model experiments would be more fruitful, at much less cost, and gave results of the tests of some models he had carried out in the river Dart. The difficulties which he and the committee foresaw in towing a ship were fully confirmed when trials were carried out two years later on H.M.S. Greyhound. The foundations of ship-model research laid by William Froude had been strengthened by many years of experience, though the results of the Greyhound trials did not afford full support for the Law of Comparison. Useful advances had been made by experiments on planks and models in tanks, but the real requirement was to obtain reliable information on actual ship resistance. Sir Maurice had stated that few experiments of this nature had been attempted. The reasons were not far to seek. One was the large expenditure of time and money involved; another was the necessity for really accurate results to carry conviction. They are greatly indebted to the author, in his capacity as chairman of the Research Board of the British Shipbuilding Research Association, to Dr. Livingston Smith, the Director of Research, and to his staff that the effort involved had been squarely faced at last and the details so admirably carried through.

Having followed the development of the project from its inception, and witnessed some of the trials, Sir Charles continued, he had complete confidence in the accuracy of the results. The real key was the method of propulsion. The ingenious application of jet engines had disposed of the serious source of inaccuracy consequent on interference. The results on the trials had been obtained at a Reynolds' number as large as 375 million. Naturally, the B.S.R.A. were keen to obtain results at higher Reynolds' numbers, and he had been approached by Dr. Livingston Smith with the suggestion that such trials might be carried out with a small warship, no longer required for naval service. Sir Charles had proposed to the Admiralty, therefore, that similar trials should be carried out with one of H.M. ships. If these proposals were approved, results would be available at even higher Reynolds' numbers. There would be the fullest co-operation and exchange of data between the Admiralty and the B.S.R.A., should the proposed trials materialise.

Mr. J. A. Milne, C.B.E., welcomed the paper as a good milestone in the annals of experimental technique, and emphasised that the work described was a co-operative effort, both in finance and brain power, on the part of the British shipbuilding industry. He commended especially the vast amount of forethought and care that had been lavished on the experimental arrangements. He thought it probable that the real reason why there were few attempts to repeat the Greyhound experiments was not expense, but the realisation that greater accuracy was then unobtainable.

Dr. F. H. Todd said that the United States Navy had a continuing programme of skin-friction research covering experiments on planks and model vessels, and full-scale ship trials. In the model basin, they had on each side of the models and planks a plate which could be removed and sent to the shipyards to be painted under the conditions in which ships were painted, and then replaced in position on the models; in that way, they could measure the relative resistances of different paint surfaces on the actual ships, and attempt to correlate the physical characteristics of the surfaces and the resistance. Most of the full-scale trials had been done with thrustmeters fixed, so as to assess the thrust necessary for the propelled vessels. The gap between the apparent skin friction of the ship and that predicted was called the "roughness allowance." Results were available from four recent merchant-ship trials in the United States. Three were tankers, about 600 ft. long, and one was a passenger ship, somewhat larger. The allowances necessary to balance the resistance of the ships with that predicted from the models varied between 10 and 37 per cent. It was proposed in the United States to carry out work similar to that described in the paper on two types of vessel, one being a small twin-screw naval ship and the other a single-screw tug. Thrustmeters would be fitted and propulsion by aircraft engines would be used to determine the ships' resistance. If it could be shown that there was not such a serious scale effect, more confidence would be felt in trials in which the resistance of a ship was predicted from model data.

Sir Amos L. Ayre, K.B.E., thought that the occasion might safely be called epoch-making. The fact that it had been possible to undertake all the work, and the time and expense, involved in the Lucy Ashton trials was due solely to the existence, for the British shipbuilding industry, of a research association; it could not have been done otherwise. It was Sir Maurice Denny who took steps to ensure that the Lucy Ashton was available, when otherwise she might have been broken up; and the great idea of propelling by means of jet engines, so that the resistance would not be affected by the means of propulsion, was due to Dr. Livingston Smith.

Dr. J. F. Allan said that the work on the Lucy Ashton had caught the popular imagination in a way that was unusual in ship research. Sir Maurice Denny had had such a trial in mind for years. In the committee stage, in the Research Association, there was a good deal of doubt concerning the possibility of carrying out the work, but there was never any doubt about its desirability. The main features were the efforts made to ensure accuracy in every direction, and the success achieved in producing a steady uniform propulsion by means of the jet units. It was most valuable to have the results, particularly to throw light on the difficult problem of correct correlation between ships and models.

Mr. R. W. L. Gawn, O.B.E., said that, with regard to the depth of water, the author quoted 17 fathoms in the trial area. That was truly deep water for the purpose of the trial, and the results would not be influenced by any restrictions due to limitations of depth. He mentioned that point, because a few years after the Greyhound experi-

# EXHIBITS AT THE BRITISH INSTRUMENT INDUSTRIES EXHIBITION.

(*For Description, see Opposite Page.*)

Fig. 4.

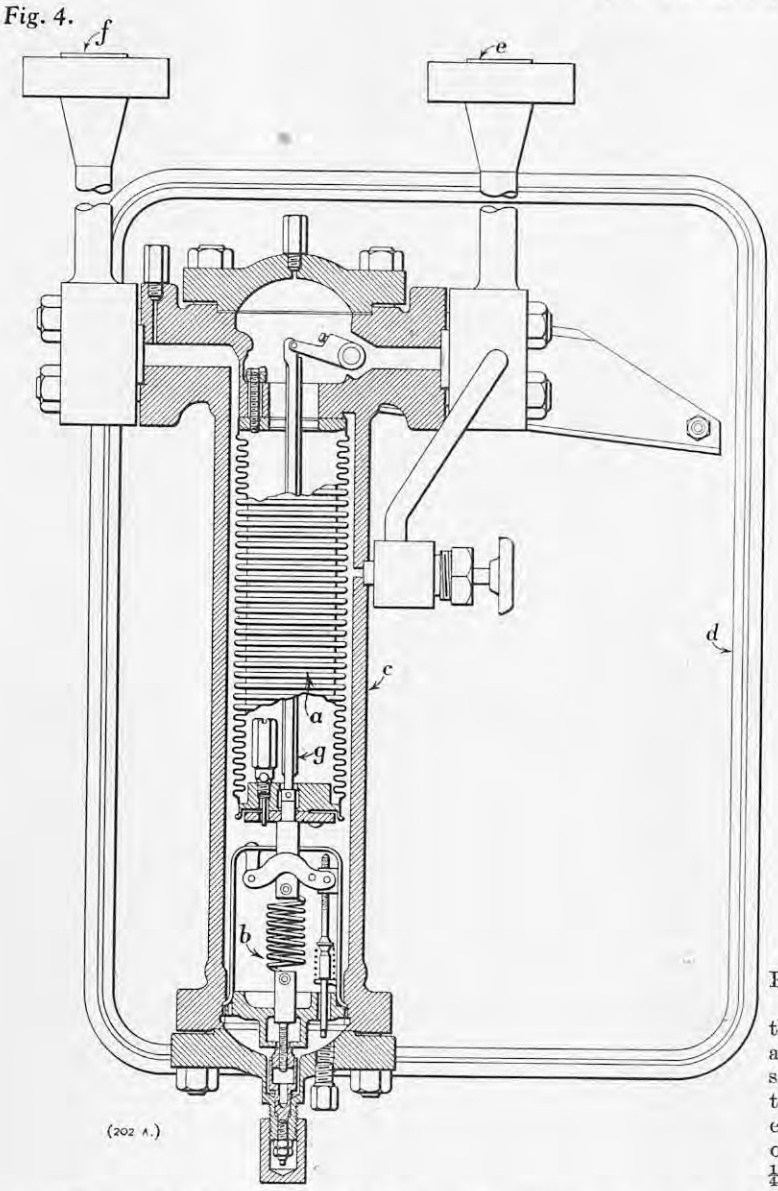
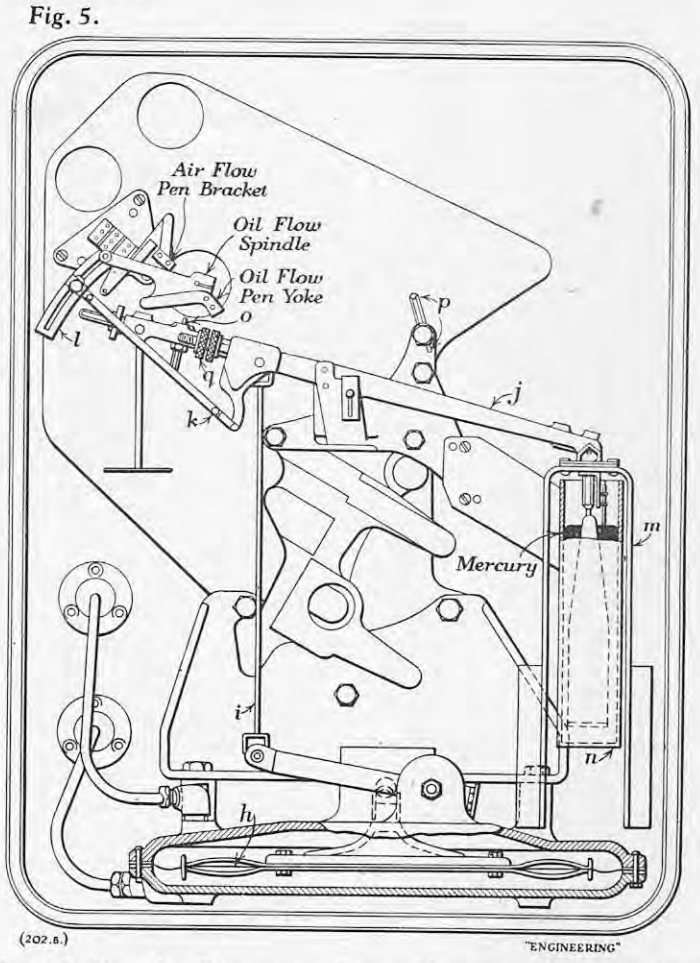



Fig. 5.




FIGS. 4 AND 5. FUEL-AIR FLOWMETER; BAILEY METERS AND CONTROLS, LIMITED.

ment, William Froude tested a model of the Greyhound in water of restricted depth, and found that the resistance was increased. He then concluded that the correction to the curve of resistance, calculated for the ship from the experiments with the model, would considerably improve its agreement with the actual curve of resistance of the ship. Sir Maurice Denny had mentioned that the Greyhound ship-trial results did not agree with the model experiment results; that was one of the reasons, which did not come out at the time. Details were given in a paper which he (Mr. Gawn) presented to the Institution of Naval Architects in 1941.* If possible, it would be useful to arrange for some trials of the Lucy Ashton in shallow water, though, no doubt, it would be difficult to find a suitable course. He was impressed by the figures showing the combined effect of fairing the seams and applying a smooth paint, namely, a reduction in hull resistance of some 6 per cent., which might be roundly expressed as equivalent to a reduction of about 9 per cent. of skin-friction resistance. It had been known for some time that resistance could be reduced by making the surface smooth, but the amount of improvement to be realised thereby had been variously estimated. There seemed to be scope for the development of bottom compositions which would be at least as smooth as that applied to the Lucy Ashton. Sir Maurice had suggested 0·6 per cent. per day as the mean increase of surface friction due to spring and early summer fouling of the Lucy Ashton; rather a high figure. Was the ship laid up during that time? Admiralty experience, based on a number of trials, averaged about ¼ per cent. per day in general service. The paper did not mention the profile of the wave against the side of the ship, or the sinkage in space at various speeds. This information would form a check on observations which were usually made during routine model tests. Had such observations been made?

Lieut.-Cmdr. (E) H. T. Meadows, D.S.C., R.N.R., drew attention to a reference in a Glasgow newspaper to this "new method of propelling ships," and thought that it should be emphasised that, while the method of propelling the Lucy Ashton was certainly novel, it was not being investigated as a new method of propelling ships.

Professor E. V. Telfer asked Sir Maurice Denny to include in the paper, and in his reply, a section of the vessel showing the actual seaming, so that the seam resistance could be calculated as a check. The amount of difference in roughness resistance, according to the different qualities of paint, was extremely interesting, and showed clearly the need for a study of paint on behalf of the shipping industry so that the maximum benefit could be derived from the new designs of ships' structures. With the ordinary riveted construction, the butt resistance would probably be dominant and would not allow improved smoothness of paint to be felt to the fullest extent. It might be possible, on the Lucy Ashton, to simulate types of butt construction by fitting a ridge on the plating, so as to obtain butt resistance figures for comparison with the known butt resistance of other ships.

Sir Maurice Denny, in replying to the discussion, said that Dr. Todd had referred to the trials of four quite large ships in America, where the propeller thrusts were measured and then, after making certain assumptions, the resistance of the ships were deduced. Dr. Todd had said that the results, in terms of apparent roughness, seemed to vary very widely. In the light of his own experience and that of other shipbuilders who had run ships, and especially sister ships, on trial, Sir Maurice suspected that there were substantial variations between the ships on trial.

Mr. Gawn had requested photographs of the waves, or measurements of wave profiles, on the Lucy Ashton while under way, and had asked whether there have been measurements of bodily sinkage. The answer to the question on bodily sinkage was "No"; but photographs were taken of the wave profiles.

Professor Telfer has asked for a section to show where the seams were; that would be provided. He also suggested that the Lucy Ashton might go out once more on trial, with little pieces of wood tacked round her to enable the resistance of butts to be measured. The Lucy Ashton, however, was lying in dock at Dumbarton, and had had her four jet engines removed after they had far exceeded their allotted running time. It was hoped that she would not need to do more trials, because the amount of time and money and energy expended on them was such that all concerned felt that they had had about enough for the moment. On that afternoon, Sir Maurice added, he was attending, with some trepidation, a meeting of the Council of the B.S.R.A.; with trepidation because, before the trials were undertaken, he was asked to give an estimate of what they would cost. He was very anxious that the ship should go on trial, and he gave a figure which was only six times wrong!

The chairman, in closing the discussion, confessed to a somewhat sentimental feeling about the Lucy Ashton, since, during part of her long life, he was one of her owners. It is pleasant to feel that she would not be forgotten. He then proposed votes of thanks to the authors of the two papers presented during the morning session, which were accorded by acclamation, and the discussions were adjourned.

(*To be continued.*)

* "Historical Notes on Investigations at the Admiralty Experiment Works, Torquay." *Trans. I.N.A.*, vol. 83, page 80 (1941).

# INSTRUMENT INDUSTRIES EXHIBITION.

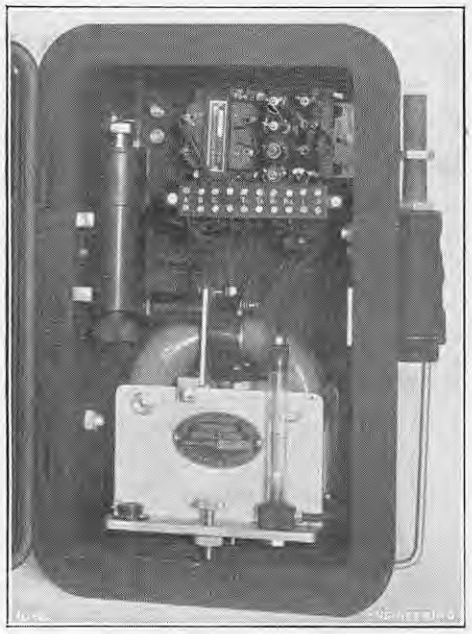


FIG. 6. MAGNETIC OXYGEN RECORDER; MESSRS. GEORGE KENT, LIMITED.

## BRITISH INSTRUMENT INDUSTRIES EXHIBITION.

(*Continued from page* 10.)

THE first industrial instrument exhibition (which, closes on Saturday, July 14) coincides with the 125th anniversary of Messrs. Griffin and Tatlock, Limited, Kemble-street, Kingsway, London, W.C.2; to celebrate the occasion, the firm have issued a souvenir catalogue giving a brief history and description of their wide range of exhibits of laboratory equipment. Among these may be mentioned the soap-film gas-analysis apparatus, designed originally by the Gas, Light and Coke Company, for coal gas and other gaseous mixtures. The instrument consists of a series of calibrated glass tubes in which soap films are made, alternating with a series of reagent vessels. The reagents used are either liquids, flowing through syphons on to glass helices, or hot granular solids, placed in pipette-shaped vessels in electric furnaces. The gas is passed alternately through a reagent vessel and a soap-film meter; the position of the soap film at the conclusion of the analysis indicates the volume of each constituent gas, in the order carbon dioxide, oxygen, unsaturated hydrocarbons, hydrogen, carbon monoxide, paraffin hydrocarbons, and nitrogen.

Among a comprehensive range of indicating, recording and controlling instruments for boiler furnaces and industrial processes, Messrs. Bailey Meters and Controls, Limited, Progress-way, Croydon, Surrey, are showing a recording instrument in which the oil flow and the air flow in an oil-fired furnace are indicated, in red and blue ink respectively, on the same chart. The instrument is calibrated, after it is installed, by means of combustion tests; analyses of the flue gases are taken at different boiler loads, with various percentages of the total air, and observations of the flame condition, the refractories, the fuel-burning equipment, etc., are made. From these tests the optimum fuel-air ratio is determined; usually it varies with the rate of flow. The mechanism of the meter is then adjusted so that when the desired ratio of air flow to fuel flow is present, the air-flow trace on the chart will be superimposed on the fuel-flow trace. When the air-flow pen rises above the fuel-flow pen, it indicates that an excess of air is present.

For measuring the oil flow, an orifice tube is installed in the fuel-oil pipeline. The pressure difference across the orifice is measured by a stainless-steel bellows. A cross-section through the differential-pressure mechanism is given in Fig. 4, opposite; a sealed metal bellows *a* and a calibrated spring *b* are housed in a pressure chamber *c*, which

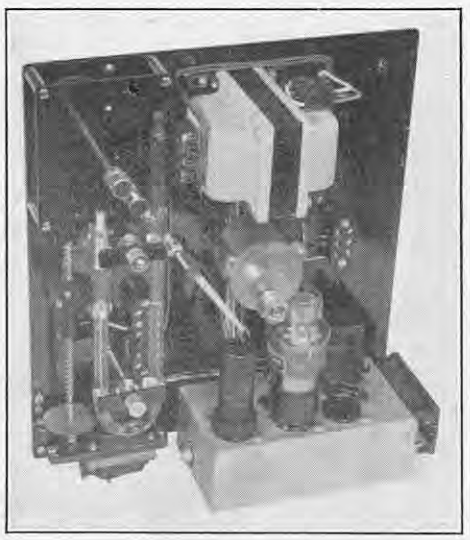


FIG. 7. ELECTRONIC RECORDING MANOMETER; FIELDEN (ELECTRONICS), LIMITED.

is supported on the back of a pressed-steel instrument casing *d* enclosing the circular recording chart, the air-flow metering and calibrating mechanism, and the recording pens. The interior of the bellows is connected through *e* to the low-pressure side of the orifice, and the space within the pressure chamber outside the bellows is connected with the high-pressure side by *f*; as the differential pressure increases, the bellows tends to contract against the resistance offered by the calibrated spring. Movements of the bellows are transmitted by the vertical rod *g* through a simple linkage and a pressure-tight bearing to the recording pen.

Fig. 5 shows in outline the air-flow metering mechanism. The two sides of an air-flow measuring diaphragm *h* are connected to tappings in the combustion chamber and wind-box; the diaphragm is connected by a link *i* to a balance lever *j* and a drive link *k* which is adjustably mounted in a quadrant *l* which carries at its upper end a bracket to which the air-flow pen is attached (not shown in Fig. 5). On the other end of the balance lever is suspended a displacer and weight assembly *m*, the displacer floating in a mercury reservoir *n*. The force due to the pressure difference across the diaphragm lifts the displacer out of the mercury until balance is obtained, and the air-flow pen is correspondingly moved through the drive linkage. Movements of the balance lever are restricted by the stops *o*, *p*. By adjustments to the air-flow linkage and the settings of the balance weights *q*, and by changing the level of mercury in the reservoir, it is possible to calibrate the meter so that the total air flow obtained when the oil-flow and air-flow pens are together varies with the boiler rating The recorder chart is driven by a self-starting, synchronous electric motor operating on a 200-250-volt 50-cycle supply. The charts are uniformly divided and complete one revolution every 24 hours.

Messrs. George Kent, Limited, Luton, Bedfordshire, are showing a range of industrial instruments for the measurement and automatic control of flow, temperature, pressure, *p*H, gas-content, etc., among which is a working model of a continuous paramagnetic oxygen recorder being shown for the first time. A photograph of this instrument is reproduced in Fig. 6. The design of the instrument is based on the fact that, among the common gases, only oxygen and nitric oxide are attracted by a magnetic field, oxygen more than twice as strongly as nitric oxide. A sample of the gas to be analysed is taken through a primary refractory filter, by a water-operated aspirator fitted to the oxygen analyser. The sample is ducted to a measuring cell consisting of an annulus with a horizontal glass by-pass tube, on the outside of which are two identical platinum windings joined in a Wheatstone-bridge circuit. One of these windings is surrounded by an intense magnetic field from a permanent magnet. Oxygen from the sample is attracted into the by-pass by the magnetic field; as it is heated by the winding, its magnetic susceptibility falls and it is displaced by cool gas, flowing through the by-pass into the annulus. The continuous gas flow thus set up, known as the "magnetic wind," causes a difference in temperature, and therefore a difference in resistance, between the two platinum windings, and unbalances the bridge. The resulting out-of-balance electromotive force, which is proportional to the oxygen content of the sample, is measured by a standard Kent Multilec potentiometer-recorder.

Another development shown by Messrs. Kent is the Dall tube, an arrangement for producing a pressure difference for flow measurement with remarkably low head losses. For a given pressure difference, the Dall tube is more compact and weighs less than a short Venturi and, it is claimed, gives an overall pressure loss some 30 to 50 per cent. less than that of a classical Venturi tube. The Dall tube, which is made in cast iron or steel with a liner of brass or gunmetal, consists of a short length of parallel pipe followed by two short truncated cones, there being an appreciable step between the pipe bore and the larger end of each cone. At the throat between the smaller ends of the cones there is a small gap. The upstream pressure tapping is taken just before the approach cone, and the throat tapping is within the chamber formed by the throat walls and in line with the gap. The overall length is little more than 1½ pipe diameters. In the smaller sizes, the cone surfaces are fully machined, but above a pipe diameter of about 24 in. only the centre portion of each cone is machined.

Fielden (Electronics), Limited, Manchester, are showing a range of industrial indicators and recorders, among which may be mentioned their recently-developed sensitive differential-pressure recorder known as the Manograph. A photograph of the interior of the instrument is reproduced in Fig. 7. It consists of a glass U-tube containing water, mercury or any other suitable liquid. One limb of the U-tube is surrounded by a small metal band which can be traversed up and down the tube by a screw mechanism operated by a servo-motor. Any change in electrical capacity between the ring and the meniscus of liquid is detected by a capacity-sensitive electronic circuit, which controls the servo-motor so as to move the ring to follow the movements of the meniscus. The ring is mechanically linked to an indicating pointer or the pen of a chart recorder; the linkage can be arranged to give either a linear or a square-root relationship of the pen movement to the differential pressure. It will be appreciated that the energy required for operating the mechanism does not depend on the differential pressure source and, therefore, the instrument is particularly well suited to measuring the flow of low-velocity gases.

Messrs. Southern Instruments, Limited, Fernhill, Hawley, Camberley, Surrey, are showing an automatic developer for developing oscillograms in daylight immediately after they have been recorded; it is designed primarily for use with their M 731 universal oscillograph recording camera. The machine works on the principle, first demonstrated by Messrs. Kodak Limited, of moistening the emulsion of the oscillograph recording paper and then drying it quickly over a heated drum, which causes the rapid development of the recorded trace. The dried paper does not blacken appreciably in daylight, and can be kept for many days without serious darkening. The auto-developer consists of a cast aluminium casing, housing a framework carrying a 6-in. diameter metal drum with internal heaters and a thermostat set at just over 100 deg. C. The drum, which is driven through gearing by an electric motor, rotates once in about 40 seconds; the paper therefore travels about ½ in. in a second. A detachable unit contains a tank full of developer, a small reciprocating pump, and a shallow container which moisten the paper as it passes through it. The top of the case is covered by a framework carrying black cloth sleeves through which the operator loads the machine, by touch. A fan is driven from the motor shaft to circulate air and discharge steam generated in the drying process. The processed paper is discharged through a slot in the side of the machine.

(*To be continued.*)

# ROLLS-ROYCE OIL ENGINES.

ROLLS-ROYCE LIMITED are embarking on the production of a range of oil engines suitable for earth-moving and oilfield equipment, for road and rail transport, heavy tractors, and stationary and marine purposes. During the past few years, considerable design study has been carried out, and test running of single-cylinder units has been followed by trials of complete engines, both on the bench and in different types of vehicles. Between 15,000 and 20,000 engine hours have been accumulated on the test-bed and many hundreds of hours in vehicles; several engines have been fitted to Vickers VR 180 crawler tractors which have been used intensively on various kinds of sites. A tractor is at present operating in Tripolitania under arduous sand and temperature conditions. The firm hope to commence a production flow of engines early next year, and a new factory adjacent to the main works at Derby has been built for the Oil Engine Division. The first batch of engines will be delivered to Messrs. Vickers-Armstrongs Limited, for installing in the VR 180 tractor. At a Press conference in London last week Lord Hives, chairman of Rolls-Royce Limited, said that the new engines would be a challenge to the Americans, who had achieved a very high standard with their earth-moving equipment.

In order to satisfy demands for different types of engines, to suit different purposes, the "C" range (as it is termed) includes four-cylinder and six-cylinder engines, which can be supercharged or normally aspirated, with wet-sump or dry-sump lubrication, with light-alloy or ferrous castings, and with or without a front-end power take-off. Certain external components can be fitted on either side, thereby enabling the maximum accessibility to be achieved in many different applications. Common parts used throughout the range include pistons and piston rings, cylinder liners, valves, valve rockers, connecting rods, main bearings, and almost all the parts that are subject to wear or are normally renewed during servicing. The engine design is orthodox and, in general, follows established practice, but the quality of design and construction accord with the Rolls-Royce tradition and can be confidently expected to give high efficiency and low operating costs.

The six-cylinder supercharged engine, type C.6 S.FL, is illustrated from opposite sides in Figs. 1 and 2, herewith; it is a four-stroke direct-injection overhead-valve machine developing 190 brake horsepower at 1,800 r.p.m. It has a high power-to-bulk ratio; when the main castings are ferrous its net dry weight is 2,480 lb., but when light alloys are used it weighs 1,970 lb. The standard cylinder bore is $5\frac{1}{8}$ in. (130·175 mm.) and the stroke is 6 in. (152·4 mm.); thus the capacity of the six-cylinder engine is 742·64 cub. in. (12·17 litres). Fig. 6, opposite, shows the rated performance of the six-cylinder engine ($\pm 2\frac{1}{2}$ per cent. at normal temperature and pressure) up to the governed speed of 1,800 r.p.m.; it will be seen that the maximum torque is 600 lb.-ft. The six-cylinder engine, normally aspirated, is rated at 150 h.p.

The crankcase, of light alloy or a special cast iron, is designed so that the wheel-case and flywheel housing can be fitted at either end. By this means the exhaust system, supercharger, and other externally-mounted units can be fitted on either side, as previously mentioned, without altering the fully-machined crankcase. Deep webs support the main-bearing caps, which are also secured by transverse bolts. The main bearings are of the pre-finished steel-backed shell type with copper-lead-indium bearing surfaces. The cylinder block is integral with the crankcase and is fitted with easily-replaced wet liners. Press-fit replaceable valve seats are used in the cylinder head. The seven-bearing crankshaft is nitride-hardened and at the front end has an externally-mounted viscous-silicone torsion damper which effectively reduces the oscillations and vibrations of the crankshaft over the full speed range. The connecting rods, which are of Rolls-Royce "forged-to-size" design, are drilled longitudinally for pressure lubrication of the gudgeon pins. Each of the light-alloy pistons is fitted with three compression rings and one oil-scraper ring, and is recessed in the crown to form a toroidal combustion chamber. The overhead valves—one inlet and one exhaust valve to each cylinder—are actuated by push rods.

When space is limited, a supercharger can be fitted to give the required power. It is of the positive-displacement type, made by Sir George Godfrey and Partners, Limited, Hampton-road, Hamworth, Middlesex, and is mounted on the crankcase and driven by a gear train and spring drive from the timing gears at approximately twice crankshaft speed. It gives a boost of about 8 lb.

## 190-H.P. SUPERCHARGED OIL ENGINE.

ROLLS-ROYCE LIMITED, DERBY.

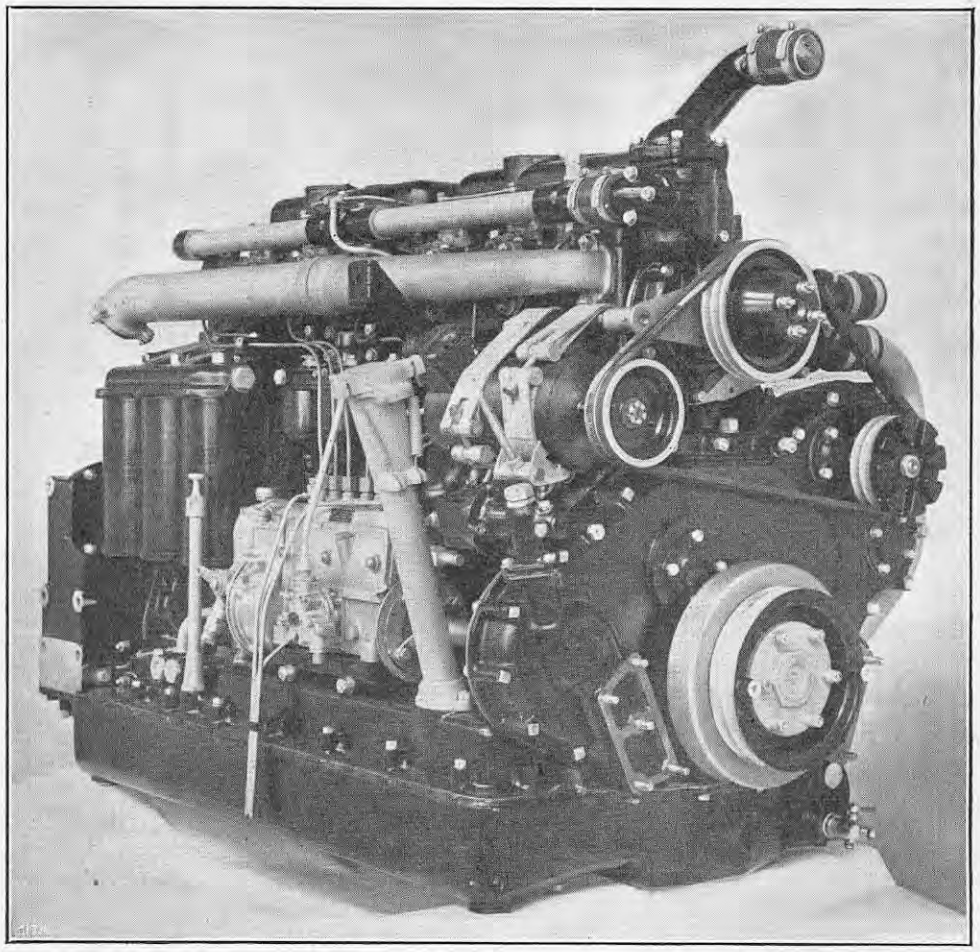


FIG 1.

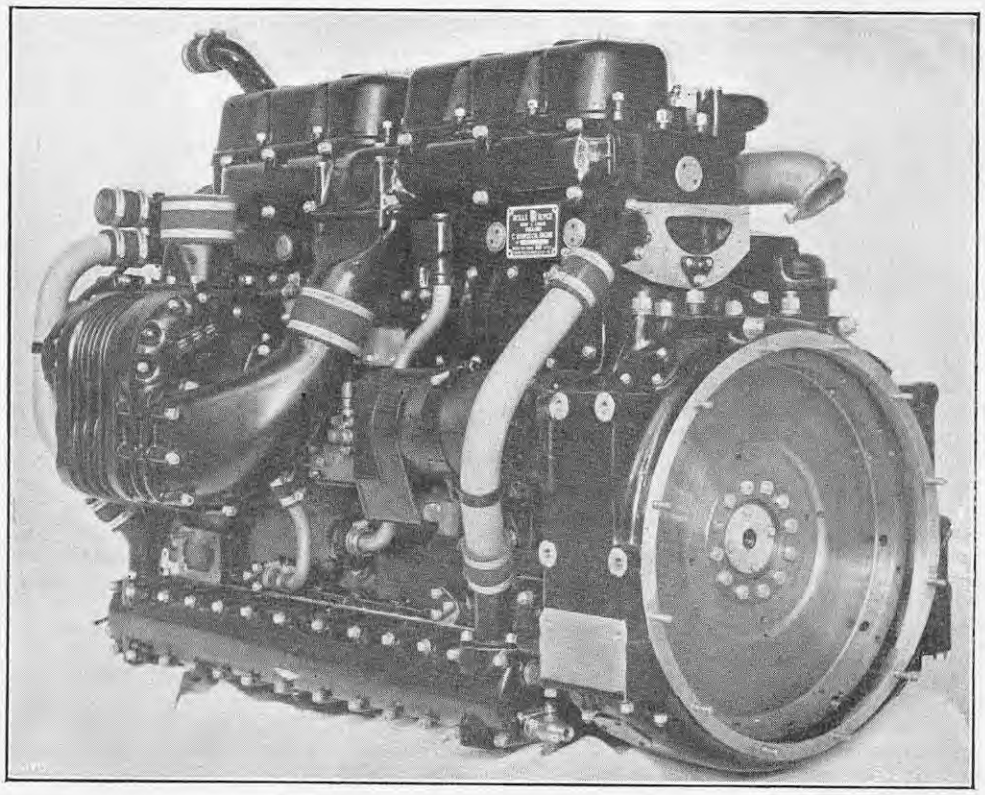


FIG. 2.

# 190-H.P. SUPERCHARGED OIL ENGINE.

ROLLS-ROYCE LIMITED, DERBY.

Fig. 4.

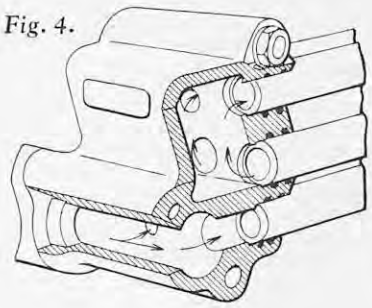


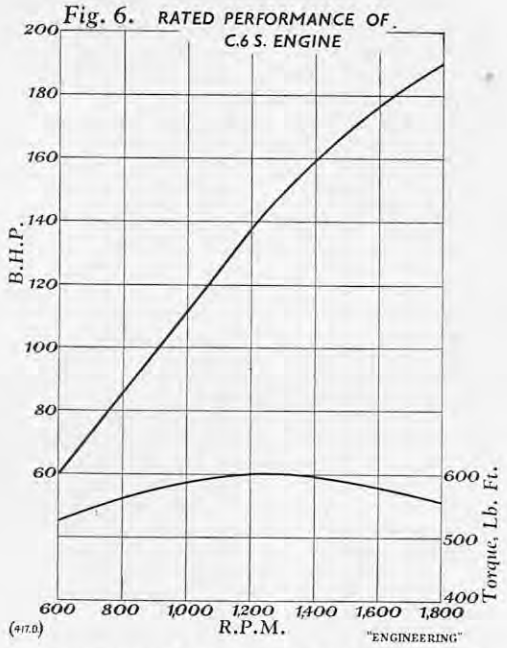
Fig. 3.




Fig. 5.




Fig. 6. RATED PERFORMANCE OF C.6 S. ENGINE




per square inch at the maximum governed speed of 1,800 r.p.m. The power take-off at the front end of the crankshaft will transmit the full power of the engine.

A heat exchanger of robust design is used to bring the engine oil rapidly to its most efficient working temperature and to maintain it at that temperature under all conditions. Maintenance of the correct engine temperatures, apart from increasing efficiency, shortens the warming-up period, so reducing wear. Figs. 3, 4 and 5, herewith, show the arrangement of the heat exchanger. On starting the engine, the cooling radiator is by-passed so that the coolant circulates through the heat-exchanger chamber and the engine. Fig. 3 shows the coolant-hose connections to this chamber, which is located on the side of the sump; it contains three pairs of tubes through which the cold lubricating oil makes three passes (as shown in Figs. 4 and 5), being warmed by the coolant. When the coolant reaches 70 deg. C., a thermostatically-controlled valve opens and allows it to circulate through the radiator.

A wet-sump system is normally supplied, but when use on uneven ground is intended, as in earth-clearing tractors, the dry-sump system is recommended. Dry-sump lubrication with an oil reservoir makes the engine suitable for working on slopes of up to 40 deg. As the oil drains into the sump, it is pumped through strainers and a gauze-type de-aerator into the reservoir. It is then pumped through the heat exchanger, from which it passes through full-flow filters to the main feed gallery for the engine bearings. Full pressure lubrication is employed; oil is fed to the main bearings, crankpins and gudgeon pins, and, at a lower pressure, to the valve rocker-shaft bearings, the push-rod ball ends and the ends of the valve stems. An externally-mounted relief valve keeps the main pressure at 40 lb. per square inch.

The coolant is circulated by a belt-driven centrifugal pump through the heat exchanger, engine, and radiator. Provision is made for fitting twin cooling fans. Though water can be used for the coolant, Rolls-Royce recommend the use of a correctly-inhibited anti-freeze mixture throughout the year, as it not only provides protection against frost but also prevents corrosion of the coolant passages.

A C.A.V. fuel-injection pump unit, mounted on the side of the engine, supplies fuel to the injection nozzles. The pump unit is driven from the engine wheel-case and includes a diaphragm lift pump for supplying fuel from the main tank. The injectors are accessible for servicing. Alternative governing systems are available. The firing order is 1, 4, 2, 6, 3, 5.

A 24-volt starter motor and a generator are the only electrical units on the engine. The starter motor is of the axial type, and, with normal batteries and S.A.E. 30 oil, the engine starts satisfactorily at temperatures down to — 8 deg. C. Special starting aids have been developed for the engine to start on suitable fuels at temperatures as low as — 40 deg. C.; air, hydraulic or combustion starters can be accommodated. The generator, which may be up to 8 in. in diameter, is mounted on the crankcase and is belt-driven in series with the coolant pump, the belt tension being adjusted by moving the generator.

A single-plate Borg and Beck dry clutch, 18 in. in diameter, has been designed for the engines; other clutches or torque converters can be fitted to the standard clutch housing (No. 1 S.A.E.) for stationary or marine purposes. Various types of single and multitple air-cleaner units have been developed for the engines by Rolls-Royce to ensure the highest practicable degree of filtration. The engine is fitted with a tachometer drive and connecting points for pressure and temperature gauges. An engine service counter, registering hours run at 1,500 r.p.m. or the equivalent, can also be fitted.

The overall dimensions of the six-cylinder supercharged engine, as arranged for tractor use, are length, 55·7 in.; width, 36·2 in.; and height, 38·6 in. The four-cylinder engine, unsupercharged, develops 100 h.p. at 1,800 r.p.m. (vehicle rating), and weighs 1,900 lb. with ferrous castings and 1,480 lb. with light-alloy castings. Its overall dimensions, with a wet sump, are: length, 43·8 in.; width, 23·9 in.; and height, 41·75 in.

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OPEN DAYS AT CHEMICAL RESEARCH LABORATORY.—The Department of Scientific and Industrial Research announce that Open Days at the Chemical Research Laboratory, Teddington, have been arranged and that applications from industrial firms wishing to send representatives should be sent, before August 31, to the Director for the following sessions: September 19 (afternoon), September 20 (morning) and September 21 (morning or afternoon). It is not necessary for firms already on the invitation list to re-apply.

## THE SITUATION IN THE NON-FERROUS METALS INDUSTRY.

IN the course of his annual report made at the sixth annual general meeting of the British Non-Ferrous Metals Federation, held in Birmingham on July 5, Mr. William H. Henman, the retiring President, stated that during the last twelve months prices of raw materials had risen higher and ever higher, until they were records. The demand which, a year ago, appeared to be falling off, was now higher than ever, and was greatly in excess of the industry's capacity to supply. It would, however, be unwise to take a superficial view of the present situation. The fact must not be overlooked that a great deal of what was regarded as demand was highly artificial, and was not really a demand for current consumption. There was the obvious example of the stock-piling of copper, zinc, nickel and other materials, carried on by the United States and other nations, including this country. A policy of stock-piling withdrew part of the annual production of metal from annual consumption, and thereby reduced the quantity available for normal uses, but it did not actually consume the metal, which remained available in case of need. This might give some comfort to the primary producer, whose rate of production was unimpaired, but it did cause considerable concern to the fabricator, who still found himself obliged to curtail output.

The continued shortage of virgin metal and the consequent drying up of scrap were matters of great concern. The present shortage was most serious in nickel and zinc, but that of copper was only slightly less serious. Under our present system of bulk purchasing and international co-operation, the prime responsibility for dealing with such shortages lay with H.M. Government and the international organisations to which the Government belonged. The advice of the Federation had been sought as to whether the Ministry of Materials should also act as a sponsoring Ministry for the wrought non-ferrous metals industry. After considerable discussion within the Federation, the Government had been advised that it was considered best that the Ministry of Supply should continue to act as the sponsoring Ministry, and this advice had been followed in the Bill which was now before Parliament. The Ministry of Materials was responsible for procuring copper, zinc, nickel and other metals, but the responsibility for the wrought industry rested with the Ministry of Supply.

So long as the present conditions continued, it was clear that the industry might have to suffer some reduction of output. In the absence of a complete licensing system, which neither the Government nor the industry desired, a great deal of responsibility rested upon the manufacturer to ensure that his limited output went to the most useful quarters. This problem had been the subject of constant discussion between the Federation and the Ministry of Supply and a reasonably successful system of manufacturing priorities had now been in operation for many months. The statement which had just been made by the Chancellor of the Exchequer on behalf of H.M. Government, however, was most welcome.

# NOTES FROM THE INDUSTRIAL CENTRES.

## SCOTLAND.

SCOTTISH STEEL.—All branches of the steel industry were busily engaged last week in clearing off as many orders as possible before the general close down of Glasgow and Lanarkshire steelworks to-day, July 13. Pressure for delivery has been strong, as consumers are anxious to have sufficient material for the resumption of work after the Glasgow Fair holiday. Raw materials for steelmaking show inadequate improvement, and there are fears that the 20 per cent. cut in steel-ingot production will not be the lowest point reached this year.

NEW FACTORY AT GREENOCK.—The American firm of International Business Machines World Trade Corporation have acquired a 110-acre site at Greenock where they are to establish a new factory, employing eventually, it is expected, about 5,000. The firm manufacture business machinery of many kinds, including accounting machines and electric typewriters.

WEAVERS SOCIETY.—The Society of Weavers in Pollokshaws, Glasgow, with a history going back to 1749, and one of the oldest institutions of its kind, is to be dissolved. The assets of the Society, stated in the last balance-sheet to be 7,000*l.*, are to be distributed among the remaining members, numbering about 85.

PRIZES FOR APPRENTICES.—Bonuses amounting to 580*l.* and 55 book prizes were distributed at the apprentices' prize-giving ceremony of Alexander Stephen and Sons, Ltd., shipbuilders, Glasgow, on June 25. About 250 apprentices received awards.

MARINE RADAR SCHOOL AT GREENOCK.—A radar operators' school, which has been established at the James Watt Memorial School, Greenock, was formally opened on June 12, by Captain R. C. Lewis, D.S.O., O.B.E., R.N., at a ceremony attended by representatives of several shipping lines and of the Ministry of Transport. The British Thomson-Houston Company's standard 3-cm. marine radar, type RMS.1C, is installed in the school, which is the first of its kind in Scotland. The installation provides a plan picture of the Clyde within a radius of 25 miles.

## CLEVELAND AND THE NORTHERN COUNTIES.

STEEL TONNAGE ALLOCATION.—The reaction of steel users to the Government plan for the allocation of steel supplies, so as to provide adequate tonnages for the defence programme and satisfactory deliveries for non-priority needs, is favourable. The movement is in keeping with measures that have long been approved in Tees-side commercial circles.

TEES SHIPPING STATISTICS.—While decreases in imports, exports and the number of ships entering Middlesbrough and sub-ports were reported at a meeting of the Tees Conservancy Commission held on July 2, Alderman B. O. Davies, who presided, declared that the situation did not warrant concern and he hoped that the position in regard to foreign ore and ships would soon return to normal. Statistics submitted to the meeting showed that, during May, 306 vessels having a total net tonnage of 300,854 were cleared, compared with 360 ships having an aggregate tonnage of 369,662 in May last year. Imports totalled 253,534 tons against 284,497 tons in May, 1950, and exports 131,410 tons, compared with 148,046 tons in May last year.

CLOSING OF NORTHUMBERLAND COLLIERIES.—Four collieries in the Throckley district of Northumberland are approaching the end of their productive capacity and are shortly to be closed. Discussions to this effect are now being concluded between the National Coal Board and the men's representatives. The four collieries are the Maria, Isabella, Blucher and Coronation pits, and the 1,300 men affected will be found work in other mines in the area.

## LANCASHIRE AND SOUTH YORKSHIRE.

THE DRIVE FOR SCRAP.—Special steps are being taken to induce farmers to collect and sell the considerable quantities of scrap, in the form of discarded machinery and other waste metal, which lie about many farms. Depots at central points, often at a railway station, are chosen and to these farmers can send their scrap to be paid for when weighed. The arrangements are being made through the National Farmers' Union. The national drive for scrap is yielding about 10,000 tons a week more than the weekly average last year.

EMPLOYING THE ELDERLY.—A letter of appeal to Sheffield employers, to consider the claims of the older men seeking situations, has met with a good response. The Sheffield and District Employment Committee were responsible for the appeal, which has been made necessary by the growing scarcity of labour. The letter, which was sent to 23 employers' organisations and more than 30 trade unions, suggested that industry should not impose any "over-age" bar to work, should give consideration to older persons in filling vacancies, and should retain employees who had reached retiring age.

LARGER SUPPLIES OF GAS.—The East Midlands Gas Board has formulated schemes for a large increase of gas supplies in Sheffield and Rotherham, and in Nottinghamshire and Derbyshire. During 1952, six million cubic ft. of gas a day should be available, under an arrangement with the North-Eastern Division of the National Coal Board, involving the installation of producers to make gas for heating the Smithywood coke-ovens, thus releasing coke-oven gas to the Neepsend Gasworks, Sheffield. Work has begun at Carr House Works, Rotherham, on an 8,000,000 cubic ft. a day installation. Large gasholders are under construction at Sheffield, Rotherham, Barnsley and Chesterfield, and smaller ones at Gainsborough and Worksop.

PROPOSAL TO SCRAP SHEFFIELD TRAMWAYS.—The Sheffield decision to scrap gradually the City's tramways is meeting with vigorous opposition. The Sheffield Tramways Development Association has been formed to combat the proposal and has passed a resolution asking the City Council to hold a referendum on the matter.

PRESTRESSED CONCRETE WATER TANK.—Sheffield Corporation Water Department is completing a prestressed-concrete water tank of 212,000-gallons capacity to serve a new housing estate. It is stated to be the first of its kind in the North of England. Professor W. G. Fearnsides, F.R.S., consultant geologist to the National Coal Board and a former Sorby Professor of Geology at Sheffield University, is stated to be interested in the method of construction as a possible means of lining new colliery shafts.

IMPROVED CARRIAGE-CLEANING DEPOT, LIVERPOOL.—A scheme has been prepared by British Railways (London Midland Region) for the modernisation and renovation of the carriage-cleaning depot at Downhill sidings, Liverpool. The work will cost about 58,000*l.*, and includes the installation of new equipment for vacuum-cleaning carriage upholstery, the preheating of trains, brake testing and charging train batteries.

## THE MIDLANDS.

THE LATE MR. C. T. BARLOW.—The death occurred at his home in Handsworth Wood, Birmingham on July 1, of Mr. Charles Thomas Barlow, O.B.E.; he was 75 years of age. Mr. Barlow was a well-known figure in Midland industry. He was born at Aston Manor, Birmingham, and educated at Perry Barr. Mr. Barlow helped to found the firm of Accles & Pollock, Ltd., serving for some years as general manager and joint managing director. He was one of the founders of Tube Investments, Ltd., Birchley Rolling Mills Ltd., British Stampings Ltd., British Tube Mills Ltd., London Works (Barlows) Ltd., and several other Midland firms.

UNITED STATES TECHNICIANS IN THE MIDLANDS.—A team of American technicians under the leadership of Mr. F. C. Greenhill, of Toledo, has arrived in this country to study British methods of pressed-steel product manufacture. Among the Midland factories to be visited by the team are those of Joseph Sankey & Sons, Ltd., Rubery Owen & Co., Ltd., and Joseph Lucas Ltd. The team will study methods of fabrication, assembly and finishing.

PROPOSED MIDLAND TRUNK ROAD.—The Minister of Transport has approved in principle the proposed section of the Bristol-Birmingham-Lancashire trunk road which will pass through the Black Country. Originally two schemes were put forward; an "outer line" which by-passed the Black Country on the West, proceeding from a point near the Lickey Hills to a point near Stafford, and an "inner line" which passed just to the west of Birmingham. Considerable opposition to the outer line was raised, on the grounds that valuable agricultural land would have to be taken for its construction. The road as now proposed will take a N.N.E. direction from Lydiate Ash, Worcestershire, and join the existing Birmingham-Wolverhampton road at Oldbury. There it will break off, and restart at West Bromwich and proceed roughly northwards to the west of Stafford. The section between West Bromwich and Oldbury has been abandoned because it would pass through a built-up area and involve much demolition.

BRITISH TIMKEN LTD.—At the annual general meeting of British Timken Ltd., held on June 27 in Birmingham, the chairman, Mr. John Pascoe, announced that, following the death of the late chairman, Mr. M. B. U. Dewar, the Timken Roller Bearing Co. of Canton, Ohio, U.S.A., had exercised their right to purchase all the late chairman's share holdings in the British company. As a result, the American Company now holds 54 per cent. of the ordinary share capital of British Timken Ltd.

EMPLOYEES' CONFERENCE.—A party of 400 employees from John Thompson, Ltd., Wolverhampton, recently attended a week-end conference at Pwllheli. The party consisted of directors, works managers, supervisors and members of welfare committees, with their families, and also apprentices. The conference was divided into three sessions, for supervisors, welfare committees and apprentices, respectively, and the meetings were addressed by the directors. The subjects discussed at the meetings included welfare matters, the scrap drive, safety, the work of the John Thompson Supervisors Association formed last year, and the opportunities available for trade, indentured and commercial apprentices.

SPECIAL LATHE FOR CANADA.—Messrs. Tangyes Ltd., Cornwall Works, Smethwick, Birmingham, competing with American and Canadian makers, undertook, on February 1, to build a special 16-in. axle lathe for the Canadian National Railways within five months. The contract was completed with a week to spare, although a considerable number of special features necessitated special machining fixtures and many new patterns.

EXTENSION OF BRONX ENGINEERING FACTORY.—The manufacturing capacity of the Bronx Engineering Co., Ltd., Lye, near Stourbridge, is to be increased; a new heavy erecting shop is now being built and will be equipped with two 25-ton travelling cranes. The extension has been necessitated by the increasing demand for Bronx machines for rolling mills.

## SOUTH-WEST ENGLAND AND SOUTH WALES.

ITALIAN LABOUR IN SOUTH WALES.—Further Italian labour was introduced into the West Wales tin-plate industry last week when a party of 54 commenced training. They arrived in Swansea on June 30, and were the first of 200 men selected last April by a joint delegation of employers and employees in the industry which visited Italy. Further batches will arrive over the next few weeks. The men will work in the old type of tin-plate mills in the Swansea, Llanelly, Gorseinon and Pontardulais districts. It is estimated that the number of Italians now employed is 300.

CARDIFF AIRPORT.—A sub-committee of three has been appointed by the Cardiff Corporation Airport Committee to attend a meeting with the Air Ministry in London to discuss the future of the Cardiff airport. The airport at Pengam Moors was requisitioned by the Air Ministry in 1939, and, after the war, was handed over to the Ministry of Civil Aviation. The Town Clerk, Mr. S. Tapper-Jones, has reported that the requisition expires in December next, but that the Air Ministry has not yet decided whether the airport should be de-requisitioned. If the Ministry decide to retain the airport, it will be purchased.

WELSH INDUSTRIES FAIR.—The 1951 Welsh Industries Fair, organised by the National Industrial Development Council of Wales and Monmouthshire, and staged at the Sophia Gardens Pavilion, Cardiff, was opened on July 4 by Lady Shawcross, wife of Sir Hartley Shawcross. The Fair closes on July 18. Over 100 firms are exhibiting.

RECONVERSION OF PICKLE LIQUOR.—A project by the Steel Company of Wales to reconvert spent pickle liquor to sulphuric acid is being closely watched by engineers and scientists. A pilot plant which, it is hoped, will prove that this is commercially possible, is being installed at the Old Castle Tin-Plate Works, Llanelly, in conjunction with Simon-Carves, Ltd., and the British Iron and Steel Research Association. If it is successful, large-scale plants will be built at the Margam and Trostre works of the Steel Company of Wales.

IRON AND STEEL EXHIBITION.—An iron and steel training exhibition, mainly to interest youth, was held at Cardiff from July 4 to 10. It was one of a series of exhibitions sponsored by the British Iron and Steel Federation in the steelmaking centres of Britain.

RESERVOIR FOR CARDIFF.—The Cardiff Corporation Finance Committee have given approval to an estimated expenditure by the waterworks committee of 35,000*l.* for a new 2,000,000-gallon reservoir. This scheme will replace an earlier proposal to repair the existing reservoir, at a cost of about 20,000*l.*

## NOTICES OF MEETINGS.

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

INSTITUTE OF PHYSICS.—*Industrial Radiology Group:* Monday to Wednesday, July 23 to 25, at 47, Belgrave-square, S.W.1. Annual Summer Meeting. Monday, July 23, 2.15 p.m.: (i) "An Analysis of the Quality of Radiographs," by Mr. D. Bromley; and (ii) "Gamma-Ray Stereography," by Mr. J. Rhodes. Tuesday, July 24, 10 a.m., Discussion on "Penetrameters," to be opened by Mr. J. C. Rockley. 2 p.m., (i) "Growth of Radiography," by Mr. W. E. Schall; and (ii) "Correlation of Radiographic Results with Weld Strength," by Dr. H. Vinter. Wednesday, July 25, 9.45 a.m., (i) "Xeroradiography," by Dr. L. van Ouwerkerk; and (ii) "Short-Range Radiography," by Mr. E. van Someren. 2 p.m., "Site Radiography of Pipe Welds," by Mr. R. Piercey, Mr. S. H. Gottfeld and Mr. R. V. Walker.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*South-West London Branch:* Tuesday, August 14, 8.15 p.m., St. George's Hall, St. George's-road, Wimbledon. "Carbon Brushes for Electrical Machines," by Mr. C. T. Lawrence.

## CONTRACTS.

STANDARD TELEPHONES & CABLES LTD., Connaught House, Aldwych, London, W.C.2, have obtained a contract for the supply of equipment for the Royal Air Force Station at Nairobi. This will include 19 short-wave radio transmitters of the DS 10, DS 12 and DS 13 types, with powers of 5 kW, 4 kW and 40 kW, respectively, together with associated drive units, monitoring and remote-control equipments. The total power of the station will be 369 kW.

HARBOUR & GENERAL WORKS, LTD., 173, St. Stephens House, Victoria-embankment, London, S.W.1, have received an order from British Railways for additional sidings to be constructed at Basford Junction, near Nottingham, London Midland Region.

During June the British Electricity Authority have placed contracts for equipment for power stations, transforming stations and transmission lines amounting, in the aggregate, to a value of 8,496,648*l*. The principal orders include circulating-water pipework for Brunswick Wharf power station, with ATTON & CO., LTD., and ash-and dust-handling plant for this station, with BABCOCK & WILCOX, LTD.; 33-kV switchgear for Willesden power station, with A. REYROLLE & CO., LTD.; coal-handling plant for Meaford "B" power station, with BABCOCK & WILCOX, LTD., and 132-kV 2,500-MVA switchgear for this station with the GENERAL ELECTRIC CO., LTD.; foundations, tunnels and works for coal-handling plant for Uskmouth power station, with JOHN MORGAN (BUILDERS), LTD.; generator and station transformers for Connah's Quay power station, with C. A. PARSONS & CO., LTD.; cables, connections and lighting installation for Keadby power station, with W. T. HENLEY'S TELEGRAPH WORKS CO., LTD.; site clearance and other preliminary works for Stella South power station, with SIR ROBERT MCALPINE & SONS (NEWCASTLE-ON-TYNE), LTD.; coal-handling plant for Roosecote power station, with ROBERT DEMPSTER & SONS, LTD.; condensing and feed-heating plants for two 30,000-kW turbo-generators for Fleetwood power station with VICKERS-ARMSTRONGS, LTD.; 132-kV 2,500-MVA switchgear for Stourport power station, with the GENERAL ELECTRIC CO., LTD.; Hawarden to Bangor 132-kV overhead line, with BRITISH INSULATED CALLENDER'S CONSTRUCTION CO., LTD.; Bonnybridge to Devonside 132-kV overhead line, with J. L. EVE CONSTRUCTION CO., LTD.; and Clydes Mill to West Melton, 275-kV double-circuit overhead line with BALFOUR, BEATTY & CO., LTD., and BRITISH INSULATED CALLENDER'S CONSTRUCTION CO., LTD. Moreover, bulk orders for 275/132-kV, 120-MVA auto-transformers have been placed with BRITISH ELECTRIC TRANSFORMER CO., LTD. (4); BRITISH THOMSON-HOUSTON CO., LTD. (3); ENGLISH ELECTRIC CO., LTD. (2); FERRANTI, LTD. (2); METROPOLITAN-VICKERS ELECTRICAL CO., LTD. (4); and C. A. PARSONS & CO., LTD. (2).

THE BURNTISLAND SHIPBUILDING CO., LTD., Burntisland, Fife, have secured contracts to build two ships. The first is a cargo motorship of 10,500 tons deadweight capacity for the Compania de Navegacion Oriental de Panama, Panama (Phocean Ship Agency, Ltd.). The propelling machinery will consist of 4,900-b.h.p. Diesel engines constructed by SULZER BROS., LTD., Winterthur, Switzerland. The second ship is a self-trimming collier of 1,800 tons deadweight for J. & A. Brown & Abermain Seaham Collieries, Ltd., Sydney, Australia. The vessel is to be built by the firm's associated company, HALL, RUSSELL & CO., LTD., Aberdeen. The propelling machinery will consist of 1,230-b.h.p. Diesel engines constructed by BRITISH POLAR ENGINES LTD., Glasgow.

## BRITISH STANDARD SPECIFICATIONS.

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

*B.A. Screws, Bolts, Nuts and Washers.*—A revision of B.S. No. 57, covering B.A. screws, bolts, nuts and plain washers has just been issued. The specification was first published in 1920 and first revised in 1944. The present edition confirms as a regular British Standard specification the war-emergency specification issued in 1944, subject, however, to certain modifications which more recent experience has shown to be desirable. General dimensions for all the common types of B.A. screws, bolts and nuts in sizes from No. 0 B.A. to No. 16 B.A., are given and the ranges of nominal sizes given in the tables are classified as "preferred," "second choice" and "not normally stocked." General requirements in respect of material, screw threads and finish are given and dimensions for two types of washers are specified. Finally, since the production of B.A. bolts is small compared with that of B.A. screws, the title of the specification has been amended so that the first word is "screws" instead of "bolts." [Price 3*s.*, postage included.]

*Woven Asbestos Binding Tape for Electrical Purposes.*—A new specification, B.S. No. 1720, covers woven asbestos binding tape for electrical purposes. It applies to plain unimpregnated tape having selvedges and does not include tapes having an all-cotton weft or warp. It is recommended that, for identification purposes, the tape covered by the new specification should incorporate green warp threads woven into the centre of the tape or the selvedges. By agreement between the purchaser and the manufacturer, however, the identification warp threads may be of other colours. In the specification are set out clauses regarding the finish, length, thickness and width of the tape and the number of warp and weft threads per inch it contains. Appendices deal with methods of conditioning specimens for test and with testing procedure. [Price 2*s.*, postage included.]

## LAUNCHES AND TRIAL TRIPS.

M.S. "BRITISH VISCOUNT."—Single-screw oil tanker, built and engined by Swan, Hunter, and Wigham Richardson, Ltd., Newcastle-upon-Tyne, for the British Tanker Co., Ltd., London, E.C.2, on behalf of the Anglo-Iranian Oil Co., Ltd. 39th tanker built for the British Tanker Co. Main dimensions: 490 ft. overall by 61 ft. 9 in. by 34 ft. 1 in.; deadweight capacity, 12,167 tons on a summer draught of 27 ft. 7½ in. Swan Hunter-Doxford four-cylinder opposed-piston Diesel engine, developing 3,100 b.h.p. at 105 r.p.m. Speed on trial, 12½ knots. Trial trip, June 20.

M.S. "STANBURN."—Single-screw cargo vessel, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the Stanhope Steamship Co., Ltd. (J. A. Billmeir & Co., Ltd.), London, E.C.2. Main dimensions: 435 ft. between perpendiculars by 59 ft. 6 in. by 38 ft. 11 in. to shelter deck; deadweight capacity, about 10,300 tons on a draught of 25 ft. 10 in. Hawthorn-Doxford four-cylinder opposed-piston two-stroke Diesel engine, developing 3,300 b.h.p. at 110 r.p.m., constructed by R. & W. Hawthorn, Leslie & Co., Ltd., Newcastle-upon-Tyne. Speed, 12½ knots. Launch, June 20.

M.S. "CHAKDARA."—Single-screw cargo liner, carrying twelve passengers, built and engined by Barclay, Curle & Co., Ltd., Whiteinch, Glasgow, for the British India Steam Navigation Co., Ltd., London, E.C.3. Eighth vessel constructed recently for these owners. Main dimensions: 485 ft. by 62 ft. 6 in. by 40 ft. 9 in. to shelter deck; deadweight capacity, about 10,000 tons on a draught of 27 ft. 3 in.; gross tonnage, 9,000. Barclay Curle-Doxford six-cylinder opposed-piston solid-injection oil engines, developing 6,800 b.h.p. at 116 r.p.m. on service. Speed, 15 knots. Launch, June 25.

M.S. "WAYFARER."—Single-screw cargo vessel, built and engined by William Doxford & Sons, Ltd., Sunderland, for Thos. and Jas. Harrison, Ltd., Liverpool. Main dimensions: 460 ft. overall by 59 ft. 6 in. by 37 ft. 8 in.; deadweight capacity, about 10,000 tons on a draught of 26 ft. 6 in. Doxford four-cylinder opposed-piston oil engine developing 3,300 b.h.p. at 108 r.p.m. Service speed, about 12½ knots. Trial trip, July 2.

M.S. "FRANCE STOVE."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Belfast, for Lorentzens Rederi Co., Oslo, Norway. Main dimensions: 580 ft. between perpendiculars by 78 ft. by 42 ft. 6 in.; deadweight capacity, 24,000 tons on a draught of about 32 ft. Harland-B. & W. seven-cylinder two-stroke opposed-piston oil engine. Launch, July 2.

## PERSONAL.

Marshal of the Royal Air Force LORD PORTAL OF HUNGERFORD, K.G., G.C.B., O.M., is retiring soon from the position of Controller of Atomic Energy. MR. M. W. PERRIN relinquished the post of deputy Controller of Atomic Energy on June 30.

DR. GEORGE WEBSTER, O.B.E., M.I.N.A., principal surveyor for Scotland, Lloyd's Register of Shipping, is to retire at the end of September after 37 years of service with the Society. His successor will be MR. H. R. GIBBS, who has been senior ship surveyor at Glasgow since March, 1950. Mr. Gibbs will be succeeded as senior ship surveyor at Glasgow by MR. H. MCQUEEN, M.B.E., who is at present stationed at Newcastle-upon-Tyne.

The University of Durham has conferred the honorary degree of Doctor of Science upon SIR ANDREW M. BRYAN, B.Sc., M.I.Min.E., J.P., F.R.S.E., and PROFESSOR C. J. HAWKES, M.Sc., M.I.Mech.E., M.I.N.A., who occupied the Chair of Engineering at King's College, Newcastle-upon-Tyne from 1920 until 1945.

MR. C. L. OLD, B.Sc. (Eng.) (Lond.), M.Sc. Tech. (Manch.), M.I.Mech.E., Principal of the College of Technology, Rotherham, since 1948, has been appointed Principal of the Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton, in succession to Dr. W. E. Fisher, O.B.E., who is retiring. Mr. Old assumes his new duties on September 1, 1951.

MR. W. J. TERRY has been elected President of the British Non-Ferrous Metals Federation, 132, Hagley-road, Birmingham, 16, for the year 1951-52, in succession to MR. W. H. HENMAN.

MR. T. A. MCKENNA, managing director of the Staveley Coal and Iron Co., Ltd., has been appointed chairman in succession to MR. D. N. TURNER, M.I.Min.E., who, as stated on page 467 of our issue of April 20, retired as from July 1.

PROFESSOR A. N. SHIMMIN, who occupies the Chair of Economics at the University of Leeds, has been appointed chairman of the Transport Users Consultative Committee for the Yorkshire area. The Minister of Transport hopes to appoint the full committee shortly.

MR. J. RATTER, C.B.E., B.Sc., M.I.C.E., who has been civil engineer (maintenance), London Transport Executive, since 1947, has been appointed chief officer, engineering (works), Railway Executive.

THE BRUSH ABOE GROUP OF COMPANIES announce that MR. C. F. BARNARD has been appointed assistant general manager, National Gas and Oil Engine Co., Ltd., Ashton-under-Lyne; that MR. E. J. BATCHELOR has been appointed vice-chairman of Brush Coachwork Ltd.; that MR. K. N. ECKHARD, M.I.E.E., M.Inst.T., M.I.Loco.E., has been elected to the board of Brush Bagnall Traction Ltd., as director and general manager; and that MR. B. D. GIORDAN, B.Sc., A.M.I.Mech.E., is the new general manager of Mirrlees, Bickerton & Day.

MR. WILLIAM JONES has been appointed manager of the Bristol office of Brookhirst Switchgear Ltd., Chester, in succession to the late MR. H. J. BARBER.

MR. L. C. JOHNSON has been appointed archivist in charge of the preservation and custody of all historical records of the British Transport Commission, 55, Broadway, London, S.W.1. His office is at 66, Porchester-road, Paddington, London, W.2. MR. J. H. SCHOLES has been appointed curator responsible for the custody and display of old prints, models, pictures, rolling stock, etc. His office is at Euston Station, London, N.W.1.

Leverhulme Research Grants for 1951 have been awarded to DR. J. NEEDHAM, F.R.S., Fellow of Caius College, Cambridge, for the completion of a study of science, scientific thought and technology in the Far East, and to MR. D. G. PECK, M.A., who is studying the urban drift in rural communities between 1850 and 1950.

The registered office of LANCASHIRE DYNAMO HOLDINGS LTD., and of LANCASHIRE DYNAMO AND CRYPTO (MFG.) LTD., is now 94, Petty France, London S.W.1. The latter subsidiary company is entirely responsible for the activities of the Trafford Park and Willesden Works.

STANDARD TELEPHONES AND CABLES LTD., Connaught House, Aldwych, London, W.C.2, have appointed A. W. GORDON, LTD., 11, Gloucester-street, Belfast, to be their sole selling agents in Northern Ireland.

ELECTRO-HYDRAULICS LTD. announce that their fork truck division, formerly known as CONVEYANCER FORK TRUCK CO., has now been incorporated as a separate private limited company. As from July 1, it has operated as CONVEYANCER FORK TRUCKS LTD., with registered office at Liverpool-road, Warrington.

The name of the SOUTH AFRICAN INSTITUTION OF ENGINEERS has been changed to the SOUTH AFRICAN INSTITUTION OF MECHANICAL ENGINEERS, as from June 1. The offices remain at Kelvin House, Cor. Marshall and Hollard streets, Johannesburg, Transvaal.

A. C. WICKMAN, LTD., announce that as from June 28 the name of the company has been changed to WICKMAN LIMITED.

# USKMOUTH POWER STATION.

FIG. 1. AERIAL VIEW OF SITE.

## NEW POWER STATIONS FOR THE B.E.A.: XX.—USKMOUTH.

THE Uskmouth power station of the British Electricity Authority is situated at Nash Point on the mouth of the River Usk. The area occupied by the station, of which a view is given in Fig. 1, is about seven acres, and, as much of the surrounding area is below high-tide level, it is proposed to cover it first with ash to a depth of 8 ft. to 10 ft. and then with soil, so that it can be used for cultivation. Owing to the fact that the marl was 62 ft. below ground level, it was necessary to drive some 9,000 piles, varying in length from 50 ft. to 70 ft., to form the foundations. The contractors for this part of the work were Messrs. John Morgan (Builders), Limited, Cardiff.

Coal from the South Wales fields will be brought in by rail and will be taken by a conveyor system with a capacity of 600 tons per hour either to the boiler-house bunkers or to a 108,000-ton storage ground. The steam-raising plant, which, like the conveyor system, is being constructed by Messrs. Babcock and Wilcox, Limited, Farringdon-street, London, E.C.4, will consist of 12 pulverised-fuel fired high-head boilers, each with an output of 360,000 lb. of steam per hour at a pressure of 950 lb. per square inch and a temperature of 925 deg. F. Each pair of boilers will supply a receiver and these receivers will be also connected in pairs. The grit will be extracted by Centicell dust collectors and electrostatic precipitators and subsequently, like the ash, will be dealt with on the hydro-jet system. A view of the boiler and turbine houses in course of construction appears in Fig. 2.

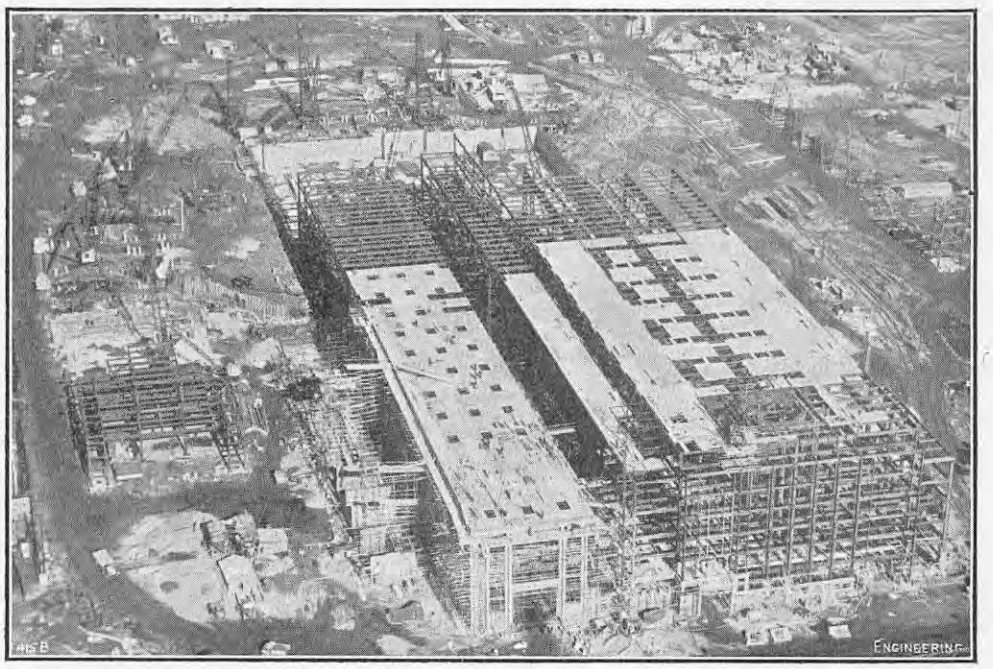

FIG. 2. BOILER AND TURBINE HOUSES UNDER CONSTRUCTION.

The generating plant will consist of six Fraser and Chalmers-General Electric Company hydrogen-cooled sets, which will generate at 11·8 kV and will discharge into Hick, Hargreaves condensers. These condensers will be cooled by river water and, owing to the tidal range of 35 ft., the pumps, which are being manufactured by Messrs. Gwynnes Pumps, Limited, Lincoln, for this purpose, and each of which will have an output of 2,500,000 gallons per hour, will be installed at a depth of 62 ft. below finished ground level. For economic reasons, syphonic assistance to the extent of 15 ft. will be utilised and, owing to the nature of the ground and the difficulty of obtaining cast iron, reinforced-concrete ducts are being laid. To erect the pump-house, a welded-steel caisson, which is reputed to be the largest of its type in Europe, had to be sunk by Messrs. Holloway Brothers (London), Limited, the operation being assisted by the reinforced-concrete structure. The consulting engineers for this part of the work are Sir William Halcrow and Partners, Alliance House, Caxton-street, London, S.W.1.

Feed-heating, the plant for which is being manufactured by Messrs. Hick, Hargreaves, Limited, Bolton, will be in five stages, to give a final feedwater temperature of 385 deg. F. Both electrically and steam driven feed pumps will be installed, the latter being brought in automatically should the electricity supply fail.

The output from the main alternators will be stepped up to 132 kV in 70-MVA transformers and controlled at this voltage by Metropolitan-Vickers switchgear of the indoor air-blast type. The work's auxiliaries will be supplied from 11·8/3·3-kV and 132/3·3-kV transformers, and the switchgear controlling the circuits is being manufactured by the General Electric Company.

# ENGINEERING,

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

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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## ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for insets, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10*s.* for the first four lines or under, and 2*s.* 6*d.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

## TIME FOR RECEIPT OF ADVERTISEMENTS.

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

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

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


## CONTENTS.




# ENGINEERING

*FRIDAY, JULY 13, 1951.*

VOL. 172. No. 4459.


## HYDRO-ELECTRIC POWER ON THE ZAMBESI RIVER.

FOR many centuries, "the glory that was Greece and the grandeur that was Rome" have been accepted appraisals of historical developments which have left impressions on the minds of nations as plain to be seen as the physical traces on the territories where Greek and Roman bore sway. Surveying the world of to-day, however, as portrayed (in most civilised countries, with tolerable accuracy) by newspapers and other printed records, we are inclined to wonder whether the contemporary opinion of Grecian glory and Roman grandeur was appreciative or the reverse; whether the peoples who became Roman vassals valued at their real worth the Roman road-making and their system of colonial government, or whether the people of Athens regarded the building activities of their authorities of the day any more favourably than British people of 1951 regard the growing mass and multitude of their Government offices. We suspect very strongly that most of them, if they thought about the matter at all, never dreamed that the activities in which they were engaged would be so highly regarded more than a thousand years later. It may even be that some intransigent Gauls or Celts thought of the public work of their administrators much as Persia views those of the Anglo-Iranian Oil Company, and looked upon their skilled engineering no more gratefully than Egypt now does the Suez Canal and the Nile barrages.

Britain is becoming accustomed to this kind of short-sighted ingratitude, and, recognising its rather puerile origins, is not deflected thereby from the task of making the great sources of power in Nature available for the use and convenience of man. Thus it is not surprising to find that, in spite of the present state of affairs in Persia, in India, and Malaya, in Egypt and the Sudan, and many other places where British initiative and British capital have succeeded in raising many blades of grass where few grew before, there is no slackening in the work of planning new schemes to harness natural forces. Political trends may enable greedy and irresponsible governments of some future era to expropriate the works when they are completed, and to ruin their efficiency by sheer incompetence; but the type of mind which conceives and carries through great engineering works is seldom diverted from its purpose by any such considerations of the future. Some day, the popular newspapers of the Middle East may write romantically of "the glory that was Britain," and dwell on legends of how a few courageous and highly knowledgeable pioneers wrested from the soil of Persia riches that the Persians themselves could not possibly have tapped.

Meanwhile, the exploring engineers of Britain carry on with their beneficial investigations, and make their reports, the latest of which, on proposals for harnessing the Zambesi River at the Kariba Gorge, was issued a week ago.* The Commission responsible for this report was appointed in November, 1946, by the Central African Council with instructions "to study the possibilities of the Kariba and Kafue hydro-electric power projects and any other large sources of power available for joint development" by the Council, which was formed in 1944 to co-ordinate the activities of the two Rhodesias and Nyasaland. The Council is an advisory body with no executive authority, and, we understand, is eventually to be superseded by an inter-territorial permanent secretariat; meanwhile, however, if it does nothing more, it can claim credit for having carried through an admirable piece of fundamental preliminary work in instigating this survey and report. The advisory panel of consulting engineers who organised the survey and prepared the report were Sir William Halcrow, M.I.C.E., of Messrs. Sir William Halcrow and Partners; Mr. H. J. F. Gourley, M.I.C.E., of Messrs. Binnie, Deacon and Gourley; Mr. C. H. Pickworth, M.I.C.E., M.I.E.E., of Messrs. Preece, Cardew and Rider; and Mr. Geoffrey Kennedy, M.I.Mech.E., M.I.E.E., of Messrs. Kennedy and Donkin.

The Kariba Gorge is about 16½ miles long, fairly wide at both ends, but deep and narrow for several miles in the middle. There is also a short restriction, less pronounced in character, at the lower end. The catchment area above the gorge is about 206,000 square miles. It was proposed to construct a dam across the gorge, with a hydro-electric power station to utilise the discharge. There appeared to be several possible sites, but the choice was eventually reduced to three. One of these (Site 3A) is at the lower end of the gorge and has the advantage of being more accessible than the other two. Site 1, about 1¾ miles below the upper end of the gorge, was estimated to require about 750,000*l.* more capital outlay than Site 3A, while giving less power; and Site 1A, about three quarters of a mile below Site 1, though affording the opportunity for a shorter dam, is much less accessible. The estimated saving in cost, however, was between 2*l.* and 3*l.* millions, compared with Site 1. The site provisionally selected is 3A, where, it is estimated, the ultimate capacity would be 1,000 MW at an annual load factor of 70 per cent. Regarding the Kafue scheme, the report observes that considerable further investigation would be necessary to enable a definite proposal to be formulated; and it is recommended that, as the capacity at Kafue would be only 380 MW, that site would not be suitable as a first

* *Report on Kariba Gorge and Kafue River Hydro-Electric Projects, by the Inter-Territorial Hydro-Electric Power Commission.* Central African Council. Published by the Crown Agents for the Colonies, 4, Millbank, Westminster, S.W.1. [Price 63*s.*]

development, though the investigation of its possibilities should be continued.

The immediate potential load in Northern Rhodesia is about 100 MW of demand by the copper-mining companies in that area. In Southern Rhodesia, there is a greater potential demand, and it is estimated that, by 1962, the Salisbury-Midlands area will require between 270 MW and 380 MW; there is a likelihood of an approximately comparable demand, in the aggregate, from the Shabani, Gwanda and Bulawayo areas. It was for this reason that the Commission decided that the Kariba scheme should take priority over that at Kafue, expressing themselves as "satisfied that the load development estimates in the territories to be served are well founded and that the Kariba scheme affords the most economical source of bulk power available to the territories." In a later paragraph of their recommendations and conclusions, they are even more emphatic, stating that they fully agree with the Advisory Panel's opinion that "the Kariba project is an unusually favourable one, and that the cost of energy therefrom is low by any standard." This opinion, they add, "is based on Kariba as a power project alone," though it offers other considerable advantages.

The estimated cost of the Kariba project, based on the prices ruling in November, 1950, and assuming an initial installed capacity of 385 MW., is 43,519,000*l.*, of which the civil engineering works and generating plant would account for 32,080,000*l.* For a final installed capacity of 1,000 MW, the total cost would be 74,504,000*l.*, the corresponding figure for civil engineering works and generating plant being 43,600,000*l.* The respective costs of the current, at the generators, are estimated at 0·157*d.* and 0·0832*d.*, per kilowatt-hour; and the corresponding costs of energy at the receiving stations, at 70 per cent. load factor, would be 0·2525*d.* and 0·1703*d.* It is recommended that a ring system of transmission at 220 kV should be adopted.

To implement the recommendations of the report, it is proposed that a Rhodesian Hydro-Electric Power Authority should be constituted "to finance, control and administer all installations at Kariba, together with the main transmission lines and associated equipment." It is also recommended that a Zambesi River Authority should be set up eventually, to consider "matters affecting common interest in, and common usage of, the river by riparian territories, including power production, navigation and transport . . . and the determination and initiation of measures necessary to preserve and improve the regime of the river." This Authority would also "act as an inter-territorial water court for the equitable apportionment of the waters of the river between the riparian territories." The suggestion is made that, "as a matter of urgency," an Interim Commission should be appointed, consisting of representatives of all the riparian territories, to make recommendations regarding the constitution, powers and financing of the recommended Zambesi River Authority.

It will be seen, from the above very brief summary of this most important report, that the British engineering skill and foresight which wrought such vast changes in India, Egypt and elsewhere in the late Nineteenth and early Twentieth Centuries is still at the service of the world, and is likely to be no less potent a force for good in the future than it has been in the past. If the effect of educating the native African—another development which Britain has sponsored more ardently than any other nation—is to arouse in him an acute jealousy of the white men who thus render available the natural resources of his home country, so that he feels impelled to seize control of them for himself, the historians of future eras will probably not be surprised; but it is to be hoped that they, at least, will appreciate that there was also a glory that was Britain, and apportion the credit where it is due.

## BRITISH TRANSPORT.

IN spite of a deficit amounting to 14,100,000*l.*, the annual report* of the British Transport Commission for 1950 affords reasonable grounds for the view that, if two major obstacles can be overcome, the transport services will no longer be a source of national concern and embarrassment, and the benefits of integration will not be overshadowed by an inability to provide the services at cost. The two obstacles are the inflexibility of the present arrangements allowed to the Commission for raising its fares and charges to meet mounting costs, and the limitations on capital expenditure which, over a long term, prevent the necessary improvements in efficiency. The deficits for each year since the Commission took over have been 4,700,000*l.* in 1948, 20,800,000*l.* in 1949, and 14,100,000*l.* last year, making a total deficit accumulated on net revenue account of 39,600,000*l.* This figure, however, must be considered in relation to the annual turnover of 500*l.* million for three years, and in relation to a diagram which shows how delay in the authorisation for increasing charges leads to an ever larger deficit, and how, when the authorisation is finally effected, the resulting excess of working surplus over central charges is slight and short-lived. A solution to the delay problem must be found, and it is therefore to be hoped that, when Parliament debates the report, attention will be focused on this aspect.

The most encouraging feature of the annual report, however, is that the total working expenses per train mile have fallen by about 2*s.* since the beginning of 1948. On the basis of the rate of train miles ruling at the end of 1950, this reduction is equivalent to between 35*l.* million and 40*l.* million per annum. Nevertheless, in the three years since nationalisation, transport users have received transport services at less than cost, and users in the future are left to make good the difference. In so far as it is possible to judge the efficiency of a virtual monopoly, it is apparent that substantial results have been achieved in limiting expenditure and improving efficiency. For example, the total expenditure on British Railways hardly altered from 1949 to 1950, the actual figures being 312,800,000*l.* and 313,700,000*l.*, respectively. The net savings due to the closing of certain stations and branch lines amounted to 350,000*l.* for the three years, and the reduction of railway staff over the same period was 55,000, or 8 per cent. of the total.

The uncertainties relating to the control of capital expenditure, which was the subject of an article in ENGINEERING last week, are clearly a reflection of the uncertain international outlook, but it is regrettable that full advantage was not taken of the modest amount allowed by the Government in 1950; actual capital expenditure was just under 68*l.* millions, although the permitted expenditure was 81*l.* millions, comprising 79*l.* millions for railways and 2*l.* millions for London Transport garages. The Government have now apparently recognised the futility of publishing hypothetical expected rates of capital expenditure, but the method of controlling it has not been explained. To a large extent, it must depend on the granting or withholding of authorisations for major schemes of development. The Commission protest at the restrictions: after affirming that the principal remedy for declining profitability is to be found in improvements in efficiency, and citing electrification in suitable circumstances as one example, they state that "such projects are practicable only if the capital resources are available, and as things are turning out, the public transport system may count itself fortunate if the ration of capital expenditure allowed to it suffices to patch and maintain the existing apparatus, let alone permit of the introduction of large schemes of capital improvement or development."

Capital expenditure is needed for many desirable schemes. In the Metropolis, for example, the implementation of the London Plan depends on major decisions by the Government, particularly with regard to the future of Charing Cross, Cannon Street and Blackfriars railway bridges. The report of the committee, under the chairmanship of Sir Robert Inglis, which is examining the transport requirements of the Glasgow area, is expected to be completed in the near future. The value of electrification is shown by the results achieved with the Liverpool Street-Shenfield service: the number of passenger journeys increased by 48·5 per cent. and the receipts by 40·8 per cent., as between nine months in 1949 prior to electrification and a corresponding period in 1950 after electrification.

Dealing with the permanent way, the report states that an investigation was begun by a firm of consulting engineers into the possibility of introducing an incentive scheme for length and relaying gangs. Four trial schemes of mechanisation of day-to-day length-gang maintenance were planned for introduction this year, and the use of Matisa ballast-tamping machines and cleaning machines is being extended. A large number of technical researches is being undertaken in the civil-engineering departments, and trials are continuing with various automatic train-control systems. The locomotive stock and the number of different types are being reduced. The carriage situation is much healthier and the proportion of wagons under and awaiting repair was 6·7 per cent. at the end of 1950, compared with 8·4 per cent. in 1949 and 9·8 per cent. in 1948. A committee of officers of the Railway Executive have reviewed the design, capacity and types of wagons, considering, in particular, the desirability of eliminating grease-lubricated wagons, the ideal design and capacity of wagons, the fitting of automatic brakes to all freight stock, the type of coupling for wagons with automatic brakes, and the comparative merits of vacuum and air brakes. There are 480 different types of wagons, and proposals under consideration would reduce this to 150.

Developments by the other Executives are also recorded. The Road Passenger Executive are testing a new double-deck 'bus, the "Lodekka," in which the seating capacity is increased from 55 to 58; the step between the conductor's platform and the lower saloon is eliminated; and the centre of gravity is lower, thus reducing the strain on tyres. The Road Haulage Executive are planning a national system of workshops, and a committee has been considering the numbers and types of vehicles to form an "ideal" fleet. The Docks and Inland Waterways Executive have been hampered by the fact that many docks, such as those built for exporting coal, are not used as intended, and the Commission are considering proposals for transferring certain waterways to other authorities.

Thus, the report devotes much space to explaining the developments and also the reasons for shortcomings in the transport services. Criticism, and, indeed, opposition, comes from some unexpected quarters: "the attempts of the Commission to regroup operations, or to alter working conditions, have met with considerable opposition from sections of the staff. This delays the whole experiment in integration and co-ordination of the services, from which a great improvement in efficiency and an elimination of waste could undoubtedly result." Three years is evidently not long enough for the feeling of dissatisfaction which has been engendered in the staff by the unavoidable inertia of planning from the top to be dissipated by evidence of improved conditions and services. From whatever angle the Commission's work is viewed, the problem is ultimately resolved in terms of finance—capital expenditure and appropriate charges.

* *British Transport Commission: Third Annual Report, Statement of Accounts and Statistics, for the Year ended 31st December*, 1950. (H. M. Stationery Office, 12*s.*)

# NOTES.

### ATOMIC POWER FOR INDUSTRY.

IN a written answer to a question about the use of atomic power for industrial purposes, in the House of Commons on Monday, July 9, the Minister of Supply (the Rt. Hon. G. R. Strauss) said that work on the planning of nuclear reactors for use as power units, and on the development of the necessary facilities for investigating materials for use in such reactors, had continued and considerable progress had also been made in the technology of the special materials required for reactor construction. Design studies of experimental reactors for marine propulsion and for static use were in progress. He added that it was too early to make any reliable estimate of the relative cost of generating electricity by present methods and from atomic power. There was, however, a reasonable prospect that generation from atomic power could be developed on a large scale and that ultimately the cost would not differ greatly from that of power from conventional sources. The relative cost would vary from place to place, according to the local availability and cost of coal and to other general economic factors. Generation from atomic energy was therefore likely first to offer advantages in particular places. It was, however, too early to form definite conclusions or to prepare plans for action.

### INTERNATIONAL MACHINE TOOL EXHIBITION, 1952.

It was announced by Mr. Robert Asquith, president of the Machine Tool Trades Association, at a press conference on Wednesday, July 11, that an International Machine Tool Exhibition will be held at Olympia, London, from Wednesday, September 17 to Saturday, October 4, 1952. It has for a long period been customary for this body to organise such exhibitions at four-yearly intervals, but none took place between 1934 and 1948, partly owing to the fact that in 1938 the industry was fully occupied in preparing for war and partly owing to the war itself. Changes in design were also largely checked by the overriding demand for output during the war and, even four years ago, the principal task of the industry was to deal with the conditions caused by a sellers' market. Since then, however, the trade position has changed, and manufacturers have, as a result, been paying more attention to improvements in detail with the laudable object of increasing the efficiency of their products. An exhibition is obviously one way of calling the attention of both home and foreign buyers to these advances. It is, therefore, a little surprising that there have been rumours that the postponement of the exhibition would be necessary, owing to the political situation. It has, however, been decided that such a display of products will be in the best long-term interests of the industry and will act as a stimulus to the export drive.

### JUBILEE OF THE VACUUM CLEANER.

The first vacuum cleaner in the world was invented in 1901 by Mr. H. Cecil Booth, F.C.G.I., M.I.C.E., then a young civil engineer working on the design of steel structures and bridges. His professional work included the great wheels erected in Blackpool, Paris and Vienna, and a part in the design of the great wheel at the Earl's Court Exhibition. After considerable experiment, he constructed and patented his machine, which he christened the vacuum cleaner, and on February 25, 1902, with some friends, he issued the prospectus of the Vacuum Cleaner Company, Limited. The great potentialities of the invention were envisaged at the outset, as the following quotation from the prospectus shows: "The advantages of the system in private houses are equally great. Rooms which are now thoroughly cleaned only once a year at an annual spring cleaning can, in future, be treated effectively and completely in a few hours, without the inconvenience caused by removal of carpets and furniture." At that time, of course, few houses were supplied with electric current, and small high-speed motors and high-pressure fans did not exist. The first cleaners, therefore, consisted of a vacuum pump driven by a petrol or electric motor and having a dust-collecting filter, the whole mounted in a van which worked in the street, with long hoses into the house. In 1903, the original firm became the British Vacuum Cleaner and Engineering Company, Limited, of which Mr. Booth is still chairman. With works at Leatherhead, Surrey, they are the makers of Goblin domestic vacuum cleaners, and they and their founder have every reason to be proud of the progress they have made in the application of engineering in the home.

### EXPERIMENTAL BOILER FOR BIRMINGHAM UNIVERSITY.

On July 3, at the University of Birmingham, the presentation was made to the University of a water-tube boiler, with the necessary auxiliary plant for instructional and experimental use in the Mechanical Engineering Department. The boiler is the gift of Messrs. Babcock and Wilcox, Limited, and the presentation was made by Mr. C. K. F. Hague, managing director of Messrs. Babcock and Wilcox. The Pro-Chancellor, Mr. Sydney Vernon, accepted the boiler on behalf of the University, and unveiled a tablet, affixed to it, commemorating the occasion. The ceremony was attended by a number of guests, who were entertained to luncheon before the presentation. The boiler, which has an evaporative capacity of 5,000 lb. per hour at 200 lb. pressure per square inch and superheat to 500 deg. F., is generally similar to one presented to the University of Cambridge, and will supply steam to a number of engines, etc., in an adjacent building. It is fitted with a Mirrlees "Combustioneer" mechanical stoker, which also has been given by Messrs. Babcock and Wilcox. The equipment, all presented by the respective makers, includes an economiser, by Messrs. E. Green and Sons, Limited; an induced-draught fan, by Messrs. Davidson and Company, Limited, and electric motor, by the General Electric Company, Limited; a centrifugal feed-pump, by Messrs. James Beresford and Son, Limited; and a feed-water regulator, by Messrs. Cope's Regulators, Limited. The valves were supplied, as a gift, by Messrs. Dewrance and Company, Limited; the insulation similarly by the Darlington Insulation Company, Limited; and Messrs. A. N. Fenner and Company, as their share, painted the boiler after erection.

### COMMEMORATION OF CHRISTOFER POLHEM.

Christofer Polhem, the great Swedish engineer, was born on December 18, 1661, at Tingstäde, on the island of Gotland, and died in 1751. To mark the bicentenary of his death, a service of commemoration was held at Tusgstäde on June 10, particulars of which we have received recently through the courtesy of Dr. H. W. Dickinson, joint honorary secretary of the Newcomen Society. The celebration was organised by Mr. Robert S. Nilsson, of Visby, Gotland, and began in the morning with the arrival at Visby of two aircraft from Stockholm, bringing representatives of the Swedish Government and some 80 members of the Swedish Association of Inventors. At Tingstäde, the ceremony opened with an address by Mr. Arvidolsson, and a prayer by Bishop E. Björlander, after which a choir and orchestra rendered folksongs and some of the folk-music of Gotland. Mr. Nilsson then delivered an address summarising the works carried out by Polhem. Later, a visit was paid to Polhem's birthplace and to the adjoining blacksmith's shop in which, as a boy, he laid the foundation of his engineering skill. After lunch, the party returned to Visby, where wreaths were placed on the statue of Polhem. The celebrations ended with a banquet. In early life, Polhem was an estate clerk in Sudermania, the province in which the southern part of Stockholm is situated. By dint of great frugality, he contrived to save enough money to enter the University of Upsala, where he studied "natural science," which was the nearest approach at that time to the subject of engineering. Subsequently, he worked as a mining engineer, introducing many mechanical devices into the copper mines at Stora Kopparberget. He is also credited with the invention of the elevating screw for guns, in place of the quoin or wedge. His ingenuity brought him to the notice of the then King of Sweden, Charles XII, who ennobled him in 1714, when he took the name of Polhem; previously, his name was Polhammar. He was then 53 years of age, and had still to make his mark as an engineer of public works. In the course of his remaining 37 years, however, he undertook many civil engineering works of magnitude, including the construction of docks at Karlskrona, the canal and lock connecting Lake Malar with the Baltic, and a system of locks to enable ships to pass the waterfalls at Trollhättan, which form the only outlet of Lake Wenern. Only the first lock was excavated, however, and this was not completed, as Charles XII died before the gates were erected, and the support which the Crown had given to the scheme ceased. Polhem carried out a great deal of other work, however, of such variety as to justify the sub-title of "The Archimedes of the North," given to the paper about him, by the late J. G. A. Rhodin, which was printed in Vol. VII (1926-27) of the *Transactions* of the Newcomen Society.

### EMPLOYMENT OF RETIRED ENGINEERS.

Rather more than a year ago (ENGINEERING, vol. 169, page 445 (1950)) we referred in a leading article to the plight of many elderly engineers who, having been forcibly retired from responsible positions overseas, find on returning home that their savings, pensions, superannuation allowances or insurance benefits are wholly inadequate to maintain them and their dependents in the face of crippling taxation, inflated prices and a devalued currency. Many such persons are still active and eager to take up temporary or part-time employment suited to their qualifications but find themselves deprived of opportunities to do so for no other reason than their being on the "wrong" side of forty. Organisations such as appointments bureaux can sometimes assist, but they do not cater for any particular age group and are chiefly successful in placing younger men. There exists, however, an organisation to which we referred at the time, whose motives are entirely beneficent and which aims at helping elderly engineers in particular. It was formed rather more than a year ago by Mr. C. E. R. Sams, President of the Old Centralians—an association of former students of the City and Guilds Engineering College. Mr. Sams outlined his aims in a letter in our issue of April 28, 1950. He now reports that he has succeeded, so far, in placing 30 men, whose ages range from 58 to 71, in posts for which their experience and qualifications were suitable, and that, at present, the demand for such men exceeds the supply. This does not mean, however, that anyone who applies to Mr. Sams is certain to find a suitable job waiting for him; there are some posts available for which there are, at present, no applicants with the requisite qualifications. The organisation does not aim to find places for individuals within commercial or industrial organisations but, rather, to attach them to such undertakings in positions where they will not be subject to the ordinary routine or be required to keep strictly to office hours, etc. The preparation of inventories is given as an example of work which can be undertaken on this basis. Those interested should communicate with Mr. C. E. R. Sams, F.C.G.I., Imperial College of Science (City and Guilds College), London, S.W.7.

### CONFERENCE ON AUTOMATIC CONTROL.

An international conference on the theory and use of automatic control in industrial processes, research laboratories and in other applications, is to be held at the College of Aeronautics, Cranfield, near Bedford, from July 16 to 21. The conference will be opened by Sir Ben Lockspeiser, K.C.B., F.R.S., who will deliver a presidential address. Among those who will be chairmen of discussions are Professor Van der Pol, of the International Telecommunications Union, Switzerland; Sir John Cockcroft, F.R.S., of the Atomic Energy Research Establishment; Sir Charles Goodeve, F.R.S., of the British Iron and Steel Research Association; Professor A. Tustin, of the University of Birmingham; Professor E. O. Willoughby, of the University of Adelaide, Australia; and Professor J. Z. Young, of University College, London. Scientists from Canada, France, Germany, Holland, Sweden, Switzerland, the United States and also from this country will present 32 papers. These deal with such matters as feed-back system engineering, stability criteria, the performance and applications of servo systems, steady-state systems engineering in automatic

process control, the characteristics of air-operated controllers, pneumatic controllers, the influence of measuring and transmission lags, new concepts and theorems concerning non-linear systems, static friction in position control systems, backlash and resilience within the closed loop of automatic control systems, free-moving versus fixed control levers in a manual tracking task, oscillatory phenomena in on-off controls with feed-back, and electro-hydraulic control of water turbines. The papers and the discussion to which they will give rise, are to be published, price 50*s.*, in October, 1951, by Butterworths Scientific Publications, Ltd., 4-6, Bell Yard, Temple Bar, London, W.C.2.

TECHNICAL TRAINING IN THE UNITED KINGDOM.

Delegates from several European countries and one from the Gold Coast Colony have been attending a course of lectures on Technical Training in the United Kingdom, which has been held in Glasgow and London under the auspices of the British Council. The course, which commenced in Glasgow on Monday, June 18, included lectures and discussions, and visits to works and other places of technical interest in Scotland. While there, the delegates were able to see the apprentice-training schemes of several important engineering concerns and also the staff-training college of the North of Scotland Hydro-Electric Board at Pitlochry. They also visited the University of Glasgow, the Royal Technical College, Stow College School of Engineering, Glasgow Engineering Centre, and the Exhibition of Industrial Power at Kelvin Hall. Travelling to London on Sunday, July 1, the party spent the two remaining days of their programme on lectures and visits in or near London, the visit concluding with a reception given in honour of the delegates by the British Council, on Tuesday, July 3. The Assistant Director-General of the British Council, Mr. G. H. Shreeve, C.B.E., acted as host on this occasion and the guests included the secretaries of the senior engineering institutions and several prominent personalities in the field of technical education, in addition, of course, to the delegates themselves. The object of the course has been to give those attending it a general survey, with specific examples, of British systems for training engineering craftsmen, technicians and professional engineers, both in educational institutions and in the industry itself.

INCORPORATED PLANT ENGINEERS.—The Scottish branches of the Incorporated Plant Engineers have arranged to hold a conference at the Dunblane Hotel Hydro, Dunblane, Perthshire, from the afternoon of Friday, October 5, to Sunday, October 7. On the Saturday morning, addresses will be given by Mr. D. Lacy-Hulbert, B.Sc., the President of the Institution, and Mr. J. F. Field B.Sc., controller of the South-East Scotland Electricity Division. At a session on the Sunday morning, Mr. L. G. Northcroft, O.B.E., B.Sc., will speak on "Coal and Europe." A varied programme of social activities has been arranged. Further information may be obtained from the secretary of the Institution, Mr. Hadleigh S. Seaborne, 48, Drury-lane, Solihull, Birmingham.

GEORGE MONTEFIORE PRIZES.—The results of the competition for the George Montefiore Prize, awarded by l'Association des Ingénieurs Electriciens sortis de l'Institut Electrotechnique Montefiore, Liége, Belgium, have been announced. The prize is awarded every five years to the author of a paper describing a definite contribution to the scientific or technical advancement of electrical science. The adjudicators comprised leading electrical engineers and technicians in Belgium, Switzerland, Sweden, France, Holland and the United Kingdom. The British representative was Mr. C. W. Marshall, B.Sc. (Eng.), M.I.E.E., deputy chief engineer (research), British Electricity Authority, London. Owing to the war, the period of the competition was extended from 1939 to 1950, and, of the 17 papers presented, four have earned prizes. The first prize has been awarded to Dr. Ulrik Krabbe, of Fruens-Bage, Denmark, for his paper, "The Transductor Amplifier"; the second to Dr. Max Hoyaux, of Charleroi, Belgium, author of "Theory of the Drop in the Arc of Mercury-Vapour Rectifiers"; the third to Mr. E. H. Hubert, of Liége, for his paper "Theoretical and Experimental Contribution to the Automatic Re-Closing of Circuit Breakers"; and the fourth to Mr. René Pélissier, of Paris, author of "The Propagation of Transitory and Periodic Waves along Electrical Lines." The next competition will be held in 1955.

# LETTERS TO THE EDITOR.

## FREEDOM TO MEASURE: YARDS OR METRES?

TO THE EDITOR OF ENGINEERING.

SIR,—Dr. H. S. Rowell, in his championship of the Imperial system of weights and measures as opposed to the metric system (in your issue of June 22), injures a strong case by overstatement. It is hardly an argument against the metric system to say that he has to convert French hotel prices into Sterling in order to compare them with English. He accuses the Weights and Measures Commission of special pleading and then goes on to use arguments which leave one wondering why he omitted to mention the plight of the three-bottle man attempting to qualify as a three-litre man. He praises the "flexibility" of the Imperial system on the grounds that 1*l.* per ton is 1*s.* per cwt. and that 1 guinea per week is 3*s.* per day. To carry this argument to its logical conclusion the ideal number of pounds in a ton should be 2,520, so that without the difficult operation of splitting lumps into recurring decimals it would be possible to divide a ton of coal into fair shares for an eight-hour shift, a seven-day week, a five-year plan or a nine-days' wonder.

The real flexibility of the Imperial system arises from the fact that it is so largely based on the scale of two; factors of 3, 5, 7 and 11 also occur but they are more nuisance than they are worth. Personally I would like to see our coinage tidied up by scrapping the present coins from a florin downwards and substituting a quarter crown divided into four groats of four pence. In weight units the pound and its subdivisions need not be touched, but the 14-lb. stone might with advantage become 16 lb., the hundredweight 128 lb. and the ton 2,048 lb.

Length units are in less need of reform. When commodities are sold by the yard it is subdivided into half and quarter yards and not, as a rule, into feet and inches; very small quantities are usually sold at a different rate so that a break of scale does not matter. These reforms would greatly assist the common man in daily transactions and the giving of change, even though the coal heaver might not like the heavier sack, the engineer should not be greatly disturbed, and the scientist would continue to use c.g.s. The best system is that which gives the greatest freedom from mistakes; if this condition is satisfied all other desirable properties will be found to follow automatically, and in this connection I agree with Dr. Rowell that the distinct monosyllabic names of the Imperial system are a priceless legacy from the original conglomeration of units which were made commensurable by centuries-old legislation.

Finally, may I put in a plea to give the pint pot priority over the condenser in the use of the term capacity; after all, it was there first. Volume will not do; volume is based on length, and capacity on weight of a standard liquid, and the two are not commensurable.

Yours faithfully,
C. H. BOSANQUET, M.A.

Stockton-on-Tees.

TO THE EDITOR OF ENGINEERING.

SIR,—I was delighted to read Dr. H. S. Rowell's spirited defence of the Imperial system of weights and measures, in your issue of June 22, as there is no doubt that quasi-scientific people are far too ready to impute to the metric system advantages it does not possess. When all is said and done, there is nothing fundamentally scientific about the metre; it is, in fact, based on a miscalculation of the radius of the earth. The claims of its advocates can only rest on the supposed advantages of a decimal system, and, as Dr. Rowell points out, these need not be so great as are sometimes suggested. Astronomers, for example, who are responsible for most complicated numerical calculations, and who therefore might be expected to seek simplification wherever it might be found, still cling to such non-decimal systems as those of time and angular measure.

No, Sir, if our system of units is to be changed, let it be to an engineers' system in which all the present needless muddle and confusion between mass and weight are avoided. Most of the computational errors in engineering problems can be traced, not to such difficulties as the translation of acres per year to sq. cm. per second, or of calories per centimetre per degree C. per second to B.Th.U. per foot per degree F. per hour, but to worry whether the symbol "lb." (or even, one suspects, kg.) in the calculations meant pounds (or kilogrammes) mass or pounds weight. How often does one hear the cry, "I seem to be out by a factor of about 30"? Let us, therefore, abolish this $g$, or, rather, render it innocuous, by choosing our new system of units such that its value is unity.

The numerical value of $g$ depends on the units chosen for distance and time, and also, of course, though these may be neglected in engineering calculations, on position and date. Time must always present difficulties for the "decimalisers" unless, fortunate creatures, they happen to live on a convenient planet whose number of rotations round its sun is an exact power of the number of digits of the creatures concerned. It is not easy for us, with 365·242 days in the year, to find a system of time that is both arithmetically simple and socially convenient, but linear measurement presents no such difficulties. The new unit—perhaps one might christen it the "Newton"—could therefore be defined as 32·2 of our present feet and 981 of our present centimetres. The exact factor could be agreed internationally, and would correspond to the acceleration due to gravity determined at a particular spot on a particular day, say at Greenwich on January 1, 2000. The variation of gravitational force with position and time is usually neglected in engineering problems, but, where it is important, it could be allowed for as presumably it is now. The new unit of mass could be based, as heretofore, on the specific gravity of water, and all other derived units follow, simply by making the constants in their equations of derivation equal to unity. Thus may we rid ourselves of that hateful $g$ and that abomination of all right-thinking engineers, the "slug."

Finally, on a more immediately useful plane, may I submit a plea for the unification of temperature units, which are not dealt with specifically in Dr. Rowell's article? Surely this is an easier first step to take than to change our systems of length or mass. Such unfortunate go-betweens as the metallurgists, who must translate the scientists' degree Centigrade into the engineers' degree Fahrenheit, suffer thereby much unnecessary hardship and waste a good deal of paper on conversion tables. A few enlightened industries (that of the aircraft gas turbine is one) have adopted the Centigrade system already, and none of Dr. Rowell's arguments in favour of Imperial units provides a really effective defence for the degree Fahrenheit.

Let us start there!

Yours faithfully,
STEPHEN L. BRAGG, M.A.,
Research Engineer.

William Jessop and Sons, Limited, Sheffield.
July 2, 1951.

[By an unfortunate typographical accident, which occurred after the issue had been passed for press, one of the paragraphs of Dr. H. S. Rowell's article was rendered meaningless. One line was omitted from, and another duplicated in, a paragraph commencing about half-way down the third column on page 745. The correct rendering of the part of the paragraph affected is as follows: The arguments of logic are risky even for philosophers. The argument that only one system of measures should be used for all trades is equal in value to the statement that every man should be restricted to one overcoat or one garment for all climates and all weathers. But is it logical of the Committee to pretend that the metric system is only one system of units?—ED., E.]

## "NORMAL ELLIPTIC FUNCTIONS."

TO THE EDITOR OF ENGINEERING.

SIR,—In a letter, on page 412 of your 170th volume (1950), it was stated by the writer that his normalised form of Lamé's differential equation for ellipsoidal harmonics made the computation of polynomial solutions practicable without prohibitive labour. No reference was given to previous work because none had been found in the numerous text-books and periodicals accessible for scrutiny.

# EXHIBITS AT THE ROYAL AGRICULTURAL SHOW.

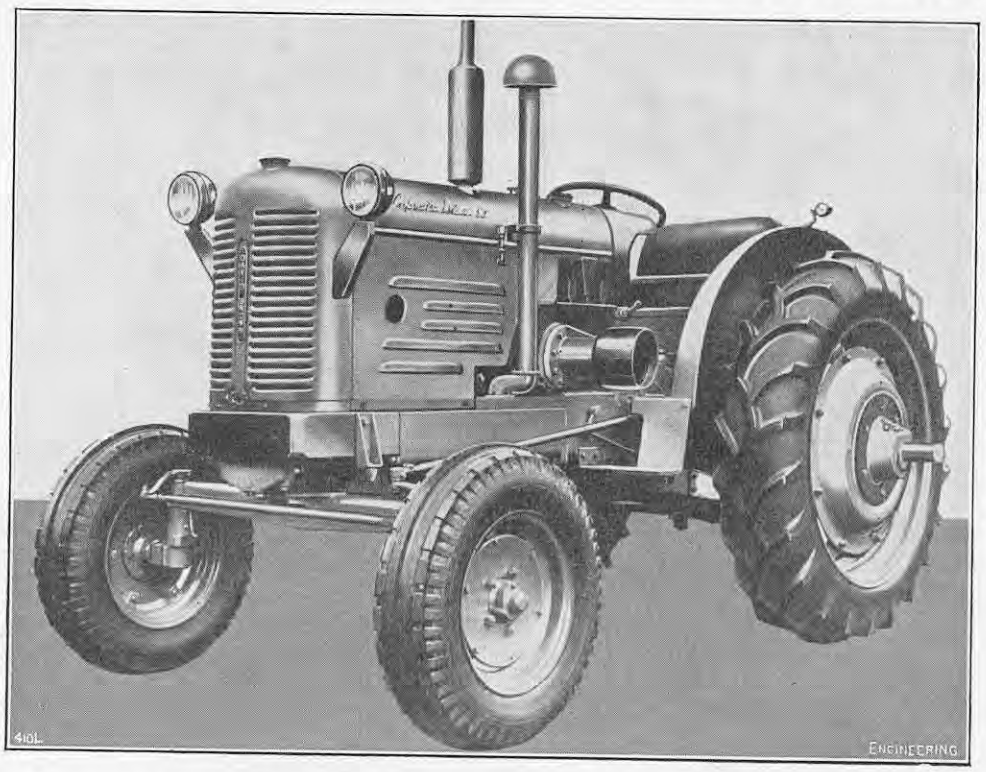


FIG. 11. "CROPMASTER" DIESEL TRACTOR; MESSRS. DAVID BROWN TRACTORS, LIMITED.

## THE ROYAL AGRICULTURAL SHOW AT CAMBRIDGE.

(*Continued from page* 23.)

THE Royal Show, which was held this year at Cambridge, closed on Friday evening, July 6, after having been open since the previous Tuesday morning. Although always a difficult task to assess accurately the tangible results of any exhibition, there appears to be little doubt that, from all points of view, another successful show has been held. Fortunately, the weather was fine on each day and, as a consequence, the attendance figures were better than for last year when it was held at Oxford to the accompaniment of torrential rain which turned parts of the showground into quagmires. Success of any Royal Show, however, has to be judged not so much on the total attendance figures but by the inquiries made regarding livestock and machinery, and the general opinion seems to suggest that the results were above expectations, particularly in the implement yard. This is most gratifying as it seemed possible that shortage of materials, coupled with rising costs, would have an adverse effect. Judged by previous shows, there were fewer new implements and machines but this was only to be expected as present difficulties are bound to deter the introduction of novelties, and the post-war era of development, therefore, has been replaced by one of consolidation.

It should not be inferred from the foregoing that no new machines were being shown; Messrs. David Brown Tractors, Limited, Meltham, Huddersfield, for example, were showing two new tractors, namely, their Cropmaster Diesel "50" wheeled tractor and their Trackmaster Diesel "50" tracked tractor. The new Cropmaster tractor is illustrated in Fig. 11, on this page, from which it will be noted that it is considerably larger than the standard Cropmaster tractor. It has been designed for use on larger farms, both at home and overseas and, in average conditions, is capable of hauling a five-furrow plough. It is fitted with a new six-cylinder Diesel engine designed and manufactured by Messrs. David Brown and capable of developing 45 h.p. at the normal governed speed of 1,600 r.p.m. Direct-injection is employed and the injection rate is determined by an all-range governor operating from 600 r.p.m. to 1,800 r.p.m. Transmission is by means of a conventional clutch to a twin-range three-speed gearbox designed to give six forward and two reverse speeds ranging from 1·33 miles an hour in first low gear to 13·55 miles an hour in third high gear. A four-speed power take-off unit forms an integral part of the rear axle and at an engine speed of 1,600 r.p.m. gives shaft speeds of from 233 r.p.m. to 1,225 r.p.m. A belt-pulley power take-off unit is fitted on the near side of the tractor and this has an estimated belt horse-power of 38·5 at 1,600 r.p.m. of the engine, the corresponding belt speed being 3,215 ft. per minute.

A notable feature of this tractor is the provision of extending rear-axle shafts for rear-track adjustment, an arrangement which also permits the fitting of twin rear wheels when working on soft ground. The standard size of rear tyre is 11·00 in. by 38 in. but oversize tyres can be fitted to meet the needs of overseas customers. The brakes operate on the rear-axle shafts, the linkage being designed so that the wheels may be braked independently or together; to give easy access, the brake drums are fitted externally. The complete machine is designed expressly for working with conventional hauled implements and is fitted, therefore, with a swinging-type drawbar, the movement of which is limited by adjustable stop pins.

The Trackmaster Diesel "50" tractor is illustrated in Fig. 12, on page 54. In general, it is similar to the standard Trackmaster tractor, but, like the new wheeled tractor just referred to, is fitted with the David Brown six-cylinder Diesel engine. The transmission assembly also is similar, comprising a conventional clutch and a three-speed twin-range gearbox giving six forward and two reverse speeds, from 1·06 miles an hour in first low gear to 6·5 miles an hour in third high gear. Steering is effected through the David Brown Duotrack system in which the tracks are never

Recently, while seeking information about continuants in Muir's history of determinants, a reference was found to a paper by E. Heine in *Crelle's Journal*, pages 87-99, 1859, which gives an equivalent reduction of the condition of compatibility to a continuant equated to zero. As in all other applications worked out by the writer, the normal form greatly simplifies the analysis. It is disappointing to find one's "discovery" anticipated by nearly a century, but surprising only in that Heine's results do not find a prominent place in text-books, especially in view of Muir's explicit reference to Lamé's equation.

The writer has no taste for controversy but takes this opportunity to say that your comment on the letter was too much concerned with the elementary transformations which are merely the starting point and too little with the far-reaching results which flow from them. The normal cubic is in close correspondence with Legendre's normal quartic and brings a satisfying unity to the exposition which is sadly lacking in standard text-books. It is indeed remarkable that the latter should have been accepted universally more than a century ago while the former is still unduly neglected. In any case, it is gratifying to find oneself in the distinguished company of Heine and Legendre.

Yours faithfully,

Kingston-on-Thames. A. R. LOW.
June 22, 1951.

## POST-GRADUATE COURSE IN APPLIED THERMODYNAMICS.

TO THE EDITOR OF ENGINEERING.

SIR,—The post-graduate course in applied thermodynamics at the University of Glasgow has just completed its first session, and, of such courses of study planned to be carried on in different aspects of mechanical engineering in a number of universities in this country, it is among the first to get under way. The setting up of such courses is largely the result of the existence of the important body of opinion which holds that we require to have greater recourse to systematic post-graduate study if we are to keep our place alongside some of our great industrial rivals. It is natural that a beginning should be made in mechanical engineering, for perhaps no other branch so influences industrial production or is so potent in the field of power generation. The course in applied thermodynamics at the University of Glasgow has so far been planned to cover one session of three terms. It includes daily lectures on advanced mathematics as well as on the main subject of study, and the student pursues, in addition, an appropriate experimental project which occupies several hours of his time each day.

Many men who graduate B.Sc. with honours and then enter industry perhaps find, after a time, that they are required to do work of a research nature. Some, again, find themselves in supervisory and administrative positions in which they have some responsibility for experimental work and for the initiation of investigations. All these require to understand research procedures and techniques. Many young engineers are entering upon scientific work in Government departments, and in all such cases it is of the utmost importance that they should possess a lively understanding of the methods of approach to experimental problems and a knowledge of the means of observation and analysis, as well as a clear perception of the theoretical bases of their work. This course is contrived to meet their needs, and, indeed, no matter in what branch of applied science a man may be engaged, the study of experimental methods and the instruction on sources of information and on analytical techniques are of an importance which makes the particular branch around which the course is planned a secondary consideration. Five young men have just completed the course, and the demand for their services suggests that industry appreciates their potential value. It is to be hoped, however, that private employers and employing authorities may, in increasing numbers, see their way to release able young men for the period of three terms so that they might attend such courses and thus increase the strength of the research side of our national industries. The University of Glasgow has offered scholarships which provide reasonable financial support to students. The course is not confined to men who are successful in obtaining such awards. The co-operation of employers is of first importance to the success of this venture.

Yours faithfully,

JAMES SMALL,
James Watt Professor of the
Theory and Practice of Heat Engines.
James Watt Engineering Laboratories,
The University, Glasgow.
June 29, 1951.

locked but are driven throughout the turn. The steering gear incorporates 11-in. diameter oil-immersed hand brakes coupled to 30-in. hand-steering levers. There are three track widths, namely, 48 in., 56 in., and 64 in., and two widths of trackplate, the latter being available in 14-in. and 16-in. sizes. As on the wheeled tractor, the rear axle is fitted with a four-speed power take-off and, if required, a belt pulley can be arranged to be driven from the power take-off shaft. This can be run at any of the four speeds but the two lower speeds will probably suffice for all normal requirements; the speed in first low gear is 961 r.p.m. and in second low gear, 1,780 r.p.m. The tractor is capable of hauling a five-furrow plough, but in view of its high power, namely, 32 drawbar horsepower, it is equally suitable for industrial applications and is available, therefore, with Blaw-Knox earth-moving equipment.

In last week's article on the Royal Show, it was mentioned that several Continental firms are showing tractors and associated equipment. Most of the tractors exhibited have been described previously in ENGINEERING, but a newcomer so far as the Royal Show is concerned, namely, the Normag, is illustrated in Figs. 14 and 15, on the opposite page. This machine, which is manufactured by Normag Zorge G.m.b.H., Zorge-Südharz über Walkenreid, Germany, is designed so that, by changing certain parts, it can be converted for a variety of purposes; Fig. 14, for example, shows it equipped with a rigid front axle of high clearance for row-crop work, whereas Fig. 15 shows it fitted with front springs and a half-track conversion for working in heavy ground. It is driven by a two-cylinder water-cooled in-line Diesel engine of the four-stroke type fitted with wet cylinder liners, overhead valves and aluminium-alloy pistons. Three different sizes of engine are available, but the tractor illustrated is fitted with a 25-h.p. unit, this power being developed at 1,500 r.p.m. The clutch is of the conventional single-plate type, but to concentrate the weight over the rear wheels, and thus increase the adhesive weight, the gearbox is situated over the rear axle, the clutch housing and gearbox casing being joined to each other by a tubular member in which the propeller shaft is located. There are four forward speeds and a reverse speed, the forward speeds ranging from 2·2 miles an hour to 11·8 miles an hour in top gear.

Gear changes are effected by sliding spur wheels in the normal manner while the final drive to the rear axle is by means of a worm and worm wheel assembly, the latter incorporating a differential designed so that, when required, it may be locked. A rear power-lift for raising the tools is fitted as standard, but, in contrast to the normal practice, compressed air is used for this purpose, air under pressure being supplied by an engine-driven compressor and stored in a bottle arranged inside the circular member which joins the engine to the rear-transmission assembly. The servo unit also is located inside this member and is connected to the linkage by an external bell-crank lever. Use of compressed air for this purpose has several advantages as there is no risk of losing the fluid normally used, the compressor can be used for inflating the tyres, while trailers fitted with pneumatic brakes may be used, thereby giving greater safety.

The half-track conversion illustrated in Fig. 15 is remarkably neat and is designed so that the drive sprockets do not support the tractor. Both drive sprockets are bolted in place of the rear wheels and each is provided with a short stub axle on which pivots a longitudinal beam. Each beam, in turn, is fitted with two rubber-tyred load-carrying wheels and two idlers, the track passing over the top of the sprockets and round the two idlers and load-carrying wheels. The idlers are located towards the ends of the beams and provision is made for adjusting their relative positions so as to maintain correct track tension.

A half-track conversion somewhat different from that just described was being shown by Messrs. James A. Cuthbertson, Limited, Biggar, Scotland who were exhibiting on the stand of the Butterley Company, Limited. This unit, which is illustrated in Fig. 13, on this page, has been designed for use with any standard tractor and has the effect of reducing the ground pressure and increasing the drawbar pull. The assembly consists of large-diameter driving sprockets, which replace the tractor rear wheels, and smaller diameter rear-mounted idlers, the latter being supported by a frame arranged so that it may be adjusted relatively to the tractor to provide the correct track tension. The drawbar is attached directly to this frame so that the drawbar pull is transmitted to the tracks through the idlers. The frame is fabricated from channel-section steel members and is located at its forward end by two pins projecting from a subsidiary frame bolted to the tractor. At its rear end it is provided with a cross tube in the ends of which are stub axles arranged to carry the idlers on taper-roller bearings. These stub axles are renewable should it become necessary and it is possible to alter the gauge of the tractor by extending them.

The track is composed of wire-reinforced rubber pads connected to each other by cleat plates on the outer circumference and by driving plates on the inside. The bolts connecting the cleat plates to the driving plates pass through steel ferrules incorporated in the pads and the reinforcing wire is wound round the ferrules in such a way that the stresses are distributed equally over eight cross sections, each of which is capable of withstanding a pull of 2·3 tons. The track-driving plates incorporate dog teeth which engage with bars formed on the driving sprockets and the complete assembly is protected at each side by a steel shield.

Various types of steel and rubber cleats can be fitted to the track dependent on the conditions in which the tractor is to be employed. For road work, a solid-rubber cleat with a steel base has been developed but it should, perhaps, be pointed out that steel cleats can be used on roads quite satisfactorily. As the track is manufactured in sections, the work of replacement and its cost is small; furthermore, there are no pins and associated bushes to cause trouble, and owing to the flexibility of the track, it is self cleaning, an important feature when employed in clay soils. Normally there are 32 pads and driving dogs to each track, each pad measuring 13 in. by $5\frac{1}{4}$ in. by $\frac{1}{2}$ in. thick. The diameter of the sprockets is 3 ft. $6\frac{3}{4}$ in. and distance between the centres of the sprockets and idlers 2 ft. $3\frac{1}{2}$ in., the length of track in contact with the ground, as a consequence, being 2 ft. 8 in.

*(To be continued.)*

# EXHIBITS AT THE ROYAL AGRICULTURAL SHOW.

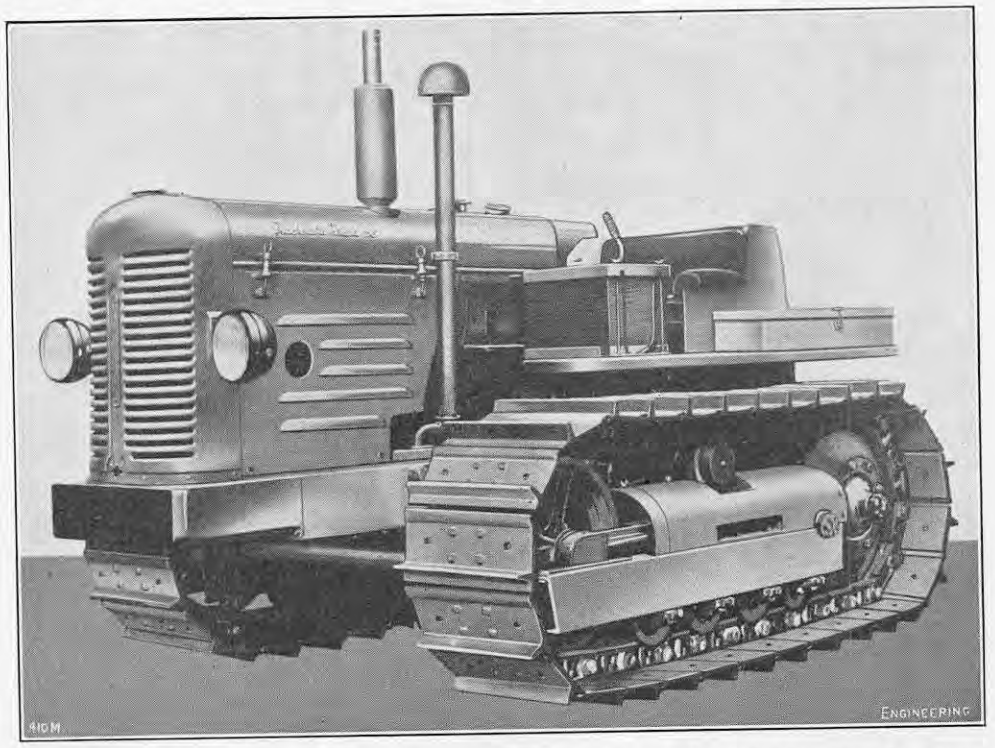


FIG. 12. "TRACKMASTER" DIESEL TRACTOR; MESSRS. DAVID BROWN TRACTORS, LIMITED


FIG. 13. HALF-TRACK CONVERSION; MESSRS. JAMES A. CUTHBERTSON, LIMITED.

# EXHIBITS AT THE ROYAL AGRICULTURAL SHOW.

*(For Description, see Opposite Page.)*

FIG. 14.

FIG. 15.

FIGS. 14 AND 15. DIESEL-ENGINED TRACTOR; NORMAG ZORGE G.M.B.H.

## RESEARCH LABORATORIES OF THE LONDON BRICK COMPANY.

THE art of brickmaking is of such antiquity and has been practised so widely throughout the centuries that one might well suppose there is little further to be known about it. To visit the new research laboratories of the London Brick Company, however, at Stewartby, Bedfordshire, is to be quickly disillusioned, for this great undertaking, the largest brick-manufacturing organisation in the world, with a total productive capacity of 35 million bricks per week, sets so much store by research that it has spent recently nearly 50,000*l.* on the construction of buildings for this purpose.

Nor does research represent a new departure, for the company have engaged in experimental work for many years, and the accommodation now provided is but a replacement of older buildings by new. Broadly speaking, the objects of the research are two-fold. In the first place, the company aim to achieve as high a degree of uniformity as possible in the quality of its bricks and other products, for not only does this ensure that the optimum, once discovered, is maintained, but it also reduces manufacturing costs. Secondly, the work is directed to producing new building materials with special properties, for which there is, nowadays, a steadily growing demand.

Much of the work in the first category is, of course, routine and not strictly research. It includes sampling and analysis of the clays in daily use, and the testing of samples of the products at all stages in their manufacture. With the information obtained in this way, the various processes can be adjusted to produce the best result. The methods of quality control are widely employed in this work. The test work also covers unworked deposits of clay which are examined to determine their extent and suitability as new sources of raw material. The machines used to prepare the clay are also subjected to constant scrutiny, to ensure that their performance is maintained and, where possible, improved.

The Oxford clay, from which Fletton bricks are made, is peculiar in the amount of carbonaceous material which it contains. The average calorific value of the latter is no less than 1,000 B.Th.U. per lb., and this accounts for the fact that Fletton brick can be burned with comparatively little extraneous fuel. Indeed, were kilns of 100 per cent. thermal efficiency practicable, no extraneous fuel whatever would be required. To secure the maximum efficiency of burning, the process is constantly under examination. Data relevant to the design of kilns are obtained both by measuring the performance of full-size kilns and from experiments on smaller-scale installations. At present, the design of flues and chimneys is receiving considerable attention.

The new laboratories are in three wings, which meet to form a T. Each wing has a central corridor with rooms on either side, and a fourth corridor runs from the junction of the others to a large entrance hall which forms the centre-piece of a block containing a conference room, library and directors' dining room. The plan view of the buildings, therefore, resembles a cross standing on a base, although the latter is unsymmetrical. In addition to the customary chemical laboratories, balance room, photographic dark-room, etc., there are a geological laboratory, instrument shop, physics laboratory, small-scale plant laboratory, microscope room, store room, sample store, and compression-test room. The last-mentioned room is equipped with an Amsler Zootan compression-testing machine.

The near-by clay pits and works of the company are also of considerable interest. The Stewartby pit requires to produce 42,000 tons of clay per week to meet the demands of the works at maximum output. This quantity is dug by a single electric excavator in the form of a face-shovel with a capacity of 10 cub. yards per lift. The 15 ft. to 20 ft. of overburden is removed previously by means of a drag-line excavator, and is transferred to spoil dumps in the worked out portion of the pit by means of a long jib-conveyor. The clay is dropped by the excavator into a sorting machine which breaks up the larger lumps and feeds the material automatically into wagons which convey it to the works. Overhead-chain haulage is employed for the greater part of the run. On arrival, each wagon is lifted mechanically and its contents are tipped into storage towers which feed two lines of grinding mills. These reduce the clay to a fine powder, which is sieved into revolving screens and conveyed on a belt to the brick presses below. In these, the powdered clay is moulded into bricks between heated dies at four pressures of increasing amount.

The "green" bricks produced in this manner are strong enough to be conveyed to, and loaded into, the kilns without preliminary drying. The kilns consist of a number of chambers, each holding 40,000 or, in some cases, 72,000, bricks, which intercommunicate through a system of flues. By setting various dampers, the bricks can be dried and pre-heated by the waste heat from burnt bricks which are cooling in other parts of the kilns. Operation is continuous, the chambers being filled, burned and unloaded in rotation. The company design and build some of the specialised machinery which they use and have a foundry and engineering shops at Peterborough.

## CONTROLLING VISITORS IN THE SOUTH BANK EXHIBITION.

THE comparatively restricted area occupied by the South Bank Exhibition has made it desirable, if not necessary, to ascertain the attendance of the public at any time so as to determine if saturation point is being approached. All the turnstiles at the eight entrances to the exhibition have therefore been equipped with switches, made by Rentrix, Limited, Millfields-road, London, E.5, which are connected to a storage device to prevent the impulses generated from two or more turnstiles operating simultaneously being merged. The impulses from the eight groups of turnstiles are transmitted to separate five-digit counters in the main control room. These counters consist of automatic telephone equipment and are associated with apparatus so that one of ten lamps which are equally spaced round the circumference of a circle can be lighted. In front of the circle of lamps is a sheet of frosted glass on which numbers are stencilled, and these are illuminated as the appropriate lamp is switched on. In the centre of the circle is the word "units," "tens," etc., which is illuminated in a similar way. The counting equipment applicable to each entrance is installed behind a separate panel and the eight panels are mounted one above the other in an oak cabinet with a "total" panel at the bottom. The number of people that have entered the exhibition through any entrance during a particular day is thus visually indicated.

To ascertain the "congestion" at any time it is, however, necessary to know, not only the number who have entered the exhibition, but also the number who have left. Counters are therefore also fitted on the outgoing turnstiles and impulses are similarly transmitted from them to a second series of illuminated panels which are arranged one above the other in the control room to the right of the first set. The number who have left the exhibition through any exit is thus ascertainable. Finally, the "in" and "out" panels are surmounted by a "total" panel which by indicating the difference

between the totals on the "in" and "out" panels, shows the number of people who are actually in the exhibition at any given time. The information displayed also indicates to the London Transport authorities the exits through which the crowds are likely to leave; and enables them to provide suitable transport. In addition to the main panels, the control room contains a second cabinet on which the numbers coming in through each entrance with advance tickets are displayed.

In addition to regulating the attendance at the exhibition in the manner just described, an emergency system has been installed by Central Rediffusion Services, Limited, Regent-street, London, S.W.1, for controlling the internal crowds, for making announcements and for transmitting time signals, as well as for broadcasting. All the functions except the last are normally controlled from the Festival control room. This room contains a large-scale map, measuring 2 ft. by 3 ft., which is mounted in an inclined position and covered with glass. The whole area covered is divided into a number of sub-areas in each of which a button is mounted. By pressing the appropriate button the loud speakers in the associated sub-area are brought in so that the necessary announcements can be made. Similar arrangements in the Rediffusion control room enable music to be broadcast. The transmitting network is divided into two separate sections, one covering the entrances and exits and the other the remaining points in the exhibition. The connecting feeders are run underground in asbestos tubing and are switched in through relays by primary switches in the control room. A total of 1,200 loudspeakers has been installed.

A further system of communication is provided by a switchboard to which 27 telephones situated in cabins having a good view of the grounds and buildings are connected. Lines from this board, which was installed by the Post Office, enable communication to be established with the police station on the site, the London Electricity Board and the main Festival switchboard. It is supplied with power from two sources. Rentrix watchmen's patrol units have been installed. These consist of 60 two-way switches at different positions in the exhibition, which are connected to a corresponding number of red lights in the control room. At predetermined times these lights are illuminated as a signal to the watchman to patrol and are extinguished one by one as the appropriate switch is operated. When all the switches in one of the sections into which the site is divided, have been actuated a green light indicates that the patrol has been completed.

Finally, it may be mentioned that a complete fire alarm system indicating at a central board has been installed by Standard Telephones and Cables, Limited, Aldwych, London, W.C.2, and that the lighting throughout the exhibition is controlled by centrally-placed time switches supplied by Venner Time Switches, Limited, New Malden.

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HANDBOOK FOR WELDED STRUCTURAL WORK.—The fourth revised edition of the "Handbook for Welded Structural Steelwork" is now available from the secretary of the Institute of Welding, 2, Buckingham Palace-gardens, London, S.W.1. The price of the handbook is 10*s*., postage included.

MILITARY RESEARCH IN AMERICAN UNIVERSITIES.—The Engineering College Research Council of the American Society for Engineering Education have recently surveyed the resources for scientific and engineering research in American colleges and universities. As a result, the Council conclude that a large number of defence-research projects can be undertaken at small college laboratories. A preliminary report giving the chief statistics has been prepared, but copies of the full report will be available shortly from the secretary of the Council, Room 7-204, 77, Massachusetts-avenue, Cambridge 39, Massachusetts, U.S.A.

BRITISH PURCHASING COMMISSION TO EUROPE.—The European Purchasing Commission have now opened offices in France, Italy and Switzerland. Sir Charles Henderson, K.B.E., is in charge at 116 (Bis), Avenue des Champs Elysées, Paris (8e), Mr. W. Rogerson at Via Borgonuovo 10, Milan, and Mr. Max Binney, at St. Peter Strasse 11, Zürich. Appointments in Spain and Denmark have also been made. Mr. W. Maude is the representative in Madrid, c/o. H.B.M. Embassy, Calle Fernande El Santo 16, and Mr. A. K. Duthie, O.B.E., the representative in Denmark, at Gentofte. Offices in Belgium and Germany were opened on May 28. Mr. Norman W. Doley is in charge at 107, Rue Belliard, Brussels, and Mr. A. S. Radford, at 5, Mehlemer Strasse, Marienburg, Cologne.

## LABOUR NOTES.

BREAKAWAY unions were condemned by Mr. Alfred Robens, the Minister of Labour, in a debate in the House of Commons, on July 5, on the labour dispute which arose in connection with the Hants and Dorset Omnibus Company. Replying to a motion to reduce the Ministry of Labour vote by five pounds, which was rejected by a majority of 15, Mr. Robens stated that a previous speaker, Sir David Maxwell Fyfe, had been forced into the position of pleading for a breakaway union. These brought anarchy into the trade-union movement and employers' associations would not share the view that it was wise to encourage them. While he, Mr. Robens, remained Minister of Labour, he would never do anything to give encouragement to a breakaway union or do anything to weaken the position that the trade-union movement had built up for itself. One way to get industrial strife was to encourage breakaway unions. The 'bus industry was operated under the terms of a national agreement, on which were based a number of local agreements, and the N.U.R. was a party to that national agreement.

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In the course of the debate, it was stated that the membership of the National Union of Railwaymen included many 'bus employees, and that another large group belonged to the Transport and General Workers' Union. The 'bus employees who were members of the N.U.R. considered that they had not secured adequate recognition by that Union. They were not represented on the national council for the omnibus industry and they had formed a "national 'bus workers association," which had come to include some 90 per cent. of the 'bus employees in Hampshire and Dorset. This association had failed to secure recognition and complaint was made that the Minister of Labour had declined to intervene. It was stated that the Minister had declared that the association was not a registered trade union, but it was contended that the association had applied for registration as such.

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The dispute between the 'bus company and its employees, it was declared in the debate, had arisen owing to difficulties relating to time schedules. The men had recently received a wage increase of 7*s*. 6*d*. a week, but, under new schedules, that increase had been wiped out, and some of those concerned were losing as much as 12*s*. 6*d*. a week. It was asked why the Minister had not considered it necessary to institute an inquiry when the schedules were brought to his notice, and why he had not supported the fundamental right of a man to join the union which he considered was best suited to his needs. Another speaker in the debate expressed the view that the men had made a mistake in breaking away from the N.U.R., to form a new organisation, and thus putting themselves in the wrong with the whole trade-union organisation. He advised those concerned to return to the N.U.R., which had given a guarantee beforehand that a 'bus section of that Union would be constituted and receive a fair degree of autonomy.

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Protests against the Government's refusal to introduce equal pay for women Civil Servants were made to Mr. Hugh Gaitskell, the Chancellor of the Exchequer, by the staff side of the Civil Service National Whitley Council on July 6. This organisation represents over 530,000 persons of both sexes employed in Government offices. The deputation expressed their great regret at the Government's decision, recently announced by Mr. Gaitskell, and maintained their previous contention that this reform could be introduced by stages. In their opinion, the Government's contention that the introduction of equal pay into the Civil Service would lead to demands for similar treatment for women in commercial and industrial positions was erroneous. Mr. Gaitskell informed the members of the deputation that the Government were unable to risk the presentation of a very large number of similar demands from many sections of workpeople outside Government employment. Such demands were very likely to follow the introduction into Government offices of equal pay, and these might well have serious effects on the national economy. Under these circumstances, the demands could not be met at the present time, but the deputation were assured that the Government accepted the principle of equal pay.

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The biennial conference of the Transport and General Workers' Union opened at Whitley Bay on Monday last and continued in session until to-day. The Union, which claims to be the largest in the world, now has a total membership of 1,314,483. Delegates attending the conference numbered just under 700. In his opening address on Monday, Mr. E. E. Fryer, the President of the Union, referred to the dangers of adopting a "smash and grab" policy on wages and suggested that the country's economic situation was such as to render it necessary to continue to act with restraint in putting forward new wage claims. At the same time, care must be taken to ensure that members of their Union did not suffer in the general wage movement which was now gathering momentum. He appealed to trade unionists throughout the country to make the largest possible contribution towards the national production and income. Substantial increases in output would fulfil the twofold duty of maintaining the existing standards of living and enabling the nation to rearm effectively.

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Mr. Fryer urged the delegates to do all in their power to uphold the sanctity of trade-union agreements and warned them of the dangers which would confront the whole trade-union movement should such agreements come to be disregarded. He emphasised the advantages which accrued from the state of full employment that now existed, and declared that the benefits from this policy should not be jeopardised by using them as a lever to secure ill-disciplined strike action. Any disregard for the sanctity of trade-union agreements would shake very badly the whole foundation on which effective trade unionism had been built. The development, even perhaps the survival, of the movement depended upon trade unionists adjusting their way of thinking. The greatest need of the movement at the present time was for the members generally to accept the leadership of those whom they had appointed to lead. He asked all members of the Union who might contemplate unofficial action, possibly from a mistaken sense of loyalty, to pause beforehand and to consider how far the movement had travelled during the last ten years.

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The urgent need for the effective control of prices was another topic referred to by Mr. Fryer in his address. He stated that the national executive of the T.G.W.U. would do all in their power to urge the Government to maintain its rigorous control. A re-imposition of controls on some commodities in general use might help considerably. Mr. A. E. Deakin, C.B.E., the Union's general secretary, submitted the annual report of the executive, which he asked the delegates to accept. Some exception was taken to a paragraph on the nation's defence programme and it was eventually rejected by a small majority of votes. The paragraph referred to stated that the defence programme forced upon Britain, equally with other western countries, "by the imperialist policy of the U.S.S.R. was greatly to be regretted." It meant placing a brake on this country's recovery and on the further development of the social services. As in the war years, industry would once again have to be adapted to military needs instead of being able to concentrate on the production of goods urgently needed for home consumption and the export trade.

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Demands for substantial increases in wages are likely to be presented in the near future on behalf of railwaymen and miners. Mr. J. B. Figgins, the general secretary of the National Union of Railwaymen, referred to new wage demands at the annual conference of the Union at Hastings, which was held last week. He announced on July 4 that a private session of the conference, on that day, had accepted the report of the committee which was formed, at the Union's special general meeting in March, to investigate wages and working conditions in the railway service. This report recommended the Union's executive committee to present claims for a substantial increase in wages. Other recommendations contained in the report included an instruction to the general secretary to expedite the negotiations for the granting of supplementary pensions for all grades of railwaymen, and proposals for increases in meal allowances, lodging payments, and payments for dirty or dangerous work, and holiday duties.

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Mr. Figgins stated that, in accordance with that report, claims would be presented to the Railway, London Transport, Hotels, Docks and Waterways, and Road Haulage Executives for wage increases. It was the suggestion of the same committee, Mr. Figgins continued, that an approach should be made, during the next few days, to the Transport Salaried Staffs' Association and the Associated Society of Locomotive Engineers and Firemen, with a view to the submission of joint demands. At the annual conference of the National Union of Mineworkers at Blackpool last week, a resolution was passed unanimously on July 5 requesting a minimum wage of 7*l*. 10*s*. a week for underground employees and proportionate adjustments in the rates for those engaged on surface work. These claims are equivalent to weekly increases of 23*s*. for underground employees and 20*s*. for all other grades.

# ANALYSIS OF ROCKWELL HARDNESS TEST.

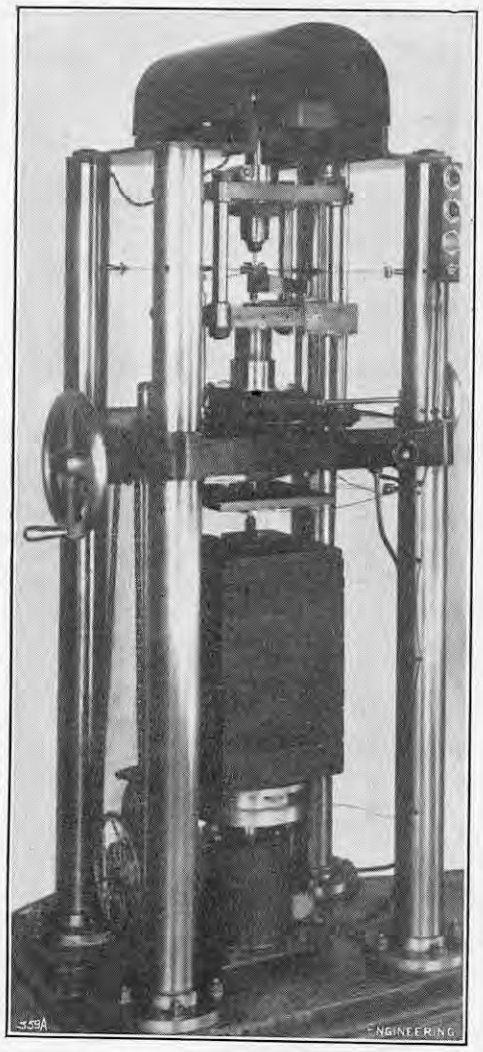
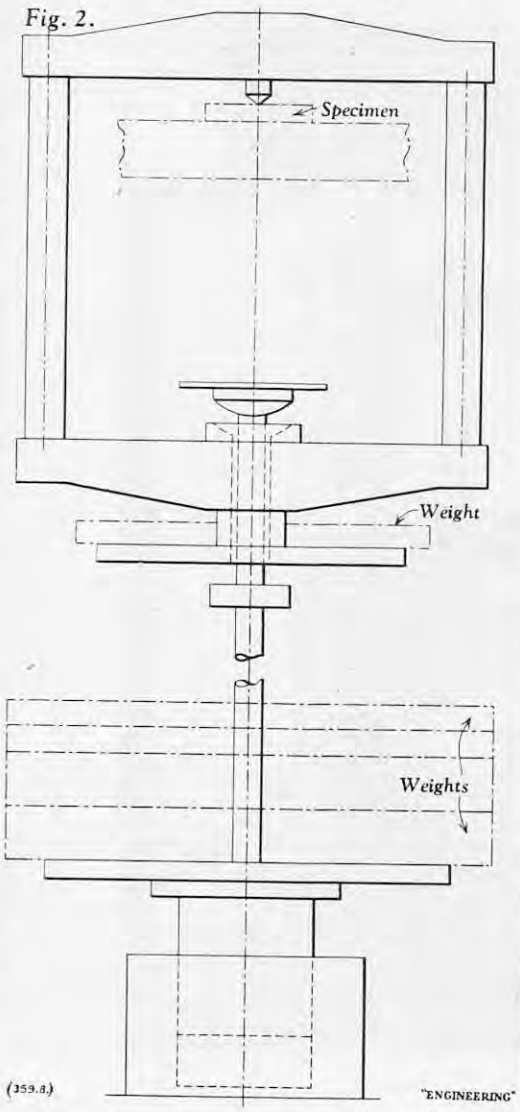



FIG. 1. DEADWEIGHT TESTING MACHINE.

Fig. 2.




## ANALYSIS OF THE ROCKWELL HARDNESS TEST, EMPLOYING A NEW DEADWEIGHT TESTING MACHINE.*

By C. E. PHILLIPS, Wh.Sc., M.I.Mech.E., and A. J. FENNER, B.Sc.(Eng.), A.M.I.Mech.E.

THE complete verification of a static indentation hardness-testing machine is normally not a simple operation; even those of simple design do not lend themselves readily to direct measurement of the applied load, owing to the smallness of the movement available at the indenter chuck. In direct-reading (Rockwell principle) hardness-testing machines, the difficulty is even more acute because of the special nature of the test. The hardness number is derived from a measurement of the net vertical movement of an indenter, from a datum position reached under an initial load (the minor load), after application and subsequent removal of a second load (the major load). For convenience, loads are normally applied by means of levers or springs, and the penetration is measured by a dial-gauge indicator, after mechanical amplification. Verification of hardness-testing machines, therefore, is usually restricted to check tests made from time to time on "standard hardness blocks"—uniform blocks of metal the hardness of which has been determined previously by tests in a machine which is considered to be accurate.

Direct-reading hardness-testing machines are now very widely employed in industry, probably owing to the simplicity and rapidity of the testing operation. The consequent introduction of Rockwell hardness tolerances into specifications for materials, however, has drawn attention to considerable discrepancies which can arise between results obtained from different testing machines. In recent years, it has also become apparent that a small but definite difference exists between "standards" of Rockwell hardness; for example, a hardness block standardised in the United States would not necessarily be allotted the same average hardness number as would be assigned to it in the United Kingdom. The investigation now described was undertaken in an attempt to assess the reasons for such differences and to provide a reliable basis for the standardisation of hardness blocks. Preliminary investigations and a detailed consideration of the conditions of the test, already specified in B.S. 891-1940, strongly suggested that the high standard of performance required of an independent reference would merit the design and construction of a special testing machine which could be readily verified from time to time. An experimental rig was first constructed; using experience gained with this, the machine described below was designed and constructed.

A general view of the machine is given in Fig. 1, herewith. The mechanism is housed in a very rigid framework, consisting of a cast-iron baseplate with four 3-in. diameter solid-steel pillars supporting the casting which carries the test platen. The specimen under test rests on this platen, which consists of a hardened-steel plate with a machined and lapped upper surface; the height of the platen may be adjusted by means of a screw, operated by a handwheel on the right-hand side of the machine. Both the minor and major loads are made up of deadweights. The speed of application of load is regulated by a hand-operated valve which controls the movement of a piston in a dashpot situated under the weights. The indenter is firmly mounted under the top crosshead of a rectangular frame, which, together with a scale pan, constitutes half the minor load (5 kg.). The remainder of the minor load is provided by a single weight resting on the scale pan.

The platform for the major load is attached to a rod passing freely through the lower crosshead of the frame, as shown in Fig. 2; the rod has a free vertical movement of about $\frac{1}{2}$ in., so that when the piston is at the top of its stroke the indenter is lifted just clear of the test block, and when the piston is at the bottom, the major load is suspended from the frame. The lower scale pan and its attachments form the first 5 kg. of the major load, the remainder being added in the form of loose weights. Lowering the piston thus brings first the minor load and then the major load on to the test piece. The piston is returned mechanically to its top position by a handwheel on the left of the machine, the oil returning to the dashpot through a quick-action non-return valve.

Measurements of the vertical movement of the indenter during the relevant part of the test are made by means of an optical comparator of the tilting-mirror type with a magnification of about 1,600. Rockwell hardness numbers are read directly from the image of a scale projected on to a ground-glass screen. The comparator is mounted on a threaded sleeve screwed into a steel plate firmly attached to the test platen. A knurled nut and a clamp are provided to enable the instrument to be moved vertically and clamped in position before tests are made. Normally no further setting is required for tests on a particular test block; the small zero adjustments needed each time the minor load is applied are made using a zero-setting device on the comparator itself. The indenter and minor load assembly are constrained to move only in a vertical direction by means of four pairs of 0·03 in. diameter steel wires passing between opposite corners of the machine, as shown in Fig. 3, on page 58. Two pairs of wires are fitted to the top, and two pairs to the bottom of the minor load framework. These wires, which serve merely as guides, are adjusted to a very small tension.

From the illustrations and the above description, it will be seen that the design of the machine differs radically from that of the ordinary commercial types of direct-reading hardness machines. The use of dead-weight loading and the frictionless support of the indenter clearly eliminate the possibility of random errors in the magnitudes of the applied loads. Particular attention is drawn, however, to the method of mounting the optical comparator. In ordinary direct-reading machines, the dial-gauge indicator, for convenience, is mounted in the head of the machine, which also carries the fulcrum of the loading lever. The reaction at the fulcrum due to the application of the major load causes a distortion of the machine frame; though this distortion is very small, it represents an appreciable proportion of the total displacement recorded by the dial gauge. If, on removal of the major load in any test, the framework failed to behave perfectly elastically, the remanent distortion would be added to the true depth of impression in the dial-gauge movement, and would introduce an error into the recorded hardness reading.

In the standard machine now described, the comparator is, in effect, firmly attached to the platen beneath the test piece, as may be seen in Fig. 3; any distortion of the machine framework which might occur as a result of transferring load from the base to the upper casting must result in a bodily movement of the platen and the comparator as a whole. In the same way, if the application of the major load causes any settling down of the screw which raises the platen, the comparator must needs follow. Regarding this latter point, it may be further mentioned that, after initial setting, the platen generally remains unmoved for all the tests on a given test plate.

The optical comparator is calibrated *in situ* by introducing slip gauges between the plunger and the small platen with which it makes contact. The upper surface of the platen is ground and lapped, and slip-gauges can be wrung directly on to it. The instrument was calibrated in this manner before and after the work described later in this article. Good agreement between the two calibrations was observed, and it is concluded that readings over the normal working range are correct to better than $\pm 0{\cdot}2$ division on the Rockwell scale.

The deadweight hardness-testing machine is ultimately intended for the purpose of standardising hardness blocks. The procedure currently employed in standardising tests is based on Appendix B of B.S. 891-1940, the relevant portions of which read as follows: The hardness of the calibrated test specimen, "as determined by a competent authority, should not vary at five points comprising the centre and corners by more than one unit for a specimen tested on the C scale. The hardness number of the calibrated specimen should be taken as the average of all five readings. It should be marked with two hardness numbers, representing one unit above and below the average for a specimen tested on the C scale."

During the course of the experiments which led to the construction of the standard machine, it was found that, in tests on a given block, differences up to about two units could arise between readings using the same indenter in different machines, and similar differences occurred between readings obtained with different indenters in the same machine, though all the tests were ostensibly made in accordance with B.S. 891-1940. It was known that specifications exist in which a tolerance of only one or two units in this scale of hardness is permitted. Accordingly, it was considered essential to explore the factors influencing the results of tests before undertaking any standard-

* Communication from the National Physical Laboratory. Abridged.

# ANALYSIS OF ROCKWELL HARDNESS TEST.

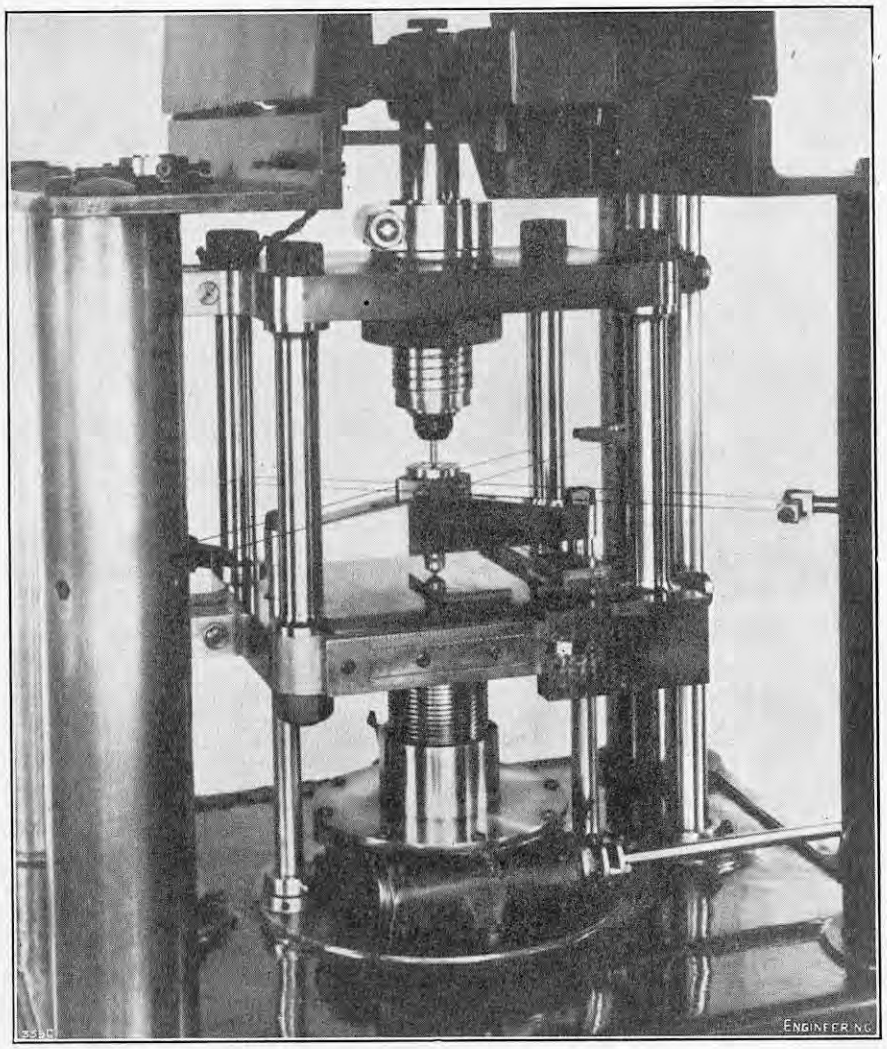



FIG. 3. MACHINE SET UP FOR TESTING.

Fig. 4.

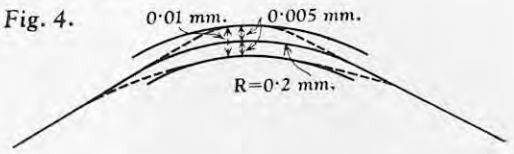



Fig. 5.

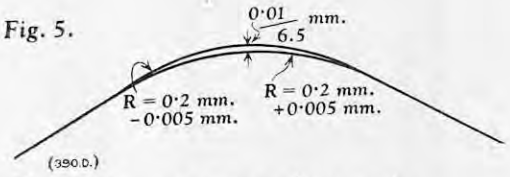



Fig. 6.(a) High C Block ($H_RC \simeq 63$)

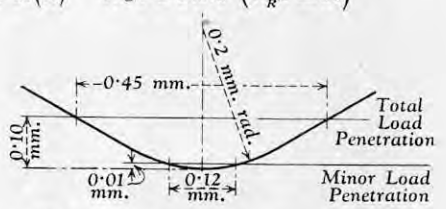



Fig. 6.(b) Medium C Block ($H_RC \simeq 45$)

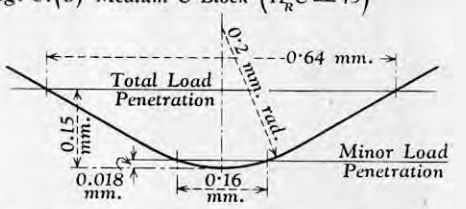
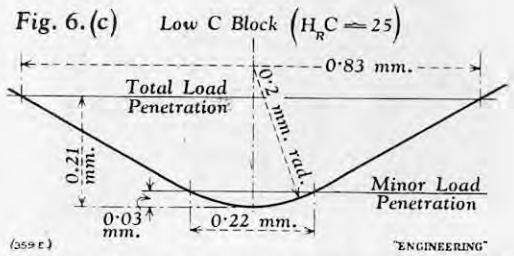



Fig. 6.(c) Low C Block ($H_RC \simeq 25$)




ising work. Leaving aside the question of direct errors which could be introduced by an inaccuracy of the measuring instrument, the most likely causes of the discrepancies noted were: (1) differences in the shapes of indenters, and (2) differences in the magnitude of the minor load or the major load, or both. The effects of varying these parameters have been explored, and a few tests have also been made to investigate the influence of the duration of application of the major load.

The shape of the conical diamond indenter is specified in B.S. 891-1940, as follows:—"The conical penetrator shall be a diamond with an angle of 120 deg. to an accuracy of $\pm$ 0·1 deg. in any axial plane. The point of the penetrator shall be rounded to a radius of 0·20 mm. and the profile shall conform to the radius of 0·20 mm. within an accuracy of $\pm$ 0·005 mm. The round and conical surfaces shall join in a truly tangential manner. The penetrator shall be clean, have a good polish, and be free from cracks and surface blemishes, and shall be solidly mounted in a suitable holder."

Twelve high-grade conical penetrators were obtained from current production and their profile shapes were determined in three axial planes in the Metrology Division of the N.P.L. The angles were measured by optical projection at 200 diameters using a protractor method, and again by an interference method developed in the Laboratory. The profile of the spherical tip was compared with the nominal radius by optical projection at 1,000 diameters. The method of measurement is fully described elsewhere*; the results of the measurements are given in Table I, opposite. All of these indenters would be expected to conform to the specified conditions stated above.

For the purpose of these measurements, the B.S. tolerance on the radius was taken to mean a nominal profile of 0·20 mm. radius, with concentric tolerance bands 0·005 mm. wide on each side of the nominal profile (see Fig. 4). Another possible interpretation is illustrated in Fig. 5. While this second interpretation is more normally accepted for specifying an outline of this type, it gives a tolerance band which, according to Tolmon and Wood, is at present impracticable from the measuring point of view. It will be noted that, even with the wider tolerance of the first interpretation, the spherical tips of eight of the penetrators failed to satisfy the specified conditions. In addition, the included angles of six penetrators lay outside the tolerance limits in each plane of measurement.

Direct-reading hardness tests (Rockwell principle—C scale) were made in the deadweight machine with each penetrator, on nine steel plates (each $2\frac{3}{4}$ in. by $1\frac{3}{4}$ in. by $\frac{1}{4}$ in.) at three hardness levels (Rockwell C scale hardness numbers approximately 27, 46 and 62, respectively), to compare the behaviour of the different penetrators. The estimated depths of penetration for minor and total loads, in plates of those hardnesses, are indicated in Fig. 6. The tests on each plate were conducted as an incomplete randomised block experiment of the type devised by Yates,* using a block size of 2, arranged for 13 treatments, one of the penetrators being used twice in each experiment. The two hardness tests in each block were made at points $\frac{1}{8}$ in. apart on the steel plates. The reasons for selecting this particular experimental design are given in the Appendix. The results of the tests are summarised in Table II, on page 60.

Inspection of Table III shows that, for the two higher levels of hardness, a low order number in the column generally corresponds to a low value of excess material at the spherical tip, and vice versa, though this behaviour does not persist in the tests on plates of low hardness. Figs. 7, 8 and 9 show the way in which the average hardness number varies with the average value of the departure from the nominal profile, for the hard, medium and soft plates, respectively. For the purpose of correlation, the hardness values for two of the plates have been reduced by constant amounts before plotting. Thus, in Fig. 7, each hardness number for plate 1 has been reduced by 0·65 division, the difference between its overall average and that of plate 2. Hardness numbers for plate 3 are likewise reduced by 0·20 division. This device has been adopted to bring into relief the agreement and discrepancies between the behaviour of any given penetrator in tests of different plates.

It will be apparent from the diagrams that for plates of the two higher hardnesses there is a distinct correlation between the hardness number and the extent by which the profile at the tip of the penetrator projects beyond the nominal outline given by the specified radius of 0·2 mm. The slopes of the lines drawn through the plotted points of Figs. 7 and 8 show that the changes in Rockwell hardness number to be expected owing to an increase of 0·005 mm. in excess material projecting beyond the nominal profile are: for a plate of hardness $H_R C$ 63, — 1·8 units; and for a plate of hardness $H_R C$ 45, — 0·9 unit. It follows that if the B.S. specification is interpreted to permit the use of penetrators with profiles departing from the nominal by $\pm$ 0·005 mm. of material, or if inspection procedure is such that such penetrators are accepted, then it is inevitable that a range of variation will occur in apparent hardness of about 3 units at $H_R C = 63$, and 2 units at $H_R C = 45$. It so happened that not one of the penetrators obtained for these tests had a tip with a radius of curvature greater than the nominal value. It may be mentioned here that the projected outline of the tip of each penetrator conformed reasonably well to a circular arc extending for the full 60 deg.; with penetrators of ideal form, each 0·001 mm. of excess material would represent a reduction in the radius of curvature of approximately 0·006 mm.

Fig. 9 shows that this linear correlation does not extend to tests of softer materials, in which greater penetration takes place. It was at first thought that the lack of correlation might be due to the increased influence of errors in the included angles of the penetrators, the effect of which would naturally be expected to become more pronounced as the depth of penetration was increased. This, however, does not appear to be a sufficient explanation. An attempt has been made to relate the hardness number with the included angle. For the hard and medium blocks, a correction derived from the slopes of the lines in Figs. 7 and 8 was applied to each average hardness reading, to eliminate the effect of the tip form. A graph typical of those

* F. R. Tolmon and J. G. Wood, "Precision measurement of Rockwell hardness diamond penetrators." (To be published in a future issue of ENGINEERING.)

* Yates, "Incomplete Randomised Blocks." *Annals of Eugenics*, 1936, page 125.

# ANALYSIS OF ROCKWELL HARDNESS TEST.

Fig. 7.

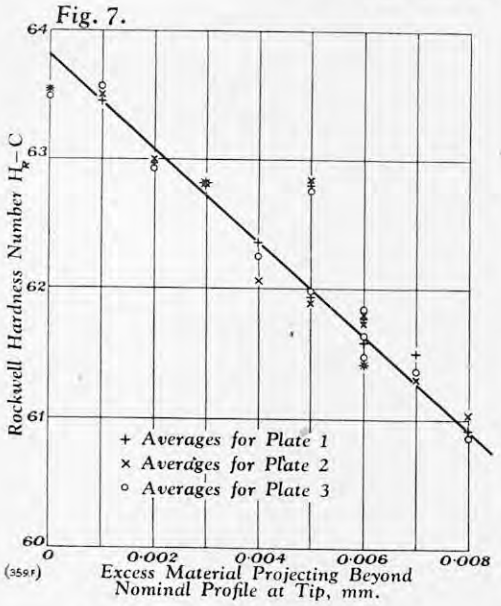



Fig. 8.

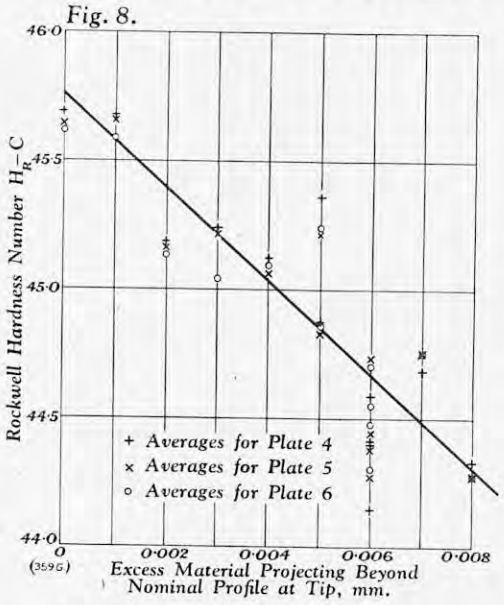



Fig. 9.

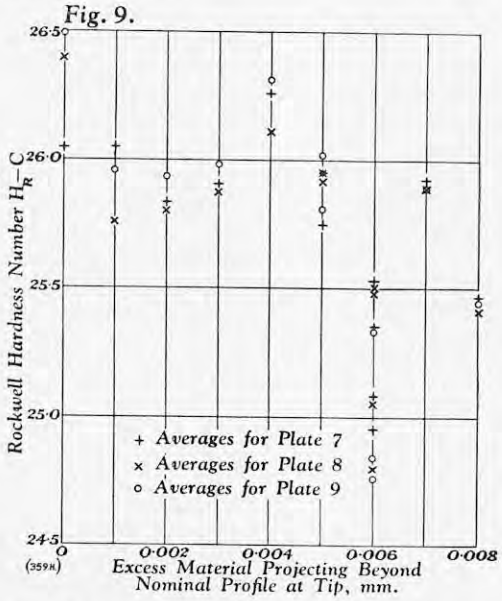



Fig. 10.

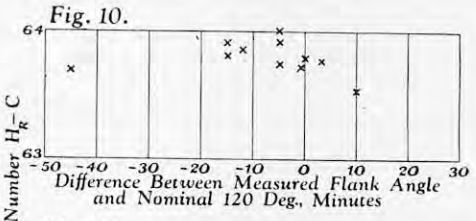



Fig. 11.

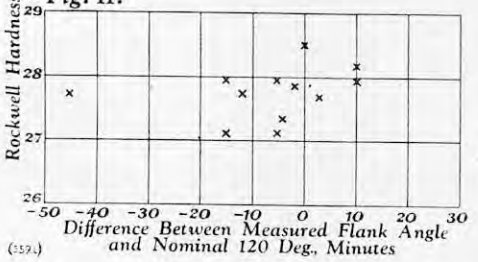



Fig. 12.

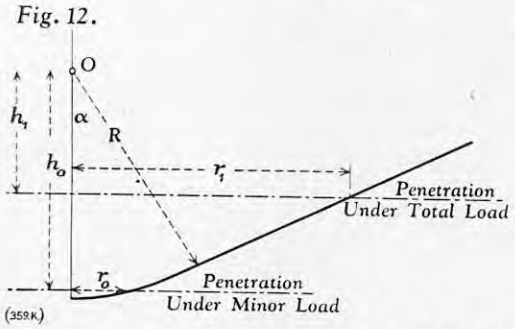
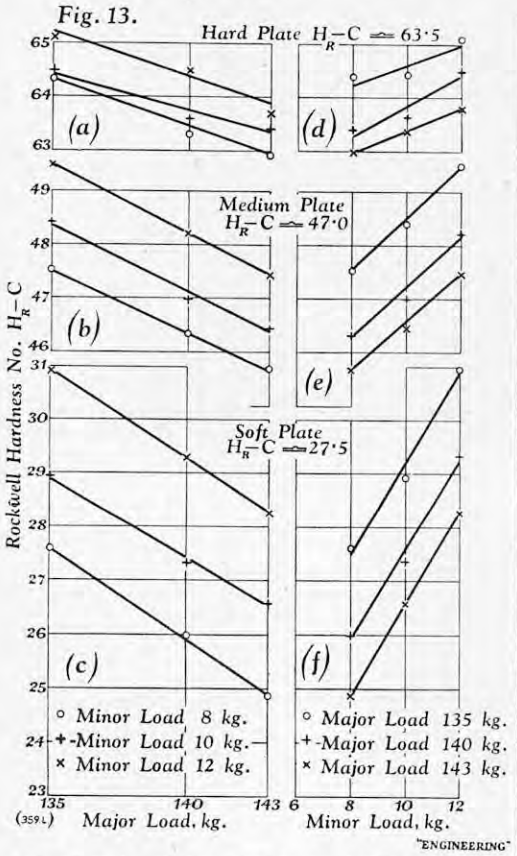



Fig. 13.




obtained is given in Fig. 10. In the case of the soft blocks, no such correction could be made, and plotting the hardness number against angle error yields diagrams of the kind shown in Fig. 11. It will be seen that in neither case is there any clear evidence of the influence of the angle.

It will also be seen that, in the tests on the soft plates, a greater degree of "scatter" of results occurred, inasmuch as the order of the penetrators in a table of descending hardness numbers is less well preserved from plate to plate. One possible cause of this may reside in the amount of "creep" which takes place under the full load in tests of soft steels. The specification requires merely that the full load be maintained until movement of the penetrator has ceased, and the criterion of this condition will depend to a large extent on the sensitivity of the recording instrument and on the machine operator. During the present series of tests it was found that movement could still be detected by the optical comparator after the full load had been maintained for 15 minutes. In tests so far described, the full load was actually maintained for approximately 2 minutes. The rate of deformation for any given diamond during this period may well differ from plate to plate to a degree which would suffice to produce the scatter obtained. A short experiment to determine the effect of time of application of total load was, therefore, carried out, and is described later.

An estimate of the change in hardness reading expected to result from variations in tip radius and angle can be derived in the following manner, if the recovery of the metal on removal of the major load is neglected, and certain assumptions are made.

Let $R$ = radius of curvature of tip of which the centre is at O (Fig. 12).
$\alpha$ = semi-angle subtended at O by the spherical tip.
$P_0$ = minor load.
$P_1$ = total load.
$h_0$ = height of O above test surface when minor load is applied.
$h_1$ = height of O above test surface when total load is applied.
$r_0$ = radius of minor load impression.
$r_1$ = radius of major load impression.
$p$ = the mean pressure over the projected area of the indentation in a plane parallel to the test surface; this is assumed to be a constant for the material under test.

From consideration of the mean pressures it can be shown that, for hardnesses of $H_R C >$ about 30, $r_0 < R \sin \alpha$ and $r_1 > R \sin \alpha$. Thus $h_0 = \sqrt{R^2 - r_0^2}$, and $h_1 = R \sec \alpha - r_1 \tan \alpha$.

Neglecting recovery, the Rockwell hardness is a function of the difference between these heights:

$$H_R C = 100\,[1 - 5\,(h_0 - h_1)]$$

where $h_0$ and $h_1$ are expressed in millimetres

$$= 100\,[1 - 5\sqrt{R^2 - r_0^2} + 5R \sec \alpha - 5r_1 \tan \alpha]$$

By substituting for $r_0$ and $r_1$ in terms of $P_0$ and $P_1$, respectively, and the constant $p$, this expression may be employed to obtain a series of "theoretical" values of $H_R C$ corresponding to arbitrarily chosen values of $p$. Further, by differentiating with respect of R and $\alpha$, the effect of varying these parameters may be assessed.

TABLE I.—*Results of Examination of Profiles of Conical Penetrators.*

| Penetrator Identification Letter. | Diametral Plane of measurement. | Error in Minutes from Nominal Angle of 120 deg. | | Excess Material at Tip, normal to measured profile, mm. |
|---|---|---|---|---|
| | | Projection Method. | Interference Method. | |
| A | 0 | + 1 | — 4 | 0·005 |
| | 60° | — 3 | — 4 | 0·005 |
| | 120° | — 7 | — 6 | 0·007 |
| B | 0 | — 4 | — 4 | 0·006 |
| | 60° | — 2 | — 5 | 0·006 |
| | 120° | — 2 | — 4 | 0·005 |
| C ≡ D | 0 | + 5 | + 5 | 0·010 |
| | 60° | + 1 | + 5 | 0·009 |
| | 120° | + 3 | 0 | 0 |
| E | 0 | + 8 | + 7 | 0·008 |
| | 60° | +10 | +11 | 0·002 |
| | 120° | + 9 | +12 | 0·003 |
| F | 0 | — 9 | —10 | 0 |
| | 60° | — 9 | —13 | 0 |
| | 120° | —14 | —12 | 0·002 |
| G | 0 | +13 | +13 | 0 |
| | 60° | +12 | + 7 | 0 |
| | 120° | + 8 | +10 | —0·001 |
| H | 0 | — | — 6 | 0·008 |
| | 60° | — | — 5 | 0·004 |
| | 120° | — | — 5 | 0·008 |
| I | 0 | — | — 2 | 0·005 |
| | 60° | — | — 1 | 0·004 |
| | 120° | — | — 2 | 0·006 |
| J | 0 | —12 | —14 | 0·008 |
| | 60° | —16 | —16 | 0·011 |
| | 120° | —13 | —15 | 0·006 |
| K | 0 | — 8 | —15 | 0·003 |
| | 60° | —14 | —15 | 0·003 |
| | 120° | —19 | —16 | 0·003 |
| L | 0 | —45 | —46 | 0·003 |
| | 60° | —43 | —45 | 0·003 |
| | 120° | —46 | —46 | 0·001 |
| M | 0 | — | — 1 | 0·004 |
| | 60° | — | + 2 | 0·006 |
| | 120° | — | — 2 | 0·003 |

*Note.*—The estimated accuracies of the angle determinations were, respectively, ± 6 minutes of arc for the projection method and ± 1 minute of arc for the interference method. The latter figures were obtained to the nearest ½ minute, but in the above table are approximated to the nearest minute.

In this manner, using values of $p$ found to correspond to Rockwell hardness of 63 and 45 respectively, the changes in apparent hardness due to an increase of 0·005 mm. excess material were found to be:—

For a plate of hardness $H_R$ C 63: — 1·8 units.

For a plate of hardness $H_R$ C 45: — 1·2 units (approximately).

The effects of varying the included cone angle over

# ANALYSIS OF ROCKWELL HARDNESS TEST.

Fig. 14.

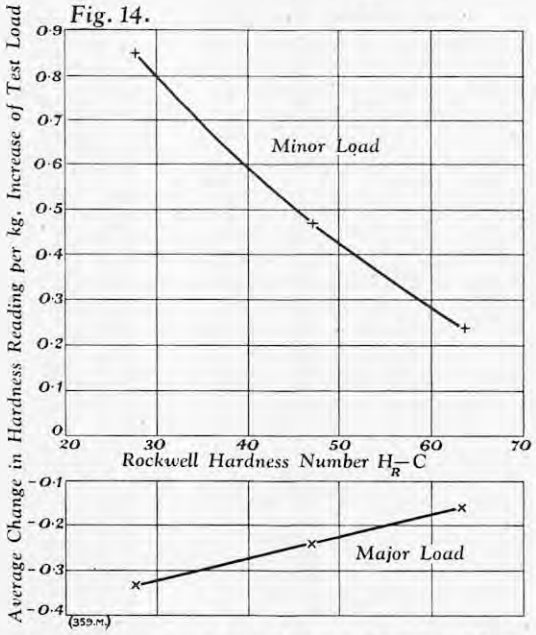



Fig. 15.

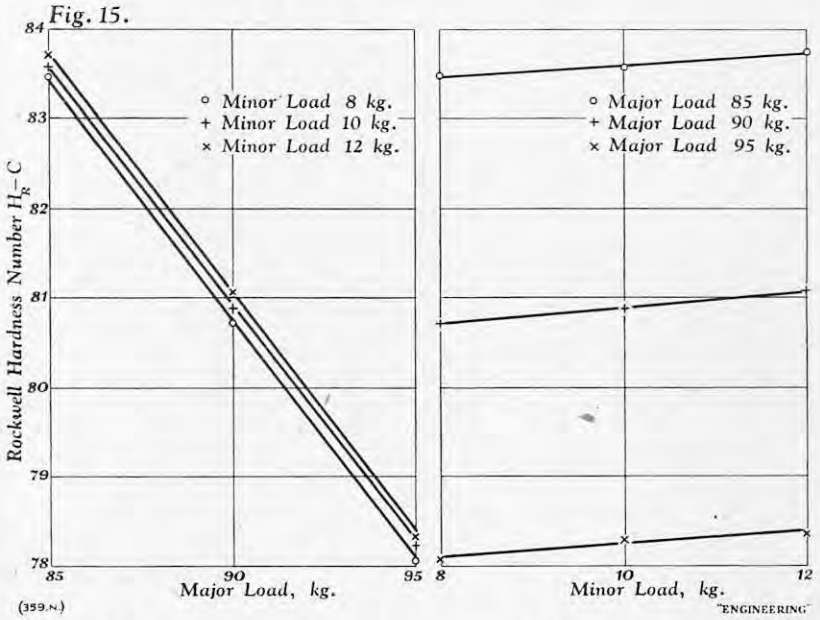



TABLE II.—AVERAGE ROCKWELL C SCALE HARDNESS NUMBERS OBTAINED WITH DIFFERENT PENETRATORS.

| Penetrator. | Average Rockwell C Scale Hardness Number. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Plate 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| A ... ... | $62\cdot4_1$ | $61\cdot8_2$ | $62\cdot0_4$ | $45\cdot1_2$ | $46\cdot0_7$ | $44\cdot4_8$ | $25\cdot0_8$ | $26\cdot7_9$ | $25\cdot4_3$ |
| B ... ... | $62\cdot2_5$ | $61\cdot7_3$ | $61\cdot9_3$ | $44\cdot8_7$ | $45\cdot9_6$ | $44\cdot3_1$ | $24\cdot9_6$ | $27\cdot9_6$ | $25\cdot3_6$ |
| C ... ... | $62\cdot0_7$ | $61\cdot4_3$ | $61\cdot6_7$ | $45\cdot1_4$ | $46\cdot1_3$ | $44\cdot5_5$ | $25\cdot3_5$ | $27\cdot5_0$ | $25\cdot9_3$ |
| D ... ... | $62\cdot2_6$ | $61\cdot7_5$ | $61\cdot8_4$ | $54\cdot3_1$ | $46\cdot4_2$ | $44\cdot7_1$ | $25\cdot5_3$ | $27\cdot5_0$ | $25\cdot9_3$ |
| E ... ... | $63\cdot4_5$ | $62\cdot8_5$ | $62\cdot9_8$ | $46\cdot0_8$ | $46\cdot9_0$ | $45\cdot2_3$ | $25\cdot7_5$ | $27\cdot9_5$ | $26\cdot4_0$ |
| F ... ... | $64\cdot1_5$ | $63\cdot5_1$ | $63\cdot7_7$ | $46\cdot3_9$ | $47\cdot3_4$ | $45\cdot5_8$ | $26\cdot0_5$ | $27\cdot7_6$ | $26\cdot5_5$ |
| G ... ... | $64\cdot2_1$ | $63\cdot5_5$ | $63\cdot6_9$ | $46\cdot4_0$ | $47\cdot3_2$ | $45\cdot6_1$ | $26\cdot0_5$ | $28\cdot4_0$ | $27\cdot0_8$ |
| H ... ... | $62\cdot1_5$ | $61\cdot3_0$ | $61\cdot5_5$ | $45\cdot4_1$ | $46\cdot4_4$ | $44\cdot7_6$ | $25\cdot9_2$ | $27\cdot8_9$ | $26\cdot4_8$ |
| I ... ... | $62\cdot5_8$ | $61\cdot9_2$ | $62\cdot1_8$ | $45\cdot5_9$ | $46\cdot5_1$ | $44\cdot8_6$ | $25\cdot9_5$ | $27\cdot9_2$ | $26\cdot6_1$ |
| J ... ... | $61\cdot5_8$ | $61\cdot0_3$ | $61\cdot0_6$ | $45\cdot0_6$ | $45\cdot9_7$ | $44\cdot2_9$ | $25\cdot4_6$ | $27\cdot4_1$ | $26\cdot0_4$ |
| K ... ... | $63\cdot4_8$ | $62\cdot8_3$ | $63\cdot0_3$ | $45\cdot9_5$ | $46\cdot9_0$ | $45\cdot0_4$ | $25\cdot9_0$ | $27\cdot8_9$ | $26\cdot5_8$ |
| L ... ... | $63\cdot6_3$ | $62\cdot9_9$ | $63\cdot1_4$ | $45\cdot9_0$ | $46\cdot8_5$ | $45\cdot1_3$ | $25\cdot8_3$ | $27\cdot8_1$ | $26\cdot5_3$ |
| M ... ... | $63\cdot0_1$ | $62\cdot0_6$ | $62\cdot4_5$ | $45\cdot8_4$ | $46\cdot7_5$ | $45\cdot0_9$ | $26\cdot2_6$ | $28\cdot1_1$ | $26\cdot9_0$ |
| Standard error... | 0·05 | 0·05 | 0·05 | 0·05 | 0·05 | 0·05 | 0·08 | 0·13 | 0·10 |

The standard errors are measures of the variability in the above figures that would occur if the same penetrator were used in all rows. They are estimated from an analysis shown in the Appendix.

*Note to Table II.*—Each hardness number given in the Table is the weighted (see Appendix) mean of twelve readings on one steel plate. The averages in the columns were re-arranged in descending order of magnitude, and each figure was then replaced by the identification letter of the penetrator from which it was derived. From the arrangement of the letters, Table III was drawn up to show the position occupied by each penetrator in the list for each plate, together with the characteristics of its profile taken from the measurements given in Table I.

TABLE III.—RELATION BETWEEN PENETRATORS ON NINE DIFFERENT TEST PLATES.

| Penetrator. | Angle Error from Nominal,* Minutes. | Excess Material at Tip,* mm. | Position in Table of Descending Order of Hardness Reading. | | |
|---|---|---|---|---|---|
| | | | Plate:—1 2 3 $H_R$ C: 62. | Plate:—4 5 6 $H_R$ C: 46. | Plate:—7 8 9 $H_R$ C: 27. |
| A .. .. .. | — 5 | 0·006 | 8 8 8 | 10 10 10 | 11 12 11 |
| B .. .. .. | — 4 | 0·006 | 10 10 9 | 12 12 11 | 12 11 12 |
| C ≡ D .. .. .. | + 3 | 0·006 | 9 9 10 | 9 9 9 | 9 9 10 |
| E .. .. .. | +10 | 0·004 | 5 4 5 | 3 3 3 | 8 3 8 |
| F .. .. .. | —12 | 0·001 | 2 2 1 | 2 1 2 | 3 8 5 |
| G .. .. .. | +10 | 0 | 1 1 2 | 1 2 1 | 2 1 1 |
| H .. .. .. | — 5 | 0·007 | 11 11 11 | 8 8 8 | 5 6 7 |
| I .. .. .. | — 2 | 0·005 | 7 7 7 | 7 7 7 | 4 4 3 |
| J .. .. .. | —15 | 0·008 | 12 12 12 | 11 11 12 | 10 10 9 |
| K .. .. .. | —15 | 0·003 | 4 5 4 | 4 4 6 | 6 5 4 |
| L .. .. .. | —46 | 0·002 | 3 3 3 | 5 5 4 | 7 7 6 |
| M .. .. .. | 0 | 0·004 | 6 6 6 | 6 6 5 | 1 2 2 |

* The average of the three values, in each case.

the specified tolerance was found to be rather less than 0·1 unit in each case. It can be seen that the experimental results are in reasonably good agreement with the calculated figures.

The difficulties inherent in verifying the loads applied by direct-reading hardness-testing machines have already been noted. From measurements of indentations made on a single steel plate in tests under similar conditions in different testing machines, and from other indirect evidence, the authors are confident that appreciable errors in applied load can occur. The effect on the hardness number of altering the minor load and the major load has been investigated for the Rockwell C scale on three plates of different hardness ($H_R$ C: 63·5, 47 and 27·5) and for the Rockwell B scale on one plate ($H_R$ B: 81). The tests on each plate were conducted as a factorial experiment using three values of minor load and three values of major load, each of the nine possible combinations being employed. The experiment was arranged as an incomplete randomised block design for nine treatments and a block size of 4, eight tests being made with each possible combination of minor and major loads. The results of the C-scale tests are shown diagrammatically in Figs. 13 and 14. The weighted average of the hardness readings obtained at each load condition is plotted against major load at (*a*), (*b*) and (*c*) in Fig. 13 with straight lines drawn through points representing tests in which the minor load had equal values. The same results are similarly plotted against minor load in (*d*), (*e*) and (*f*). The average slope of the three lines in each diagram has been estimated and is recorded in Table IV, which indicates the change in hardness reading to be expected from an increase of 1 kg. in the minor and major loads respectively.

The figures in Table IV are shown in Fig. 14 plotted against the nominal hardness of the test plate. Fig. 15 shows the weighted averages of the B scale hardness numbers, plotted against major load and minor load in the manner described above. It will be observed

TABLE IV.—*Variation of Rockwell C Scale Hardness with Applied Load.*

| Hardness of Test Plate $H_R$—C | Change in Observed Hardness Due to an Increase of 1 kg. in | |
|---|---|---|
| | Minor Load. | Major Load. |
| 27·5 | + $0\cdot8_5$ units | — $0\cdot3_3$ units |
| 47 | + $0\cdot4_7$ ,, | — $0\cdot2_4$ ,, |
| 63·5 | + $0\cdot2_4$ ,, | — $0\cdot1_6$ ,, |

that, in these tests, alterations in major load produced an important effect, whereas changes in minor load were relatively unimportant. From the slopes of the lines, it can de deduced that the changes in apparent hardness number of the plate which might be expected as a result of an increase of 1 kg. in applied load are: + 0·08 unit for change of minor load; and — 0·54 unit for change of major load.

A complete experiment, similar to those described above, was made on a new low C-scale plate of approximately the same hardness. All 12 indenters were again employed, but the 13th "treatment" in this case was obtained by using one indenter for tests of long duration, the full load being maintained for 15 minutes instead of the 2 minutes adopted in the other tests. The corrected averages of the hardness numbers obtained with this indenter were :—

Total load applied for 2 minutes .... 28·0
Total load applied for 15 minutes .... 26·9

It may be recorded here that the results of the tests in which the full load was maintained for only 2 minutes were used to obtain the positions of the penetrators in a table of descending order of hardness number, as in Table III, and appreciable divergencies from those given for plates 7, 8 and 9 were observed.

Though the results of the tests are by no means free from inconsistencies, the following general conclusions may be drawn :—

(1) It is probable that many of the conical diamond indenters produced and employed in industry do not conform to the tolerance limits of radius and angle laid down in B.S. 891. (Tolmon and Wood express the view that the specification of the form of the spherical tip is open to more than one interpretation.)

(2) The hardness number obtained in a Rockwell C-scale test is a function of the profile of the spherical tip of the indenter. Variations up to 2 or 3 units may arise between indenters conforming to the B.S. specification tolerance on radius, as interpreted in Fig. 4.

(3) On the other hand, there is no clear indication that small departures from the nominal included angle of 120 deg. have any important influence on the hardness number. It would appear possible, in the light of the tests reported above, to assign wider tolerance

# CABLE HOLDERS FOR POWER-TRANSMISSION LINES.


FIG. 1. PROTECTIVE COVERING OF CABLE.

Fig. 2.

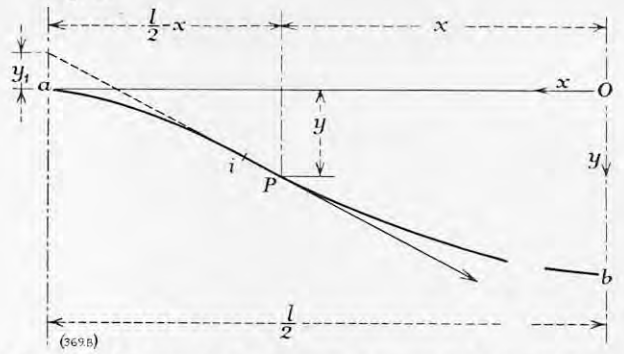
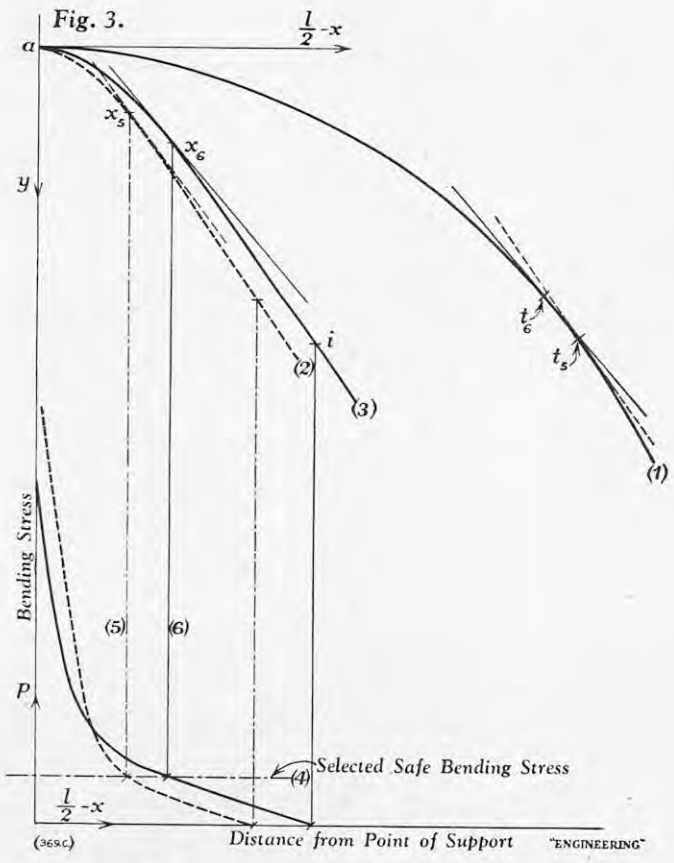



Fig. 3.




limits for the angle (for example, 2 or 3 times the range now permitted).

(4) Errors in either of the applied loads have an important effect on the hardness number obtained in a C-scale test, particularly in tests of comparatively soft materials. For B-scale tests, accuracy of the minor load appears to be less critical, but variations in major load have a noticeable influence on the test results.

(5) Under the C-scale test load of 150 kg., it was found that unrecoverable creep of test material of low hardness took place over a period in excess of 15 minutes, leaving room for doubt as to when the test should be regarded as complete. Further investigation of this phenomenon is clearly desirable; with the much shorter time of application which is often employed in quality control in industry (less than 15 seconds), the variability of apparent hardness would be expected to be greater than that found in the present tests.

The authors acknowledge the valuable co-operation of Messrs. W. and T. Avery, Limited.

## APPENDIX.

By E. D. VAN REST, B.A., B.Sc., F.Inst.P.

The purpose of a designed experiment should be to obtain (*a*) unbiased estimates of low error variance (variance is a measure of variability) of the effects being investigated and (*b*) unbiased and valid estimates of that error variance. An earlier experiment had shown that the differences to be expected between results from the different penetrators were not so great that a large residual variance or error of the experiment could be tolerated. It was thought that the smallest residual variance that could be achieved would be that between two replications made within a few millimetres of each other on a standard plate. Thus a design was selected which would enable the different penetrators to be compared when their indentations were next to one another on the standard plate. This involves an arrangement of balanced, incomplete, randomised blocks; "incomplete" because only two out of the 13 penetrators can appear in each pair of indentations which form the fundamental block for a comparison; "balanced" because it must be arranged that each pair shall occur together in a block the same number of times as any other pair; and "randomised" in order that unbiased estimates both of the effects and their error variance shall be obtained. The 13 penetrators can be arranged in 78 different pairs so that multiples of 78 blocks of two spaces for indentation are required. The number of tests is of course larger for the smaller block size but this was not considered any disadvantage by those carrying out the experiment. The block size of two has the additional advantage that very few additional blocks would be required for the addition at a later stage of new penetrators.

The actual design was derived by writing out in a systematic way all the possible pairs of penetrators and then randomising the order of the pairs by reading through a page or two of random numbers. Finally, the order within pairs (left or right) was randomised by a similar method. The resulting list forms the order in which the indentations made by the penetrators were arranged on the standard plate but not necessarily the order in which they were made; it was considered preferable to make all the necessary indentations with one penetrator before removing it from the head. The method of analysis of an incomplete block experiment is described by Yates in *Annals of Eugenics*, 1936, vol. 7, page 121, and in Fisher and Yates Statistical Tables for Biological, Agricultural and Medical Research, Oliver and Boyd. In this particular case, the analysis results in Table V which enables the errors of either a within-

TABLE V.—*Analysis of Variance of Results from One Plate; 2 × 78 Tests.*

| Source of Variation. | Degrees of Freedom. | Sum of Squares. | Sum of Squares ÷ deg. of Freedom. |
|---|---|---|---|
| Blocks— | | | |
| 1. Different tools .. | 12 | $\frac{(\text{Dev W})^2}{1{,}716}$ | |
| 2. Between block error | 65 | | |
| 3. Total for blocks .. | 77 | $(\text{Dev B})^2 \div 2$ | M′ |
| 4. Tools within blocks | 12 | $(\text{Dev V})^2 \div 12$ | |
| 5. Error within blocks | 66 | | M |
| Total .. .. .. | 155 | $(\text{Dev } y)^2$ | |

$V_i$ = sum of all results with the $i$th tool.
[dev V]$^2$ = sum of the squared deviations of each V from mean of all values of V.
G = Total of all results.
$B_i$ = $i$th block total.
$T_i$ = sum of all block totals which have $i$th tool.
$W_i = 11V_i - 12T_i + G$.
[dev]$^2$ has the meaning corresponding to that already given for [dev V]$^2$
From M and M′ of Table V, are calculated

$$w = \frac{1}{\text{M}} \text{ and } w' = \frac{132}{154\,\text{M}' - 11\,\text{M}}$$

and further $\mu = \dfrac{w - w'}{13\,w + 11\,w'}$.

block comparison or a between-block comparison to be evaluated. The quantities to be entered in the third column are represented by symbols which are explained below. The quantities involved are less straightforward than might be expected because the information to be obtained from comparisons between blocks is used as well as that within blocks. Thus, the mean value of the result for a given tool consists of a weighted mean of all the results with that tool and the error of a comparison must also involve those weights.

Then the best (weighted) estimate of the hardness value given by the $i$th tool is $\frac{1}{12}(V_i + \mu W_i)$ and the error variance of these estimates is $\dfrac{2}{13w + 11w'}$; this last is the source of the standard deviation used in the paper to assess the significance of an observed difference. For example, a difference between two quantities $\frac{1}{12}(V_i + \mu W_i)$ for two tools would have to be some 2 to 2·5 times $\sqrt{\dfrac{4}{13w + 11w'}}$ before it could be regarded as significant.

# IMPROVED CABLE HOLDERS FOR POWER-TRANSMISSION LINES.

By SVERRE SANDBERG and JULIUS LINDBLOM.*

IN erecting power-transmission lines, one of the most difficult problems is to provide a device for suspending the cables at the insulators which will prove satisfactory from the point of view of the stresses which occur. The sharper bends at the points of suspension obviously result in greater bending stresses in the cable at these points than in the free span between them. This is particularly so when cable-holders of the older types, which support the cable by means of short and often straight or sharply bent surfaces are employed. The bending stress is also increased by the tension in the cable and even light winds readily cause vibrations which increase the stresses at the points of suspension so that, sooner or later, the cables break. Efforts to improve matters were first directed wholly at reducing the effect of cable vibrations, while ignoring the need to diminish the much larger and more dangerous bending stresses caused by unsuitably designed cable-holders. In the 1920's, this problem was solved in a satisfactory but costly manner by employing protective coverings of armour rods, the arrangement being illustrated in Fig. 1, on this page. These armourings lessen the stresses caused by bends and vibrations sufficiently to avoid breaks in the cable, but, at the same time, they render any damage to individual wires in the protected cable difficult to detect. In recent years, the Svenska Aluminiumkompaniet, Stockholm, have developed a cable-holder of improved design; the theory on which the design is based and a brief description of the holder are given below.

As already mentioned, the bending stress in a cable can be considerable if the bearing surface at the support is straight or too acutely bent. When the cable leaves

* Svenska Aluminiumkompaniet, Stockholm, Sweden.

# CABLE HOLDERS FOR POWER-TRANSMISSION LINES.

Fig. 4.

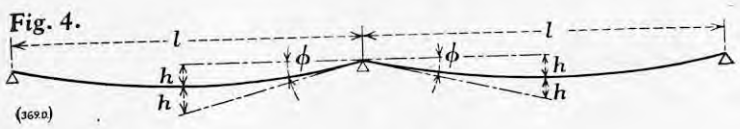
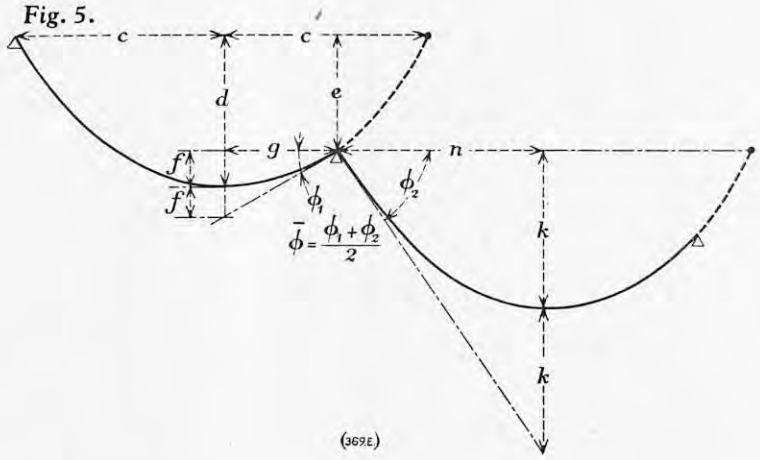



Fig. 5.



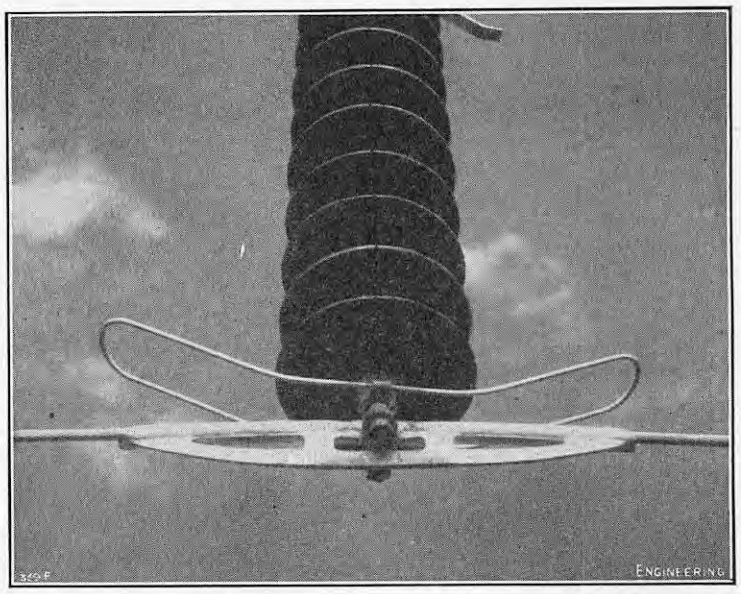




FIG. 6. CABLE HOLDER IN POSITION.

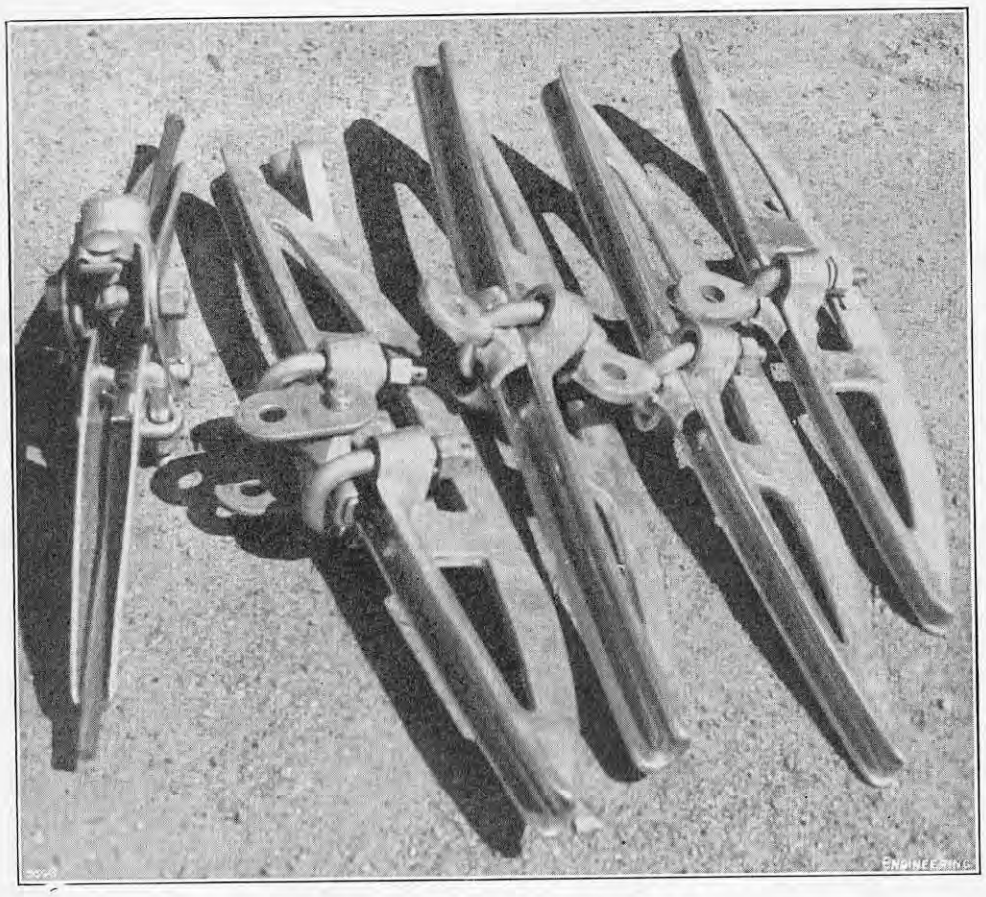
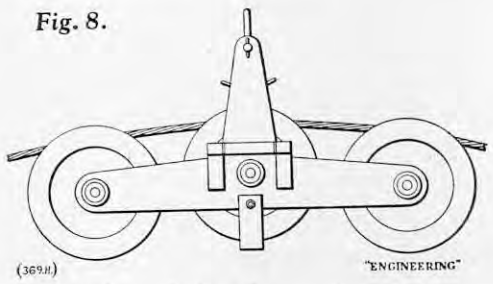



FIG. 7. GROUP OF CABLE HOLDERS.

Fig. 8.




the bearing surface—which may be regarded as two points of support a short distance apart—it is free to follow a natural curve, a fact which can be very detrimental to the cable. The elastic line of the cable, and the bending stresses at various points near the point of support, may be determined by the following method, which was described by the first author in a paper presented to the American Institute of Electrical Engineers at Cincinnati, Ohio, in October, 1949.

In Fig. 2, page 61, $a$ is the point of support and $b$ is the lowest point of the span ; $i$ is the point of inflection, and O the origin of co-ordinates, of which the $x$-axis is horizontal and the $y$-axis vertically downwards.

Let

$x, y$ = co-ordinates of any point P in the elastic line.
$y_1$ = eccentricity at $a$ of the tangent to the elastic line at $i$.
T = tension in cable in kg, at $a$.
$\rho = \frac{w}{g}$ = line density of cable.
$w$ = weight of cable in kg. per metre run.
$g$ = acceleration of gravity.
E = Young's Modulus.
I = second moment of cross-section.
$l$ = length of span in metres.

Write

$$c^2 = \frac{T}{\rho} \quad \text{and} \quad k^2 = \frac{E\,I}{\rho},$$

If the cable under consideration is of aluminium with a steel core, let

$E_a$ = modulus of elasticity for aluminium.
$E_s$ = modulus of elasticity for steel.

Since $E_s \simeq 3{\cdot}3\,E_a$, the effective second moment $I_r$ is

$$I_r = I_a + 3{\cdot}3\,I_s,$$

where $I_a$ and $I_s$ are the second moments of the aluminium and steel parts of the cable, respectively.

$Ty_1$ = bending moment at $a$ due to tangential eccentricity. Let $d_a$ = diameter of individual aluminium strands. It may be shown that the ordinate of the elastic line at $x$, in the neighbourhood of $a$, is

$$y = \frac{g\,l}{2\,c^2}\left(\frac{l}{2} - x\right) + \frac{g\,l\,k}{2\,c^3}\left[e^{-\frac{c}{k}\left(\frac{l}{2}-x\right)}\right] - 1, \quad (1)$$

approximately, and that the curvature at the same point is, approximately

$$\frac{d^2y}{dx^2} = \frac{g\,l}{2\,c\,k}\left[-\frac{2\,k}{c\,l} + e^{-\frac{c}{k}\left(\frac{l}{2}-x\right)}\right]. \quad . \quad (2)$$

The second equation shows that the curvature is zero when

$$\frac{l}{2} - x = \frac{k}{c}\log\frac{c\,l}{2\,k}, \quad . \quad . \quad . \quad (3)$$

an equation which determines the position of the point of inflection, $i$.

The curvature at the point of support, $a$, is $\frac{T\,y_1}{E_a\,I_r}$.

The bending stress $p$, at any point, is $p_a = \frac{E_a\,d_a}{2\,R}$, for aluminium wires, and $p_s = \frac{E_s}{E_a}\,p_a$, for steel wires, where R is the local radius of curvature determined from equation (2). If, for instance, the total permissible stress in a cable is 14 kg. per square millimetre and the vibrational stresses can be deemed equivalent to a static stress of 2 kg. per square millimetre (the value obtained in practical tests has been found to lie between 1 and 2 kg. per square millimetre), 12 kg. per square millimetre will be left for other stresses. These may be distributed so as to make the tension and bending stresses each 6 kg. per square millimetre, but, in order to provide an adequate margin of safety, the maximum allowable bending stress has been fixed at 3 kg. per square millimetre. The minimum permissible radius of curvature, $R_m$, of the cable slot in the holder, therefore, may be determined from the equation $p_a = \frac{E_a\,d_a}{2\,R_m}$, with the appropriate value of $p_a$ inserted.

The curves shown in Fig. 3, page 61, can now be plotted. Curve (2) is for ice-covered and curve (3) for ice-free cables. The corresponding bending-stress curves are shown below the others. As the slot of the cable-holder is designed to prevent the bending stress in the cable between the points of inflection, $i$, on either side of the bearing surface exceeding a given value, this maximum value is represented by line (4). The lines (5) and (6) then give the corresponding points $x_5$ and $x_6$ on the curves (2) and (3), from which points the maximum bending stress on the naturally curving cable dwindles to zero at the points of inflection. The slope of the cable at the points $x_5$ and $x_6$ can be determined from equation (2). The curve (1), in Fig. 3, corresponding to the bearing surface of the cable-holder, is plotted with the minimum radius $R_m$. The slopes of the cable at points $x_5$ and

$x_6$ are now transferred to the corresponding points of tangency $t_5$ and $t_6$ on curve (1), which indicate how far the cable slot must extend from the centre *a* of the holder to prevent the bending stress in the cable before the points of inflection from exceeding its value in the cable slot.

The cable-holder should, when convenient, be made at least as long as would be required for an ice-covered cable. The cable will then fit snugly into the slot, which is advantageous from the point of view of vibrations. The vibrations may, if desired, be damped down still more, by lining the cable slot, especially its ends, with soft material. Practical tests have shown that the vibration-damping power of the improved cable-holder is at least as great as that of the armouring used with the earlier forms of holder. The vibrations extend only a short distance into the cable slot and are almost entirely absent in the region of its centre. The only effect of the vibrations is to make the cable roll to and fro at the ends of the holder, and this motion is unlikely to produce any significant wear, as only a faint sound is audible close to the place of rolling.

The calculations can frequently be made more simply than by the method outlined above. The sag, $h$, of the cable can be determined with the aid of diagrams or some equivalent method. When the sag is known, the slope of the cable, $\phi$, at its points of inflection, can be determined from the approximate formula, $\tan \phi = \frac{4h}{l}$ (see Fig. 4, opposite). If the cable holders are at different levels, as in Fig. 5, $\tan \phi_1 = \frac{2f}{g}$, $(f = d - e)$ and $\tan \phi_2 = \frac{2k}{n}$, are determined, and the mean slope of the cable at the holders will be $\overline{\phi} = \frac{\phi_1 + \phi_2}{2}$. The angle $\phi$ will then correspond to the above-mentioned $\phi$. The minimum allowable radius of the slot of the holder is determined in the same way as before. The requisite length, L, of the slot is then approximately $L = 2\,R \sin \phi$ if the slot is circular. The first requirement in designing a cable holder is accordingly a line profile, which is best plotted for an ice-covered cable. From this, the values of $\phi$ at each support can be obtained. The problem is complicated if there is a bend in the line, but can be solved easily. A few types of holder generally suffice for all the supports of a line and layouts are possible in which one type of holder suffices for the whole line. Typical examples are illustrated in the photographs reproduced as Figs. 6 and 7, opposite. Attention should be paid to the treatment of the cables in the process of suspending them. Instead of the single pulleys usually employed for hoisting the cables, a bridge consisting of several pulleys, as shown in Fig. 8, should be used. The question of the cable drums comes before that of these pulleys, and their internal diameter should be large enough for the cable not to be bent beyond the limit of proportionality.

The new cable holder designed by the Svenska Aluminiumkompaniet has been tested as to its ability to carry the weight of the cable. The holders were usually deformed, without breaking, at double the breaking strain of the corresponding cables. The ability of the holders to withstand unilateral drag on the cable, which corresponds most closely to conditions when a cable breaks, has also been tested. In this respect, also, very satisfactory results have been obtained. Cable stresses at, and after, cable breakages have been investigated by practical tests in the United States.

Large numbers of the new clamps have already been installed on transmission lines in Sweden, Norway and Finland. It is advantageous to use clamps made of non-magnetic material as, otherwise, there may be appreciable hysteresis loses at the supports. For this reason, the holders are normally made of chill-cast Silumin, a silicon-aluminium alloy, but they can be manu factured from other materials.

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WORLD METALLURGICAL CONGRESS.—A World Metallurgical Congress, organised by the American Society of Metals, w ll be held in Detroit, Michigan, U.S.A., from October 14 to 19. Some 500 delegates from 20 countries are to take part. The director-general of the Congress is Dr. Zay Jeffries, and further information may be obtained from Mr. W. E. Eisenman, American Society for Metals, 7301, Euclid-avenue, Cleveland, Ohio, U.S.A.

UNITED KINGDOM PRODUCTION OF PIG IRON AND STEEL.—Statistics issued by the British Iron and Steel Federation, Steel House, Tothill-street, London, S.W.1, show that the production of steel ingots and castings during June was at an annual rate of 16,007,000 tons, compared with 15,864,000 tons in May, and 16,249,000 tons in June, 1950. The autput of pig iron was at an annual rate of 9,497,000 tons, compared with 9,482,000 tons in May and 9,474,000 tons in June, 1950.

## ANNUAL CONVENTION OF THE BRITISH INSTITUTION OF RADIO ENGINEERS.

THE third Radio Convention, which has been organised by the British Institution of Radio Engineers, opened at University College, London, on Tuesday, July 3, and continued until Friday, July 6. At the opening meeting the general subject was "Electronic Instrumentation in Nucleonics," and the chairman (Dr. D. Taylor) gave an address in which he described the radiation and particle detectors used in modern instruments. These could be classified under the headings of integrating systems, counting systems, ratemeter systems and systems in which the mean current through the detector was measured. The long-term stability of the radiation and particle detectors used in assay instruments was considered and the relative advantages of Geiger-Müller counters, proportional counters and scintillation counters were discussed. Finally, the problem of industrial instrumentation, in which high reliability was of the first importance, was reviewed.

A paper on a "$\beta$-Ray Thickness Gauge for Industrial Use" was then presented by Mr. K. Fearnside, who reviewed the methods of using $\beta$-particles for measuring the thickness or weight per unit area of sheet or strip material. In one of the methods the radioactive source was placed on one side of the sheet and the detector on the other. The variation in $\beta$-particle transmission through the material was then approximately proportional to the weight per square centimetre of the interposed material and the output of the detector was applied to a meter to read this quantity directly. The characteristics of the radioactive source and the choice of the detector element in relation to the design of thickness gauges were discussed and, as an example of the techniques employed, a description was given of a $\beta$-ray thickness gauge, in which a double ionisation chamber and direct-current amplifier was used. Finally, the back-scattering and transmission methods of measurement were compared.

The concluding paper at Tuesday's meeting was by Dr. J. E. Johnston on "The Use of Radioactive Tracers in Industry." As a result of the large quantities now being produced in atomic piles isotopes of a wide variety of elements were being employed for an increased range of industrial purposes. For instance, radioactive tracers could be used to measure minute quantities of impurities in metals; the wear in extrusion dies and piston rings; and the content and rate of production of metal in electrolytic furnaces. Moreover, they could be employed to check the uniformity of the mixing of ingredients in animal foods; to detect the mixing of various grades of oil sent one after another over long distances in pipe lines; to trace the sources of water pollution; to study ventilation systems; to locate leaks in underground cables; and to measure the rate of wear of blast-furnace linings.

At the meeting on Wednesday morning, July 4, a paper on "Self-Balancing Recording Instruments and Their Application to Nucleonic Measurement" was read by Messrs. W. A. Kealy and R. E. Medlock. In this the authors briefly described the general principles of operation of both mechanical and electronic self-balancing recording instruments and their application to the measurement of temperatures and radioactivity in atomic energy plants. The versatility of self-balancing recording instruments was illustrated by examples of circuits which permitted simple addition, subtraction, multiplication, division, roots and powers and derivatives and integrals to be dealt with. Several arrangements in which combinations of these circuits could be used to solve problems associated with nucleonic projects were also described.

At the meeting on Wednesday afternoon, Mr. E. H. Cooke-Yarborough presented a paper on "The Counting of Random Pulses," in which various possible electronic and electro-mechanical methods of measuring the mean rate of such pulses were described. In particular, the means of measuring the duration of the counting period and automatically terminating the count at an appropriate point were dealt with. This paper was followed by one by Messrs. J. Hardwick and E. Franklin on "The Design of Portable $\beta$- and $\gamma$-Radiation Measuring Instruments." The principal considerations that enter into the design of the air ionisation chamber or Geiger-Müller counter, which were used in portable instruments for detecting or measuring nuclear radiation, were described and the methods which have been used, and were being investigated, to achieve optimum performance with reliability were discussed. In ionisation-chamber instruments the main factors which had to be considered were the characteristics of the electrometer valves, the high-value resistors and the selection of insulating materials suitable for dealing with very small currents. The ionisation chambers themselves must also be designed with the correct radiation characteristics.

In the Geiger-Müller counter the problem of providing a stable source of high voltage had been eased to some extent by the development of an instrument operating at 300 to 400 volts, instead of at the usual 1,000 to 1,500 volts. Power supplies, using cold-cathode valves and selenium rectifiers, could also be made to give a stable output voltage over a wide range of battery voltage. The short shelf life of miniature high-voltage batteries was, however, still a problem; and the possibility of replacing them by a spring-driven generator was being investigated. Cold-cathode valves were preferable to filament valves, owing to their reliability and robustness.

The final paper on Wednesday afternoon was by Mr. F. Wells, on "Pulse Circuits for the Millimicrosecond Range." In this a review was given of the circuit techniques used in measurements on short pulses and the time intervals between pulses in the range $10^{-9}$ to $10^{-7}$ second with particular reference to nuclear physics measurements. The circuit described in the paper had been developed for work with scintillation counters and spark counters; and included shaping circuits, pulse generators, amplifiers, scalers and recording oscillators. Examples of the use of these circuits for high-speed coincidence measurements, millimicrosecond time-interval measurements, and fast counting, were given.

On Thursday, July 5, a further meeting was held at University College, at which the subject of "Valve Technology and Manufacture" was dealt with in five papers. In opening the proceedings the chairman (Mr. J. W. Ridgeway), briefly reviewed the problems of valve manufacture and standardisation and dealt with the questions of staff training and research in relation to progress in the communications and industrial electronics fields.

A paper on "Triode Amplifiers in the Frequency Range 100 Megacycles to 450 Megacycles per Second," was then presented by Mr. D. C. Rogers, in which he pointed out that there were very few valves available for use in this range, owing to the concentration of effort during the war years on those suitable for decimetric wavelengths. This state of affairs was particularly noticeable in the case of small transmitting amplifiers. Exceptions were the expensive all-glass "disc-seal" or "lighthouse" types. It had, however, been found possible, by careful attention to the geometry of electrodes and leads, to design triode valves capable of operation at frequencies up to 450 megacycles in grounded-grid circuits. These were mounted on conventional pressed-glass bases and used only the recognised techniques of receiving-valve manufacture. The features in the design of such valves and the results obtained with various special types were outlined.

A paper on "Aluminium-Backed Screens for Cathode-Ray Tubes," was next read by Mr. R. W. Dudding. This included a summary of the advances made in the design of cathode-ray tubes, including, in particular, a description of the "all-magnetic" (electromagnetic) tube for use in television. The methods of preventing "ion-burn" screen blemish, including the ion-trap and metal backings to the screen phosphor, were also detailed. The reasons why aluminium was chosen for the metal film were stated and the methods of forming the necessary sub-layer between the phosphor screen and the aluminium, and of depositing the latter were described. A description was also given of an electronic instrument which had been designed for performing the important function of measuring and controlling the thickness of the aluminium film during deposition.

In a paper on "Dynamic Measurements on Receiving Valves," Mr. A. J. Heins van der Ven said that it was usual, in order to maintain a constant product, to subject all valves to a limited number of measurements at the end of the manufacturing process. A small percentage of the production was also subjected to a much larger number of tests to ensure that the characteristic data remained at the correct level. These measurements usually covered such items as $I_a$-$V_g$ characteristic slope, internal resistance, leakages and capacities. It was however often useful to supplement these static measurements by checks on such dynamic properties as hum, noise, cross modulation and power output. The loss of valuable information about the trend of production, which arose from the impracticability of subjecting large numbers of valves to the more complicated measurements, could be overcome by employing direct-reading measuring equipment, three types of which were described.

A paper by Mr. D. A. Wright on "Rare Metals in Electron Tubes" indicated how some difficulties in the manufacture of these tubes could be overcome by the employment of rare metals. Such applications included electrodes for high temperatures; the improvement of vacuum by the use of getters; the production of high thermionic, secondary and photo-emission; the reduction of electron emission from grids; and the use of rare metals in brazing and soldering.

In "A Survey of Quality and Reliability Standards

in Electronic Valves for Service Equipment," Mr. G. L. Hunt described the principles underlying the procedure and methods adopted to obtain a supply of satisfactory valves. The widening of the field of application of the electronic valve, the growing complexity of modern Service equipment and the conditions of shock and vibration which had to be withstood were also discussed. The need for greater reliability was examined and an indication given of the very low failure rate it was necessary to achieve.

At a meeting on Friday, July 6, which was held at University College and over which Mr J. W. Ridgeway also presided, a paper on " The Production of Miniature Valves in France " was presented by Mr. M. Martinoff and illustrated by a colour film. The manufacture of the component parts and the electrode structure was described, as well as the methods of sealing and pumping, treatment after evacuation and final testing.

In a second paper, " The Application of Image Converters to High-Speed Photography " was dealt with by Messrs. J. A. Jenkins and R. A. Chippendale, in which the performance of various types of these instruments was compared; while in a third, by Messrs. D. Latham and B. D. Power, on " Vacuum Technique," the authors surveyed the methods of producing and measuring high vacua, especially in connection with the manufacture of electronic tubes. Methods of making vacuum joints and of detecting leaks were described and various vacuum processes of interest to the electronic industry were discussed.

The final paper was on " Line Scanning Valves and Circuits," and in this the authors, Messrs. B. Eastwood and C. C. Vodden, pointed out that the trend towards higher operating voltages and wider scanning angles in cathode-ray tube design had necessitated the development of high-efficiency scanning circuits, in order that the advantages of these tubes might be obtained without unduly high power consumption. This economy had been effected by making use of the resonant return type of time base, which recovered a part of the energy stored in the deflection field at the end of each line. The requirements of scanning valves arising from these circuits were discussed. Generally speaking, pentodes had to withstand high anode voltage for a fraction of the cycle with the cathode current cut off, while diodes had to withstand a high inverse peak voltage and should have a low forward impedance. The insulation properties of valves had been investigated under these conditions; and valves using all-mica insulation had been rated at 6 kV on the anode.

## TRADE PUBLICATIONS.

*Private Automatic Dial Telephone Systems.*—Details of the equipment used in their private automatic telephone dial system are given in a leaflet received from Automatic Telephone and Electric Co., Ltd., Strowger Works, Liverpool, 7.

*Outdoor Oil Circuit Breakers.*—The English Electric Co., Ltd., Queen's House, Kingsway, London, W.C.2, have sent us a leaflet dealing with their OKD1B oil circuit breakers which have been designed for rupturing capacities up to 1,000 MVA at 33 kV.

*Square-Hole Broaches.*—W. H. Marley & Co., Ltd., 105, High-road, London, N.11, have issued a leaflet on their new range of square push broaches, which are made of high-speed steel. A round hole is first drilled and reamed in the workpiece, and then one pass of a broach is sufficient to form a square hole. The broaches are made in eight sizes, namely, $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$, $\frac{7}{16}$, $\frac{1}{2}$, $\frac{9}{16}$, $\frac{5}{8}$ and $\frac{3}{4}$ in.

*Ripple Switching-Control Systems.*—A pamphlet, received from Automatic Telephone and Electric Co., Ltd., Strowger Works, Liverpool, 7, describes how the signal availability of their well-known " Rhythmatic " ripple control system can be increased by transmitting two signals instead of one for each remote switching operation and using relays with two selective units instead of one at each switching point.

*Diesel Engines.*—A pamphlet prepared by the National Gas and Oil Engine Co., Ltd., Ashton-under-Lyne, Lancashire, gives a general specification of their AH1-type Diesel engine—a cold-starting horizontal water-cooled totally-enclosed compression-ignition engine which is rated at 3, 4 or 5 b.h.p. Issue No. 284 of *The National Bulletin* contains two articles on the use of the firm's Diesel engines for driving alternators in a sugar mill and a mine in South Africa.

*50-Cycle Alternating-Current Traction.*—A detailed description of the 4,300-h.p. locomotive and the 1,560-h.p. suburban motor-coach which have been built for the Société Nationale des Chemins de Fer Français and are designed for operation on the single-phase alternating-current system at 20 kV and 50 cycles is given in a pamphlet published by Ateliers de Construction Oerlikon, Oerlikon, Switzerland. The reasons for the adoption of this system are explained, and an account of its characteristic features is given.

## THE "ROTAVISOR" FILM-LOOP PROJECTOR.

THE " Rotavisor " diascope which is now being manufactured by Messrs. Newton and Company, Limited, 72, Wigmore-street, London, W.1, has been designed as a self-contained fully-automatic film-loop which can be used under daylight conditions where a supply of electricity is available. In both the table and console form it is therefore a convenient means of demonstrating to small groups of people processes that can be recorded on 35-mm. film.

The projector of the " Rotavisor " is a standard Newton " Lightmaster " diascope which is equipped with an electric motor and a 250-watt high-pressure mercury lamp having a life of about 500 hours. The light from this lamp illuminates the film, the image being thrown on to a 10-in. by 8-in. screen. The film is in the form of a loop and the mechanism controlling its motion is normally set so that each frame is projected for a period of 12 seconds before the one succeeding it is moved into position. This timing can, however, be varied within certain limits and the mechanism can also be halted to allow for the examination of any individual picture. Normal operation is entirely automatic. Loops of up to 80 frames can be accommodated in the standard machine, but loop absorbers can be fitted when a larger number of frames is necessary.

## BOOKS RECEIVED.

*An Introduction to the Theory of Control in Mechanical Engineering.* By R. H. MACMILLAN. Cambridge University Press, Bentley House, 200, Euston-road, London, N.W.1. [Price 30*s.* net.]

*Polyphase Commutator Machines.* By B. ADKINS and DR. W. J. GIBBS. Cambridge University Press, Bentley House, 200, Euston-road, London, N.W.1. [Price 21*s.* net.]

*Der Weg zum Atom.* By DR. W. HOLZAPFEL. Verlag G. Braun, Karl-Friedrich-Strasse 14, Karlsruhe, Germany. [Price 9·20 D.M. in cardboard covers, 11·20 D.M. cloth bound.]

*Mitteiungen aus dem Institut für angewandte Mathematik an der eidgenössischen technischen Hochschule in Zürich.* No. 2. *Programmesteuerte digitale Rechengeräte (elektronische Rechenmaschinen).* By HEINZ RUTISHAUSER, AMBROS SPEISER and EDUARD STIEFEL. Verlag Birkhäuser, Basle, Switzerland. [Price 8·50 francs.]

*The Social Survey. Domestic Utilization of Heating Appliances and Expenditures on Fuels in* 1948/49. By LESLIE T. WILKINS. Offices of the Survey, Central Office of Information, Montague Mansions, Block 1, Crawford-street, London, W.1. [Price 15*s.*]

*Wellington Harbour Board, New Zealand. Statement of Accounts with Annual Reports and Other Statistics for the Period Ended 30th September,* 1950. The Secretary, Wellington Harbour Board, Wellington, New Zealand.

*Annual Report of the Governor of the Panama Canal for the Fiscal Year* 1950. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 40 cents.]

*United States Coast and Geodetic Survey. Annual Report of the Director of the Coast and Geodetic Survey for the Fiscal Year Ended June* 30, 1950. U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 25 cents.]

*United States National Bureau of Standards.* Miscellaneous Publication No. 197. *Fire Tests of Bulb-Type Carbon-Tetrachloride Fire Extinguishers.* By O. J. HODGE. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 10 cents.]

*The British Electrical and Allied Industries Research Association.* Technical Report No. G/T 234. *Gas-Blast Circuit-Breakers. Aerodynamic Conditions in Nozzle as Affected by Arcing and Nozzle Diameter.* By A. M. CASSIE and A. A. HUDSON. [Price 12*s.*] No. G/T 239. *Restriking Voltage in British* 66-*kV Networks.* By L. GOSLAND and J. S. VOSPER. [Price 7*s.* 6*d.*] No. G/T 250. *The Maximum Energy Dissipated During First Current Loops of Different Asymmetry on Closing an A.C. Series Circuit.* By H. GOLDENBERG. [Price 6*s.*]. No. IB/T5. *Some Notes on the Design, Testing and Performance of an All-Electric In-Sack Grain Dryer.* [Price 2*s.* 6*d.*] No. L/T 256. *The Development of a Vacuum Torsion Balance and its Use to Measure Sorption in Dielectrics.* By A. G. DAY. [Price 12*s.*] No. W/T 21. *Electrode Soil Sterilizing. (Preliminary Report.)* By A. E. CANHAM. [Price 9*s.*] Offices of the Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey.

*Plant Layout. Planning and Practice.* By RANDOLPH W. MALLICK and ARMAND T. GAUDREAU. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 7·50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 60*s.* net.]

*The British Shipbuilding Research Association.* Report No. 17. *Simplified Heat Transfer Data for Design Calculations.* Part I. By G. BROWN, DR. M. FISHENDEN, and DR. O. A. SAUNDERS. No. 54. *Simplified Heat Transfer Data for Design Calculations.* Part II. By J. E. BACON, DR. M. FISHENDEN, and DR. O. A. SAUNDERS. No. 27. *A Survey of Present Methods of Superheat Control.* By LIEUT.-COMMANDER (E.) J. E. J. NOTTIDGE, R.N. (Ret.). No. 38. *Engine Running-Gear Bolts—Periodical Heat Treatment, Renewal or Inspection.* By B. TAYLOR and R. COOK. No. 56. *Comparisons of Convective and Radiant Methods of Heating.* By DR. T. BEDFORD and DR. M. FISHENDEN. No. 63. *Effective Modulus of Elasticity for Wire Ropes. Survey of Published Information.* By W. OSSOWSKI. Offices of the Association, 5, Chesterfield-gardens, Curzon-street, London, W.1. [Gratis.]

*Some Aspects of Fluid Flow.* Papers presented at a Conference organized by the Institute of Physics at Leamington Spa on October, 25 to 28 1950, and the reports of the Conference Discussion Groups. Edward Arnold and Company, 41, Maddox-street, London, W.1. [Price 50*s.* net.]

*Electric Circuits for Engineers.* By PROFESSOR EDWARD K. KRAYBILL. The Macmillan Company, 60-62, Fifth-avenue, New York II, U.S.A. [Price 3·85 dols.]; and Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 30*s.* net.]

*Servomechanisms and Regulating System Design.* Volume I. By HAROLD CHESTNUT and ROBERT W. MAYER. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 7·75 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 62*s.* net.]

*The Action of Cutting Tools.* By A. J. CHISHOLM, J. M. LICKLEY, and J. P. BROWN. Machinery's Yellow Back Series No. 31. The Machinery Publishing Company, Limited, National House, West-street, Brighton, 1. [Price 3*s.* 6*d.*]

*Cutting-Tool Materials.* By ERIC N. SYMONS. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 21*s.* net.]

*Compressed Air in Mining and Industry.* By SYDNEY H. NORTH. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 18*s.* net.]

*Pneumatic Grain Conveying with Special Reference to Agricultural Application.* By PROFESSOR G. SEGLER. The National Institute of Agricultural Engineering, Wrest Park, Silsoe, Bedfordshire. [Price 30*s.*]

*Der Werdegang eines Ingenieurs.* By E. ROSENBERG. Springer-Verlag, Mölkerbastei 5, Vienna 1, Austria. [Price 17*s.*]

*Technische Thermodynamik.* By PROFESSOR ANTON PISCHINGER. Springer-Verlag, Mölkerbastei 5, Vienna 1, Austria. [Price 34*s.*]

*Jahrbuch der Hafenbautechnischen Gesellschaft.* 19th volume, 1941-1949. Springer-Verlag, Reichpietschufer 20, Berlin W.35, Germany. [Price 40 D.M.]

*Beton-Kalendar,* 1951. In two volumes. Fortieth Year. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany. [Price 16 D.M.]; and Lange, Maxwell and Springer, Limited, 41-45, Neal-street, London, W.C.2. [Price 28*s.*]

*Central African Council. Report on Kariba Gorge and Kafue River Hydro-Electric Projects.* By the Inter-Territorial Hydro-Electric Power Commission. Offices of the Commission, Salisbury, Southern Rhodesia; and the Crown Agents for the Colonies, 4, Millbank, London, S.W.1. [Price 63*s.*]

*The British Coal Utilisation Research Association. Annual Report,* 1950. Offices of the Association, Randalls-road, Leatherhead, Surrey.

*Report on the Work of the Tin Research Institute,* 1950. Offices of the Institute, Fraser-road, Greenford, Middlesex.

*Productivity Team Report. Valves, Steel, Iron and Non-Ferrous.* Report of a visit to the U.S.A. in 1950 of a Productivity Team representing the Valve Industry. Anglo-American Council on Productivity, 21, Tothill-street, London, S.W.1. [Price 3*s.* 6*d.* post free.]

*Boiler Explosions Acts,* 1882 *and* 1890. *Report of Preliminary Inquiry.* (No. 3356.) *Explosion from Three Steam-Heated Drying Cylinders at the Premises of Messrs. Century Dyeworks, Limited, Elland, Yorkshire.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 6*d.* net.]

*Engineering College Research Council of the American Society for Engineering Education. Review of Current Research and Directory of Member Institutions,* 1951. The Secretary of the Council, Room 7-204, 77, Massachusetts-avenue, Cambridge 39, Massachusetts, U.S.A. [Price 2·25 dols.]

*Department of Scientific and Industrial Research.* Road Research Technical Paper No. 22. *Bituminous Roads in North America. Research and Construction.* By DR. A. R. LEE. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* 6*d.* net.]