THE 28,000-TON TANKERS OF THE ANGLO-SAXON PETROLEUM COMPANY.

The Anglo-Saxon Petroleum Company, Limited, the shipping organisation of the Royal Dutch Shell Group, are evidently more than satisfied with the performance of their new 28,000-ton tankers as already five more of a similar type have been ordered. The first of the new tankers, namely, the Velutina, was launched, it will be recalled, by Her Royal Highness Princess Margaret from the Wallsend-on-Tyne yard of Messrs. Swan, Hunter, and Wigham Richardson, Limited, on April 4, 1950, and ran her trials off the Northumbrian coast in July of the same year. The Velutina was followed by the Verena, built by Messrs. Harland and Wolff, Limited, at their Belfast yard; the Volsella, launched from the Birkenhead yard of Messrs. Cammell Laird and Company, Limited; and the Velletia, launched from the same berth as the Velutina on October 31, and now in the course of being fitted out. As the first three vessels have now completed several round trips, and the last-named will shortly be completed, it would appear to be an opportune time to describe their construction. Before doing so, however, it may be advantageous to refer briefly to the factors which led to the building of such large vessels.

In general, the increase in the size of tankers which has taken place since the war is due very much to the same economic factors that have governed similar trends in other shipping trades. With the present-day high costs of building and operating, transport costs can only be kept at a tolerable level by ensuring the best possible economy in the utilisation of space. It is axiomatic that the larger the ship, the lower is the capital cost for its construction on a deadweight-ton basis, and the same principle applies largely to running costs. In addition, the saving of personnel by the concentration of greater loads in fewer vessels has become a factor of considerable importance, particularly in these days of shortage of both officers and crews. Economic factors have, however, not been the sole cause of this scaling-up of tankers as, during the Second World War, greater carrying capacities allied with higher speeds were deemed necessary to reduce the hazards of surface or submarine attack.

Fig. 1. The "Velutina" Leaving on her Maiden Voyage.

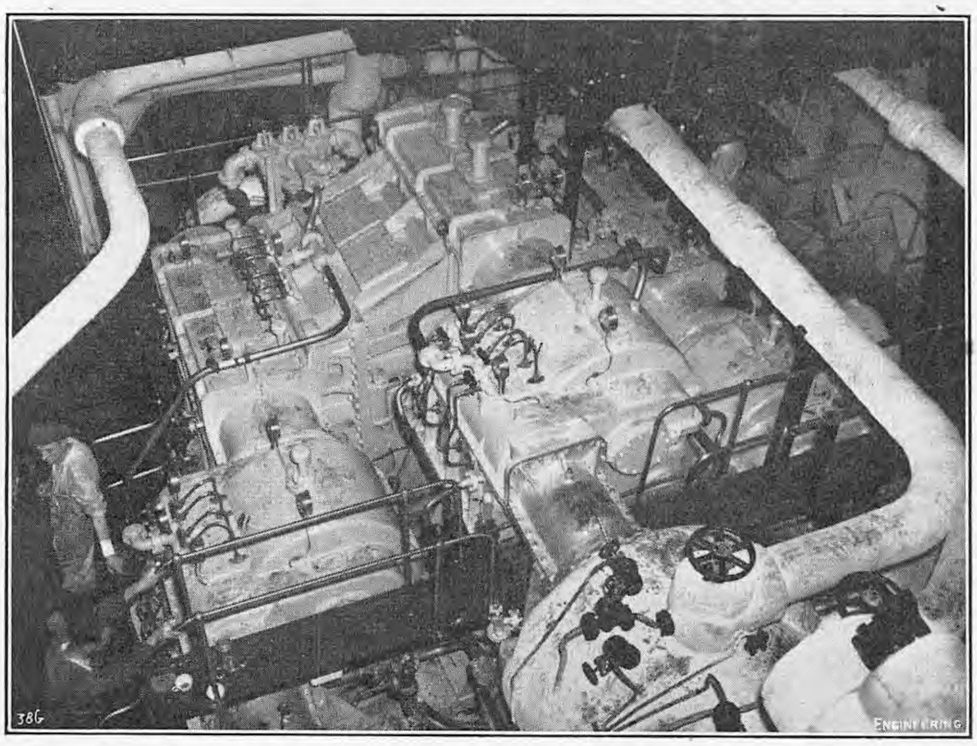


Fig. 2. Reduction Gearing of "Velutina."

It may well be argued, of course, that if the large tanker is so much better then why are so many of the medium size still being built? The short answer here is that only a very few of the loading and discharging ports are capable of accommodating these large vessels, with their greater length and loaded draught, or are equipped with the necessary loading, unloading and storage facilities to permit a quick turn-round. For the present, therefore, the new large tankers will be confined to serving the specific purposes for which they were designed and will sail only on those routes where there is a large concentration of trade and between those ports where adequate arrangements exist for docking and discharging and storing their cargoes. There is little doubt, however, that as the economy of operation of the larger tankers becomes manifest, pressure will be brought to bear on the authorities concerned for the provision of deep-water approaches, suitable berthing arrangements, etc., at other ports primarily concerned with the shipping of oil and oil products. Indeed, tankers up to 50,000-tons deadweight capacity are already considered a practical proposition and may well be on certain selected routes.

The four 28,000-ton tankers under review have been designed primarily for carrying crude oil from the Middle East to the Shell Petroleum Company's refineries at Shell Haven, on the Thames, and at Stanlow, on the Manchester Ship Canal. These refineries are at present being expanded to reach a total throughput capacity of some six million tons a year. The vessels have an average speed of 16 knots; each tanker, therefore, will be able to bring to the United Kingdom about 200,000 tons of oil annually from the Persian Gulf, or about 360,000 tons from the Mediterranean ports, these figures having been estimated on the basis of eight and fourteen round trips per annum, respectively. The four tankers are, of course, sister ships and, although the following description is based largely on the specification for the Velutina, it serves equally well for the other three vessels, which differ only in detail.

The general appearance of the tankers will be apparent from the photograph of the Velutina reproduced in Fig. 1, on page 641, and from the profile and deck plans given in Figs. 7 to 10, on Plate XLIII. The principal dimensions are: length, between perpendiculars, 610 ft.; breadth moulded, 80 ft. 6 in.; depth moulded to upper deck, 45 ft.; and the deadweight tonnage about 28,000 on a 34-ft. draught. All vessels have been constructed to the highest class of Lloyd's Register of Shipping for carrying petroleum in bulk, and before the hull form was decided model tests were carried out at the National Physical Laboratory. Construction is on the combined transverse and longitudinal system, two longitudinal and 17 transverse bulkheads dividing the hull into a forepeak and forehold with a deep tank, 11 sets of cargo tanks, and two pump rooms, the after cofferdams, cross-bunkers, wing bunkers and machinery space aft. Fuel is also carried in the double-bottom tanks in way of the engine room and in the deep tank at the forward end of the ship. Welding was adopted for practically the whole of the ship's structure, the main exceptions being the connections of the side frames to the shell plating and the transverse beams to the decks at the ends of the ship.

Allowing 2 per cent. for expansion, the cargo tank capacity is approximately 26,000 tons, this figure being estimated at 50 cub. ft. per ton. The two pump rooms are situated one forward between Nos. 3 and 4 tanks and the other aft between Nos. 7 and 8 tanks. Each room accommodates two horizontal duplex steam pumps manufactured by Messrs. J. P. Hall and Sons, Limited, and designed to operate on saturated steam, the capacity of each pump being approximately 500 tons per hour. They are connected to the company's usual form of ring main comprising 12-in. diameter cast-iron pipes with suctions to the wing and centre tanks. The deck fuel lines include a 6-in. steel pipe-line extending to the forward deep tank with 4-in. diameter branches to each bunker compartment. All fuel-loading connections are situated approximately amidships and valves are provided for isolating the forward and after sections. The deck machinery includes two steam winches, one forward and one aft, supplied by Messrs. John Lynn and Company, Limited, the forward winch is used for operating a derrick as well as for mooring purposes. There are also two capstans fitted aft and a windlass forward, suitable for $2\frac{3}{4}$-in. Tayco cable, all of which were supplied by Messrs. Emerson Walker, Limited.

28,000-TON TANKERS FOR THE SHELL FLEET.

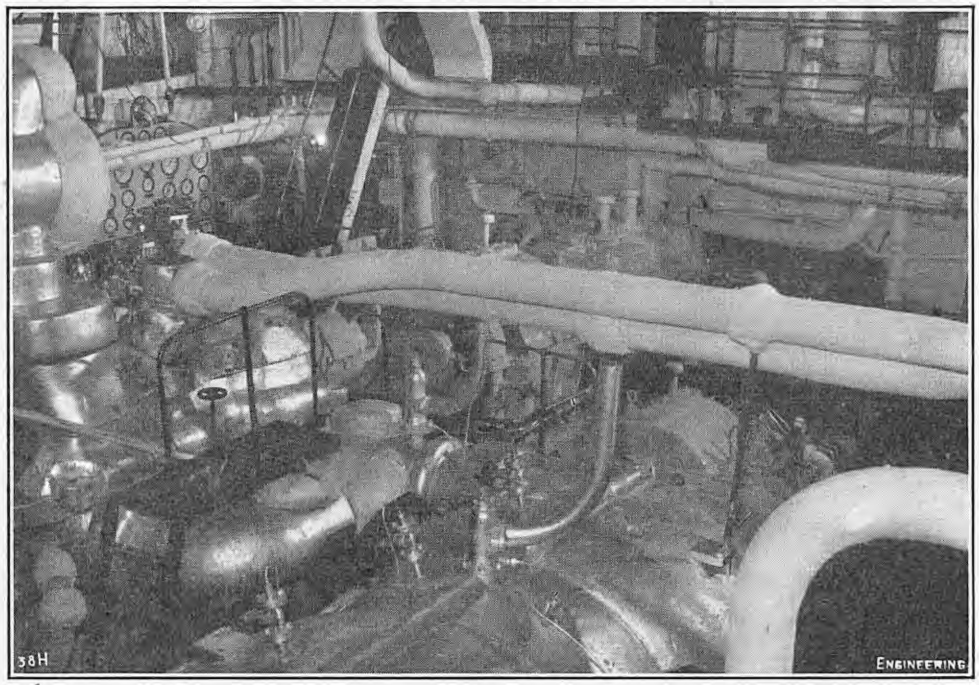


Fig. 3. Main Turbines of the "Verena."

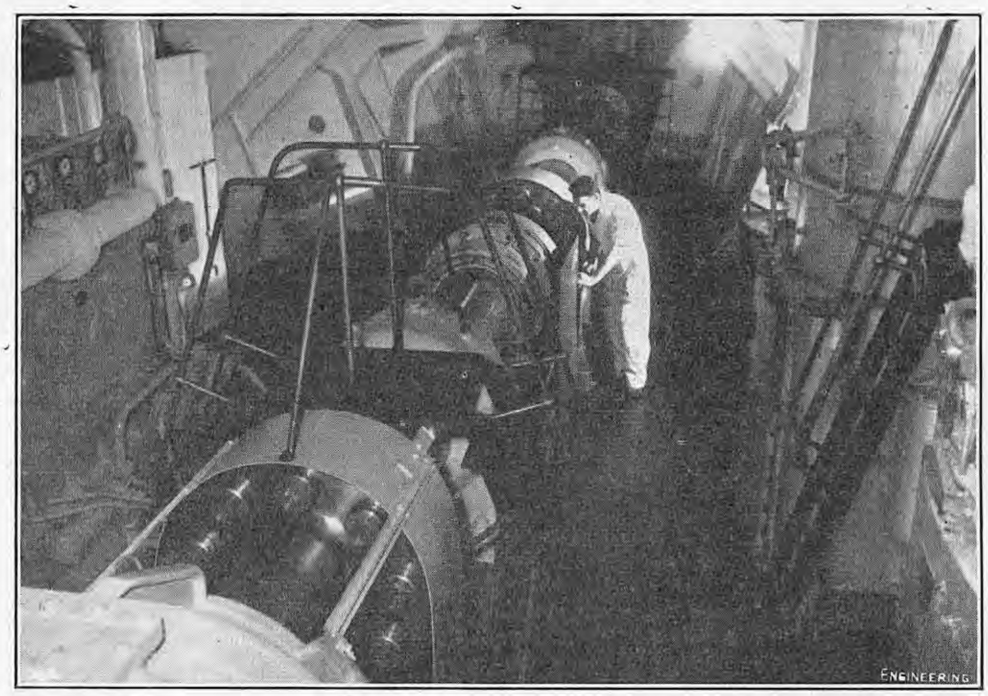


Fig. 4. Main Shafting of the "Verena."

The vessel is propelled by a set of impulse-reaction turbines arranged to turn a single screw through double-reduction gearing and taking steam from three Babcock and Wilcox single-pass boilers. Drawings showing the layout of the machinery spaces, boiler room, etc., are reproduced in Figs. 5 and 6, on Plate XLII, and in Figs. 11 and 12, on Plate XLIV. The turbines, together with their associated reduction gearing, and the boilers, were constructed by the Wallsend Slipway and Engineering Company, Limited, Wallsend-on-Tyne. The vessel has a service speed of 16 knots and the machinery is designed to develop a total service power of 11,000 shaft horse-power when the propeller is rotating at approximately 100 r.p.m.; and a maximum power of 13,000 shaft horse-power for 24 hours continuously when supplied with steam at a pressure of 500 lb. per square inch (gauge) and a temperature of 750 deg. F. At the latter output, the speed of the high-pressure and intermediate-pressure turbines is approximately 3,700 r.p.m., that of the low-pressure turbine about 3,450 r.p.m., and the propeller revolutions approximately 106 per minute. The high-pressure turbine is of the impulse type and the intermediate and low-pressure turbines of the reaction type, the last named being arranged for double flow. The astern turbines are designed to develop 70 per cent. of the maximum ahead power and comprise separate high-pressure and low-pressure impulse turbines incorporated in the intermediate - pressure and low - pressure ahead casings, respectively.

In general, the turbines are of straightforward construction; part of them can be seen, with the associated reduction gearing, in Fig. 2, on page 641, which shows a general view of the Velutina's engine-room. The similarity between the four ships will, perhaps, be apparent from a comparison of this illustration with the photograph reproduced in Fig. 3, on this page, which shows part of the engine-room for the Verena. Cast steel is used for the high-pressure and intermediate-pressure casings and close-grained cast iron for the low-pressure casing. All turbine rotors are machined from steel forgings, suitably heat-treated after forging, and fitted with stainless-steel blading. The high-pressure diaphragms are built from steel with stainless-iron vanes and a similar form of construction is used for the nozzle plates. Radial labyrinth-type glands are fitted to the turbine shafts, and the gland-sealing system incorporates the usual form of evacuating and condensing gear. The main bearings are whitemetal-lined and each turbine is provided with the usual form of Michell thrust block designed to permit easy adjustment of the axial clearances. As previously mentioned, the reduction gearing is of the double-reduction articulated type, each turbine rotor being connected with its corresponding pinion shaft by a flexible claw-type coupling. The primary pinions are manufactured from nickel steel, and the primary gearwheels are of the fabricated type with forged-steel rims welded to combined forged-steel wheel centres and shafts. The main gearwheel is of built-up construction, comprising steel side plates, a forged-steel rim and the shaft bolted together to form a single unit.

The main thrust block is situated immediately aft of the main gearwheel; it is of the Michell type and has bearing pads of gunmetal faced with whitemetal. The shafting is $20\frac{1}{4}$ in. in diameter clear of the bearings and $20\frac{3}{8}$ in. in diameter at the bearings, which are of the Michell type with whitemetal-faced

THE 28,000-TON TANKERS OF THE ANGLO-SAXON PETROLEUM COMPANY.

(*For Description, see Page* 641.)

Fig. 5. SECTION THROUGH ENGINE ROOM AND BOILER ROOM.

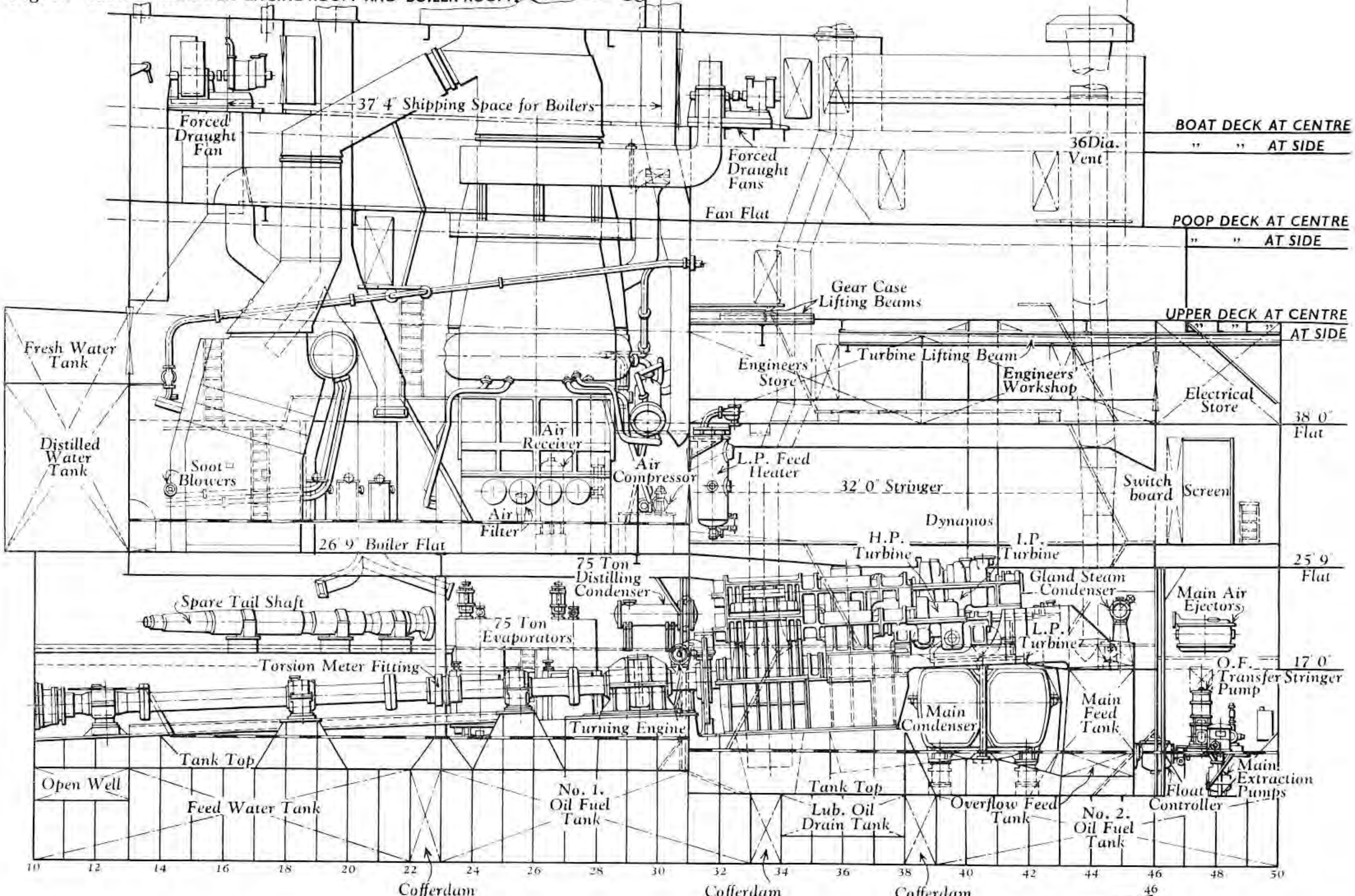
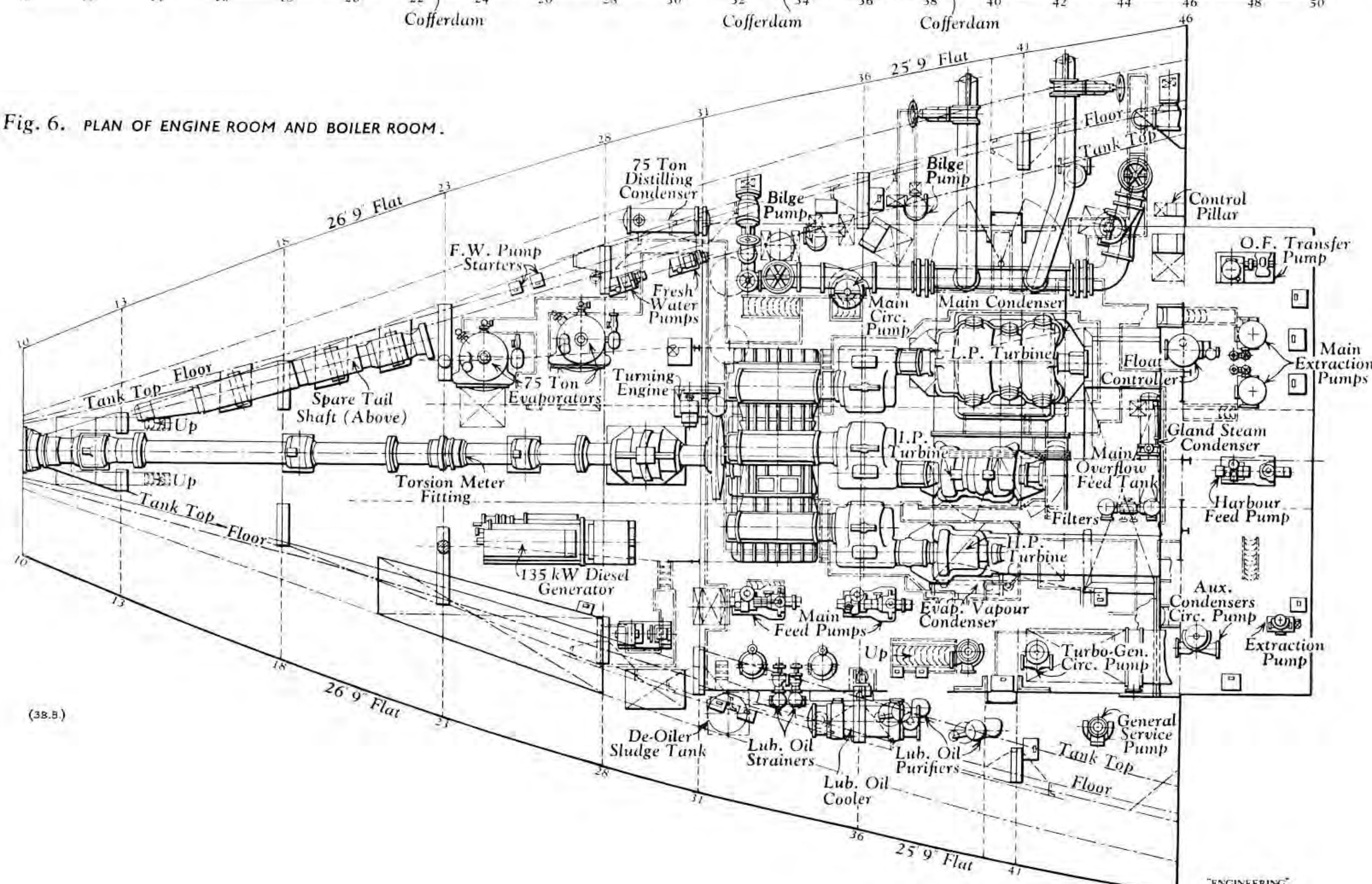


Fig. 6. PLAN OF ENGINE ROOM AND BOILER ROOM.



THE 28,000-TON TANKERS OF THE

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Fig. 7.

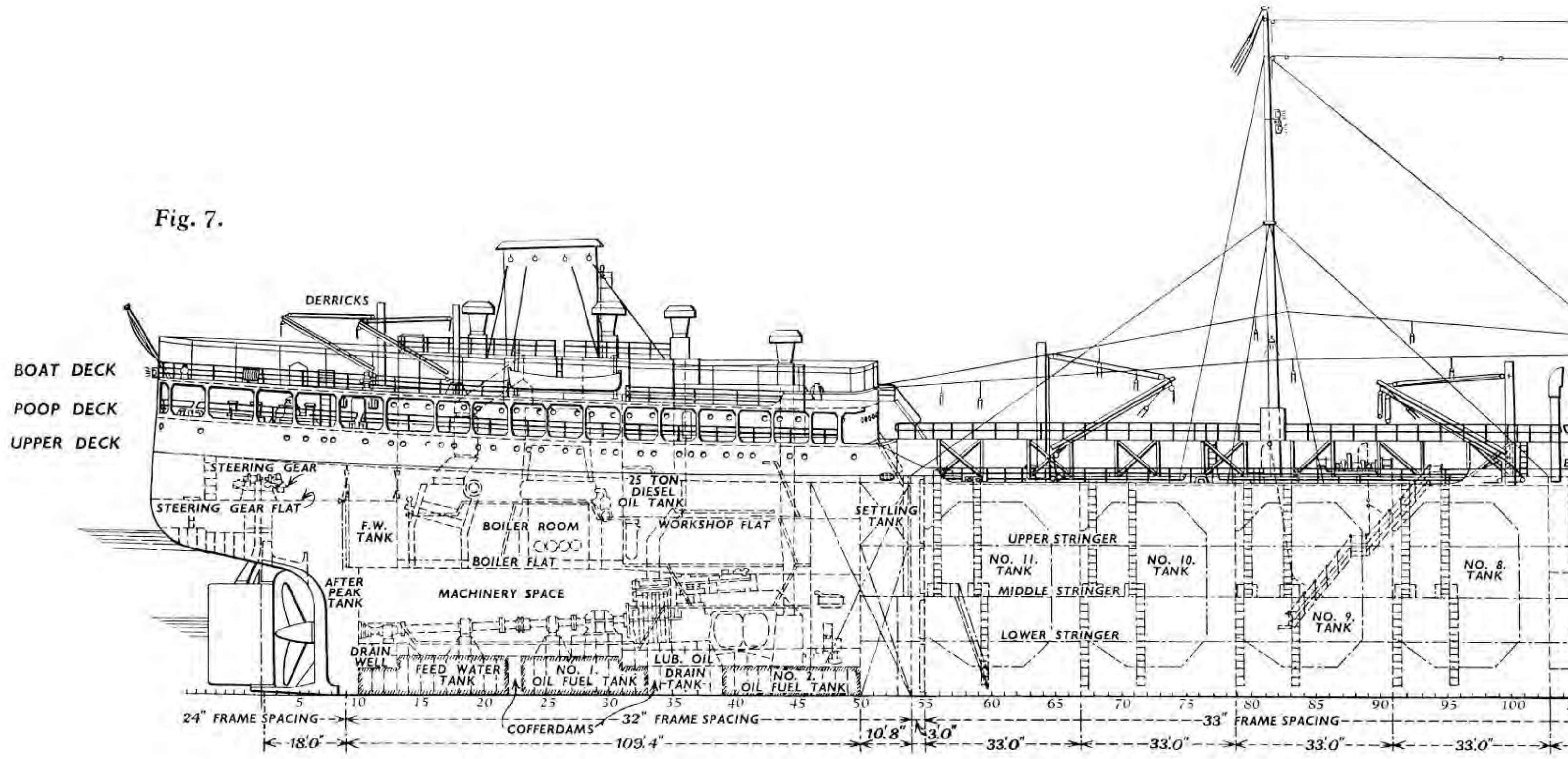


Fig. 8.
POOP DECK.

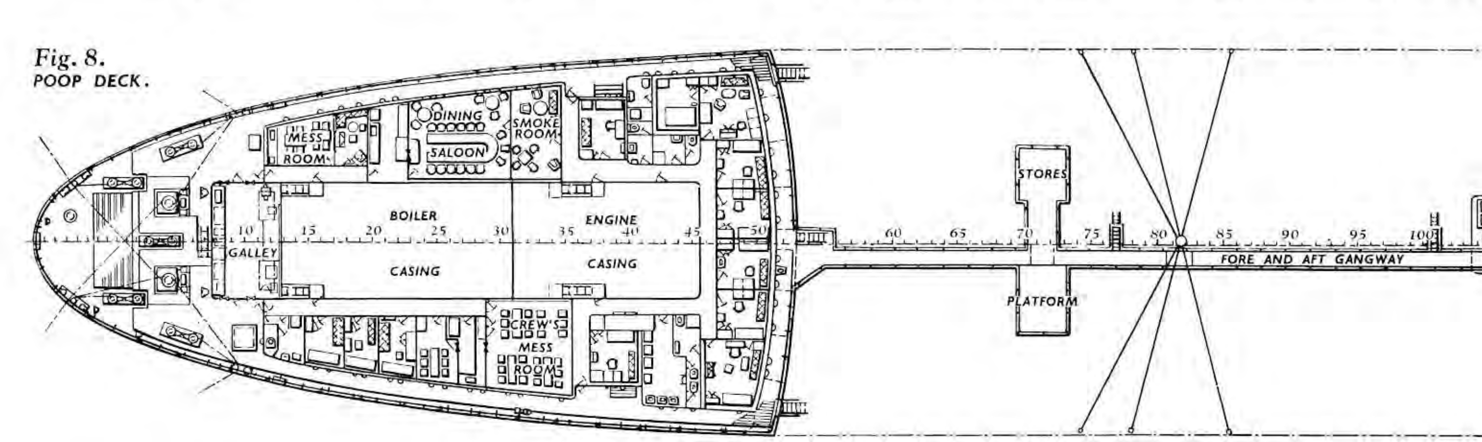


Fig. 9.
BOAT DECK.

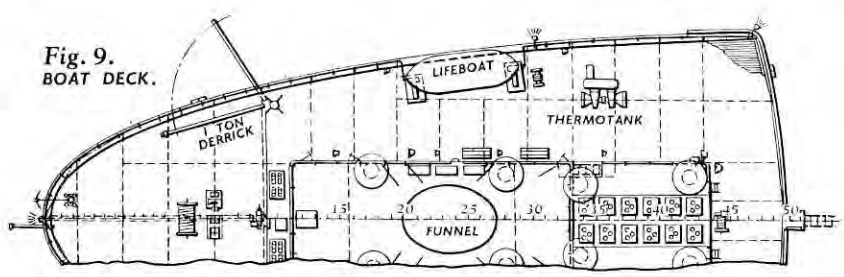
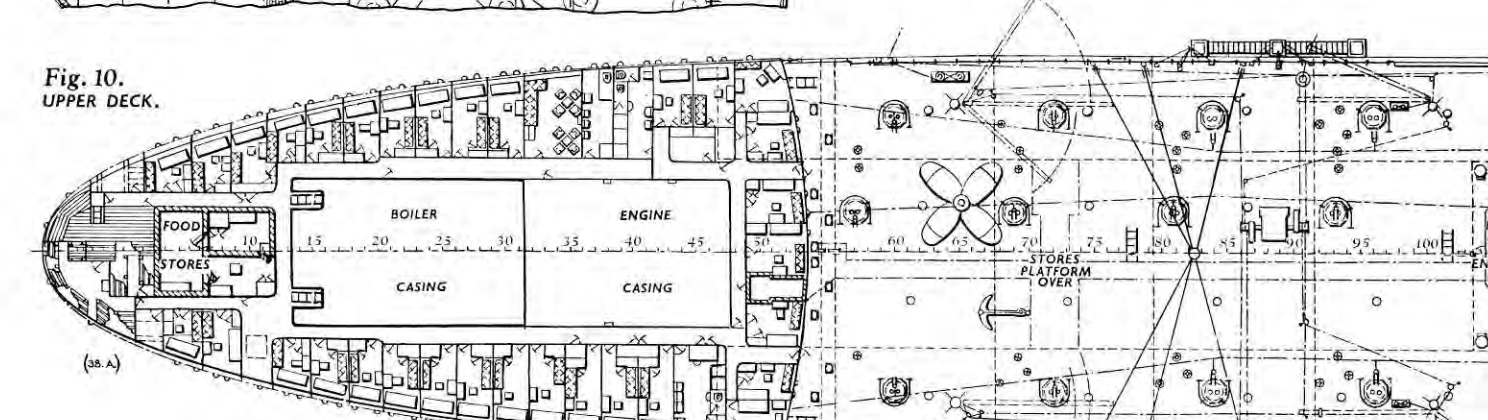
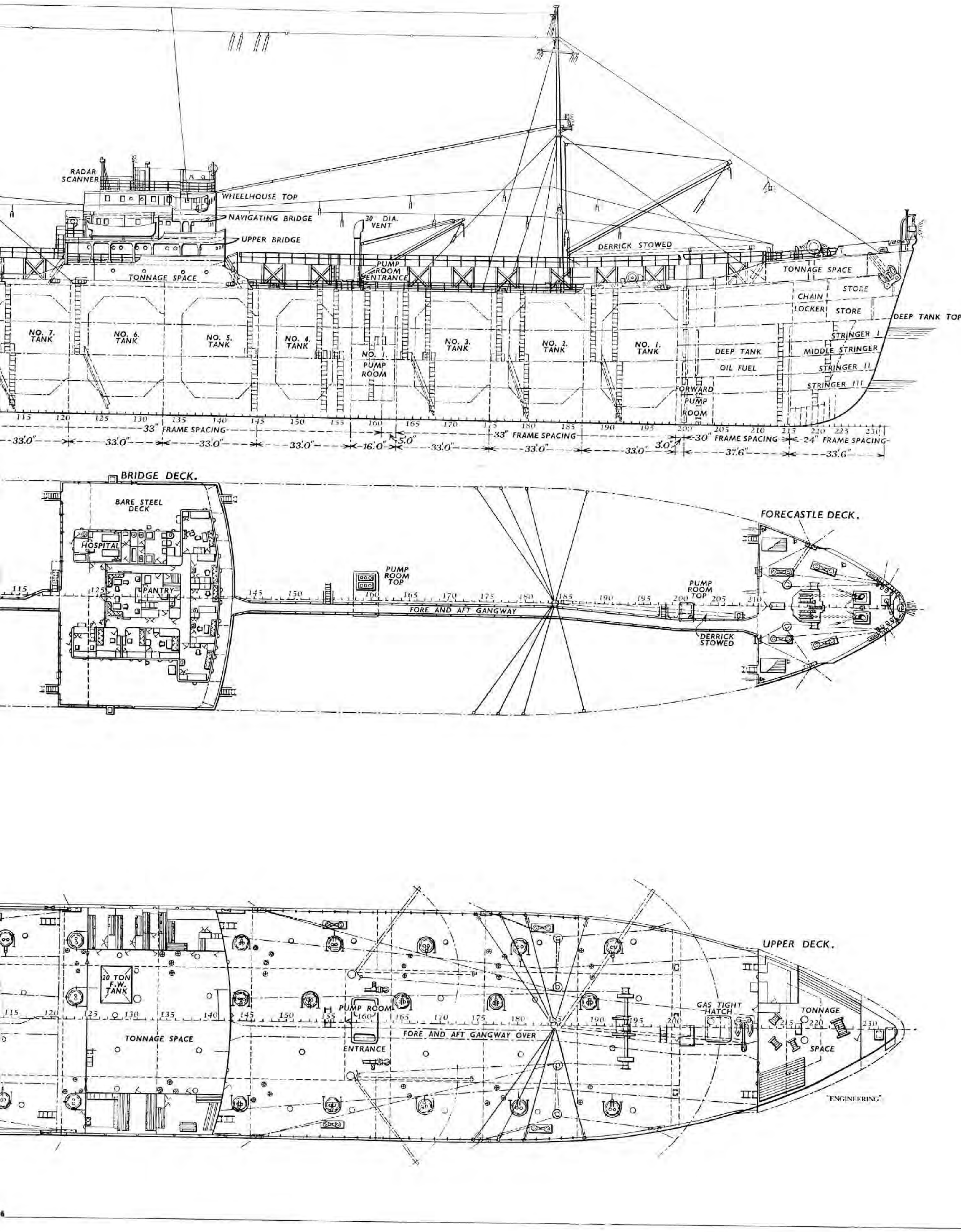


Fig. 10.
UPPER DECK.



GLO-SAXON PETROLEUM COMPANY.

(e Page 641.)



THE 28,000-TON TANKERS OF THE ANGLO-SAXON PETROLEUM COMPANY.

(*For Description, see Page* 641.)

Fig. 11. SECTION AT FRAME 28 LOOKING AFT.

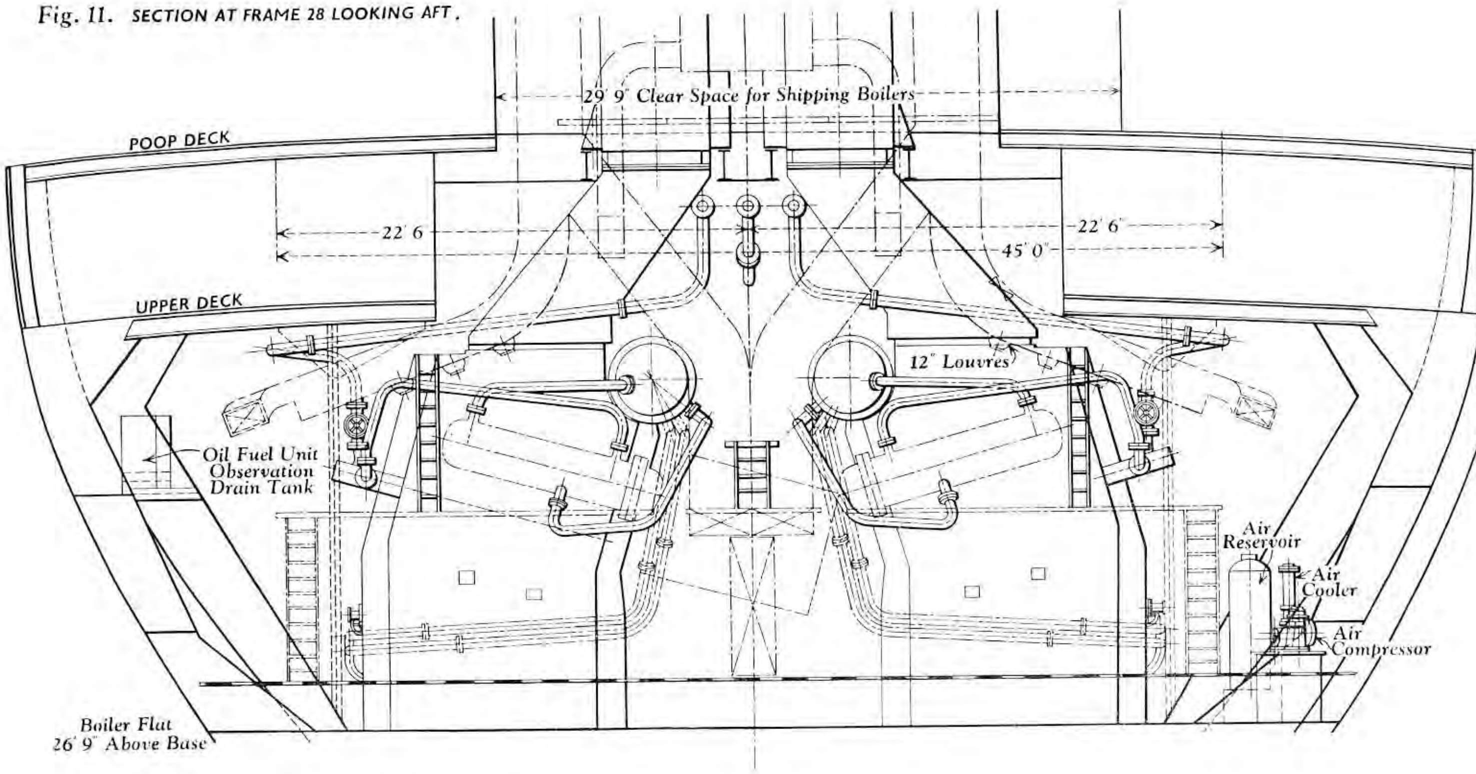
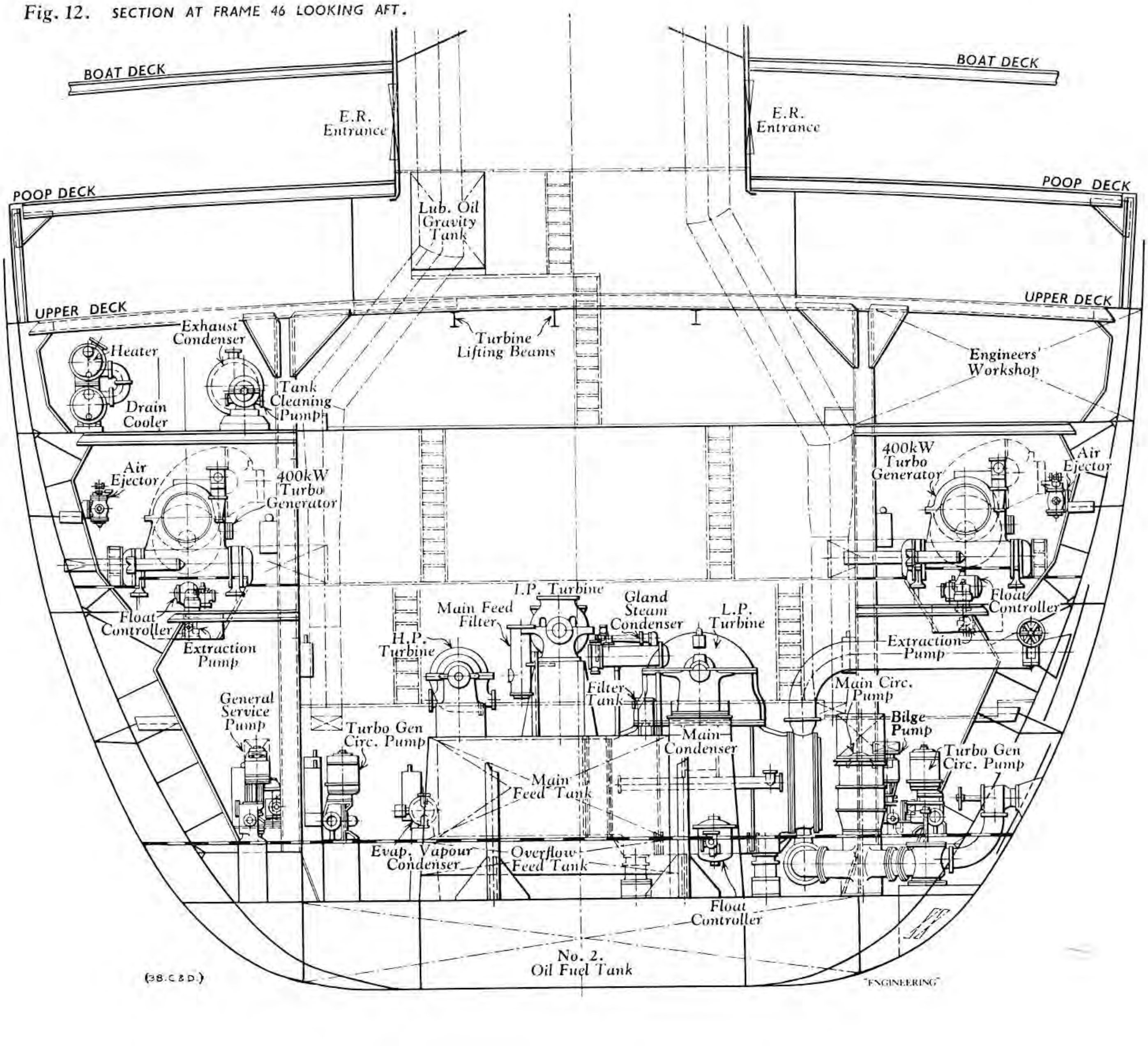


Fig. 12. SECTION AT FRAME 46 LOOKING AFT.



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28,000-TON TANKERS FOR THE SHELL FLEET.

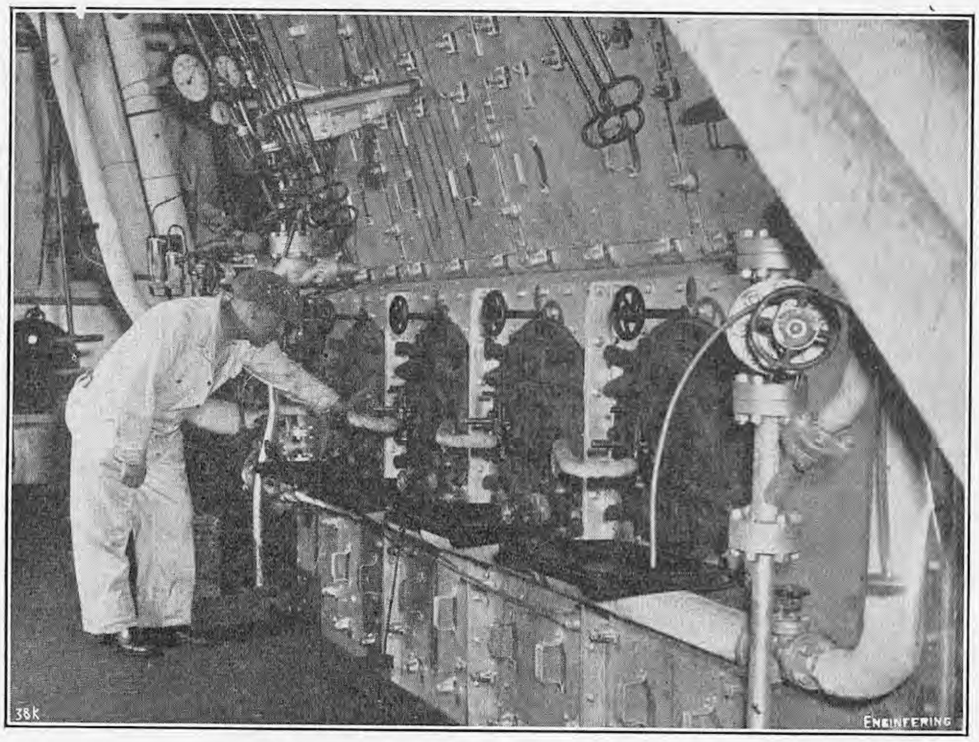


Fig. 13. Boiler-room of "Velutina."

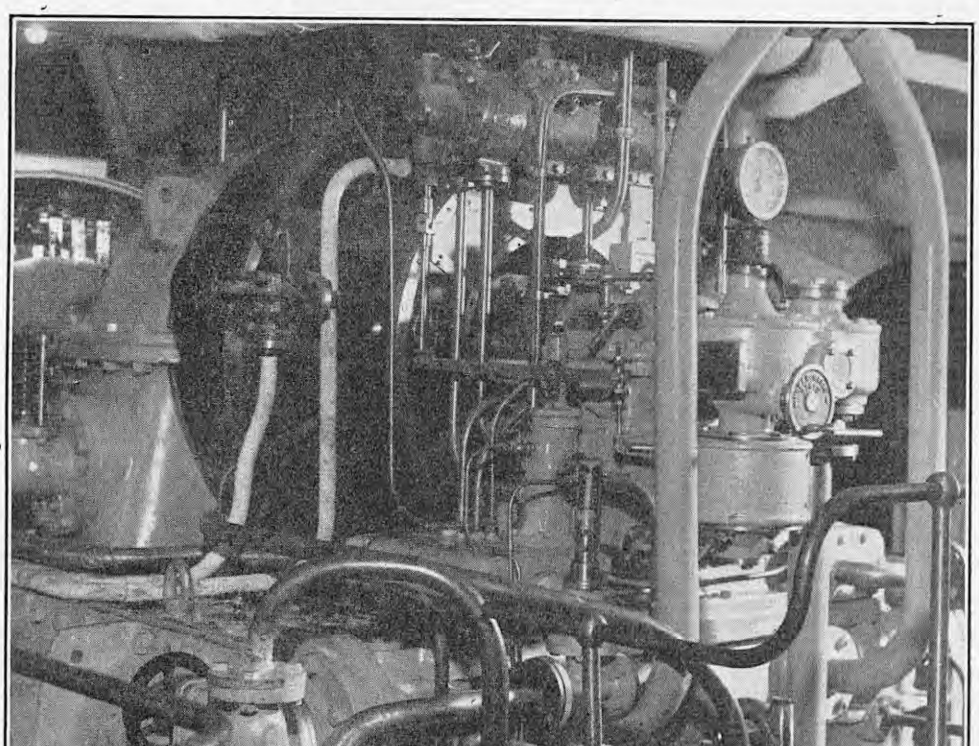


Fig. 14. Turbo-Generator in "Verena."

pads in the lower half. Part of the shafting and associated bearings can be seen in the photograph reproduced in Fig. 4, on page 642; this photograph, it should be added, was taken on board the Verena. The propeller, which is of Scimitar design, has four blades and is made from manganese bronze.

Steam for the main engines and auxiliary machinery, as previously indicated, is supplied by three Babcock and Wilcox boilers; these are situated on a flat arranged over the after-end of the engine room. Part of the boiler room is shown in Fig. 13, herewith, and the position of the boiler flat relative to the main engine will be apparent from Fig. 5. The boilers are constructed for a working pressure of 500 lb. per square inch (gauge), and are fitted with superheaters designed to raise the steam temperature to 750 deg. F. Steam is supplied directly to the main turbines, generating sets, air ejectors and turbo feed pumps, while steam for other purposes is passed through desuperheaters installed on each of the two forward boilers, which reduce the temperature to 50 deg. F. above saturation. The three boilers are designed to burn oil fuel only, under forced draught on the open-stokehold system. There are three electrically-driven forced-draught fans; these were supplied by Messrs. James Howden and Company, Limited, and each has a capacity of 16,000 cub. ft. of air per minute at 80 deg. F. The oil-burning installation, which was supplied by Messrs. Swinney Brothers, Limited, comprises two electrically-driven oil-fuel pumps and two heaters, each of which is capable of maintaining a fuel-oil temperature of 300 deg.F. Combustion is controlled automatically by the Hagan automatic combustion control system, the controls and instruments for which are grouped together on a panel in the boiler rooms.

The main condenser is of Messrs. G. and J. Weir's regenerative design and, in accordance with usual practice, is suspended from the low-pressure turbine casing. It has a surface area of 14,300 sq. ft. and is capable of maintaining a vacuum of $28\frac{1}{2}$ in. of mercury with a circulating-water temperature of 70 deg. F. Solid-drawn aluminium-brass tubes are used, having an external diameter of $\frac{3}{4}$ in., and they are secured to the tubeplates by the John Crane method, comprising a fixed attachment at one end and a sliding attachment through metallic packing at the other. A Weir's closed-feed system is installed; it consists of two electrically-driven condensate-extraction pumps: two sets of steam-jet air ejectors, one working and one standby; primary and secondary feed heaters; two turbine-driven main feed pumps, one working and one standby; main and overflow feed tanks; and the usual form of float-operated control valve installed on the condenser. The primary and secondary feed heaters are fitted to the main feed discharge, the secondary heater taking steam bled from the main turbines and the primary heater the exhaust from the turbo-feed pumps. Each heater has a surface area of 500 sq. ft. and is capable of dealing with 150,000 lb. per hour. The drains from the feed heaters are led to a drain cooler having a cooling surface of 350 sq. ft. Each feed pump is capable of dealing with the total feed requirements, the maximum output being 195,000 lb. an hour when supplied with superheated steam at main boiler working pressure.

The majority of the auxiliary machinery is electrically operated, direct current at 220 volts being supplied by two turbine-driven generators made by the British Thomson-Houston Company, Limited, and each rated at 400 kW. The same type of generating equipment is installed in all four vessels, and part of one of the sets for the Verena can be seen in Fig. 14, herewith. The two generators are self-contained units, being provided with their own condensers, circulating pumps, etc., and each is capable of supplying the total load. For supplying the electric-lighting circuits, Thermotank motors, gyro compass, echo-sounding gear, radar set, etc., two motor-driven generators are installed, each of which supplies direct current at 110 volts; the output of each machine is 45 kW and, like the turbo generators, they were supplied by the British Thomson-Houston Company, Limited. There is also a Ruston and Hornsby Diesel-driven generating set rated at 135 kW and supplying direct current at 220 volts for use when the boilers are shut down. It is a self-contained unit, with lubricating-oil cooler, heat exchanger and circulating pumps. Compressed air for starting the Diesel engine is supplied by a Reavell two-stage air compressor having a capacity of 40 cub. ft. of free air per minute. It is driven by an electric motor and delivers the compressed air to a reservoir of sufficient capacity to give twelve starts. The reservoir is also connected by suitable piping to various points in the engine room and on deck, so that the compressed air can be used for operating pneumatic tools. There is also an emergency hand-operated air compressor connected to a separate reservoir.

In general, the circulating pumps, etc., are electrically driven. There are two circulating pumps, each of which is capable of operating against an inclusive head of 25 ft. and delivering 10,200 gallons a minute. They were supplied by Messrs. Drysdale and Company, Limited, and have gunmetal casings, aluminium-bronze impellers and bronze spindles.

In addition to supplying the main circulating water, they are arranged so that they can discharge to the oil coolers. The condensate is extracted by two vertical-spindle pumps of Messrs. G. and J. Weir's Lo-Hed type, each of which is capable of dealing with the whole of the condensate from the main turbines. The pump bodies are of gunmetal, the first-stage impeller of Monel metal, the second-stage impeller of gunmetal and the shaft of stainless steel. Each pump draws from the condenser and delivers through the air-ejector condenser, gland-steam condenser and drain cooler to the suction of the main feed pumps.

Forced lubrication is employed throughout the main propelling machinery and the oil for this service is supplied by two electrically-driven pumps manufactured by Messrs. Stothert and Pitt, Limited, each of which is capable of supplying all the necessary oil when the machinery is developing full-service power. Magnetic and Auto-Klean filters are installed in the lubricating system and two Alfa-Laval oil purifiers are provided, each of which has an approximate capacity of 300 gallons an hour. The oil is also passed through a Serck oil cooler which is capable of maintaining the temperature of the oil at 100 deg. F. when supplied with sea water at 80 deg. F. Aluminium-brass tubes are incorporated in the cooler, and water and oil detectors are fitted at the appropriate outlets. Cooling water is supplied by an electrically-driven pump made by Messrs. Worthington-Simpson, Limited, with a capacity of 320 tons of water an hour.

Other auxiliary machinery installed in the engine room includes a heater and drain cooler for the Butterworth tank-cleaning gear, together with an associated pump; a general-service pump; two fire, bilge and sanitary pumps; circulating pumps for the turbo- and Diesel generators; evaporating and distilling plant; fresh-water pumps; a cargo-pump condenser; a filter for the auxiliary condensate; and a feed pump for harbour duties. The heater used in connection with the Butterworth system is capable of raising the temperature of 500 gallons of sea water per minute from 70 deg. F. to 200 deg. F., the capacity permitting two sets of apparatus to be used simultaneously. The heated water is delivered to the system by an electrically-driven booster pump of the rotary non-self-priming type, made by Messrs. Worthington-Simpson, Limited, the pressure in the system being 200 lb. per square inch. The fire, bilge and sanitary pumps were also supplied by Messrs. Worthington-Simpson; they are arranged so that they can draw from the sea, cofferdam and bilge lines, and discharge either overboard or to the wash-deck and fire service.

Two evaporators are installed, each of which is capable of producing 75 tons of fresh water per day; only one unit is used for evaporating sea water, however, the other being reserved for the evaporation of fresh raw water, the vapour from which passes to the primary feed heater. For condensing the vapour from the salt-water evaporator, a distiller having a capacity of 75 tons per day is installed. The cargo-pump condenser is of sufficient size to take the condensate from the Butterworth heater as well as the four duplex cargo pumps. In general, it is of similar construction to the main condenser, having tubes of solid-drawn aluminium brass secured by the John Crane method. It is provided with its own air ejector and electrically-driven extraction and circulating pumps, and is designed to give a vacuum of 20 in. of mercury with a sea-water temperature of 70 deg. F. A duplex filter made by Messrs. G. and J. Weir, Limited, is used for extracting the grease, etc., from the condensate of the cargo-pump condenser; it is installed at the discharge side of the extraction pump and is designed to treat 60,000 lb. of de-aerated auxiliary condensate an hour. The harbour feed pump is turbine driven and is capable of delivering a maximum of 78,000 lb. of condensate an hour.

The accommodation provided for the crew is of the usual high standard associated with the Anglo-Saxon Petroleum Company. The majority of the crew are accommodated in the poop, all in separate rooms, with added amenities such as recreation rooms, etc. The engineers' accommodation is situated in the house on the poop deck, which also provides room for the catering staff and their mess, the crew's messroom, the petty officers' mess and smoke room, and the galley. An unusual feature of the ship is the arrangement of the officers' and engineers' dining saloon and smoking room in the poop-deck house, so that it is adjacent to the galley. The officers' cabins are located on the bridge deck, together with a lounge and hospital, and a house on the upper bridge contains accommodation for seven passengers, the chief steward and the radio officer. The captain's rooms are on the navigating bridge, abaft the chartroom, wireless office and wheelhouse. Mechanical ventilation and heating are provided throughout the accommodation, the system having been installed by Messrs. R. B. Stirling and Company, Limited. The lifesaving equipment consists of four 24-ft. lifeboats, one of which is fitted with a propelling engine; they were supplied by Messrs. Mechans Limited and are carried under Optimum davits. Navigational aids include wireless direction-finding gear, echo-sounding apparatus and auto-alarm, a Sperry gyro-compass installation and a radar set.

LITERATURE.

Scientific Survey of South-Eastern Scotland.

Edited by C. J. Robertson. The British Association Local Executive Committee, University of Edinburgh. [Price 15*s*.]

For a number of years, it has been the practice of the Local Executive Committees of the British Association, at the cities chosen as centres for the annual meetings of the Association, to prepare a substantial brochure, sometimes actually a bound book, dealing with those aspects of the *locale* likely to appeal to the participants in the meetings. These are distributed to those taking part and, as the interests covered by the meetings are so wide, the annual volumes often present a survey of local history, commerce, industry, geology, topography, etc., that is a valuable work of reference. The present volume, prepared by an editorial board headed by Professor Alan G. Ogilvie, is a worthy addition to the series; more than usually interesting, in fact, as it deals with a region which, for centuries, has been a centre of learning comparable with any in Europe.

There are 21 chapters, each dealing with a specific subject and all contributed by experts. Some, such as those on archæology, political history, and biology, hardly come within the scope of this journal; but there are others, such as the chapter on "Mining," by Professor R. McAdam, that on "Manufacturing Industries," by Mr. William V. Stevens, the survey of "Transport," by Mr. H. P. White, and the section on "Research Institutions," by Dr. H. Buckley, of the Department of Scientific and Industrial Research, which in themselves would justify the inclusion of this volume in any reference library catering for an engineering, scientific or industrial public. The chapter entitled "The Outlook," which Professor Ogilvie has contributed in addition to that on his own special subject of geology, is an object-lesson to planners on the broad outlook that is necessary in preparing schemes for the future of even a small area or community.

Physical Mechanics: An Intermediate Text for Students of the Physical Sciences.

By Professor Robert Bruce Lindsay. Second edition. D. Van Nostrand Company, Incorporated. 250, Fourth-avenue, New York 3, U.S.A. [Price 5·00 dols.]; and Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 37*s*. 6*d*.]

The aim of Professor Lindsay's *Physical Mechanics*, first published in 1933, was to provide a course of undergraduate standard covering the fundamental principles of mechanics and laying special emphasis on their applications to physics. The careful revision and considerable modification undertaken for this second edition, while keeping the original plan in view, have widened its scope and given it a more unified presentation. Greater stress is laid on dynamics, and statics, having fewer physical applications, is treated as a limiting case of dynamics. Freer use has been made of vector notation, and the important concepts of impulse, momentum, work and energy are introduced earlier. Commendable care has been taken throughout to supplement formulae with statements of what is meant by and implied in them. Not only are the classical foundations thoroughly and systematically developed, but an early opportunity is taken to introduce quantum considerations by taking electron motions in the Bohr model of the hydrogen atom as an example of plane curvilinear motion. A simplified version of the kinetic theory of gases, and of some of the deductions therefrom, likewise provides an apt illustration of the motion of a system of particles.

The clear treatment of moving axes in the chapter on the mechanics of a rigid body is noteworthy, and, as might be expected from Professor Lindsay's interest in acoustics, the chapters on oscillations, elasticity and wave motion are excellent. The equations of motion of an ideal fluid are derived, Bernoulli's theorem and its consequences are discussed, and gravity waves in a long straight shallow canal are considered in the chapter on the mechanics of fluids, which ends with a brief account of viscosity and capillarity. The concluding chapter deals with the more advanced topics of Hamilton's principle, generalised co-ordinates, and Lagrange's equations, in which energy is the basic concept, and outlines the method of approach of wave mechanics to the study of atomic particles and atomic processes. Certain types of problem are shown to be amenable to more direct and efficient attack by the use of one or other of these alternative formulations of the fundamental principles, together with D'Alembert's principle and the Gaussian principle of least constraint, considered earlier. To the well-graded problems at the ends of the chapters is added a more difficult set of supplementary problems, to some of which answers are provided. The only misprints noted are minor ones on pages 141, 359 and 432.

Modernisation of Whitechapel Station Signal Box.—The locking frame at Whitechapel station signal box on the London Transport system, which has been in operation for some 40 years in conjunction with direct-current track circuits, has been replaced by a new frame with 47 miniature levers of the full-stroke type. A new relay room has also been brought into use. The new frame, which will be rolled into its final position in about three weeks time, controls point equipment and signals of the two-aspect colour-light type, with junction indicators and alternating current condenser-feed track circuits.

The Late Mr. Alan Sinclair.—It is with regret that we record the death of Mr. Alan Sinclair, which occurred on November 3, after an operation. Mr. Sinclair, who was only 42 years of age, was managing director of the British Tyre and Rubber Co., Ltd., and the Silvertown Co., Herga House, Vincent-square, London, S.W.1. He had spent all his business life with the British Tyre and Rubber Co. Group; after coming down from Cambridge University, he was, for some years, at the various factories of the Group and was elected a director in January, 1937. He served as President of the Federation of British Rubber Manufacturers' Associations during the year 1945-46, and played an active part in the post-war work of the National Joint Industrial Council, in connection with the rubber industry.

Babcock and Wilcox Exhibition Hall and Cinema.—Many modern boilers are of such great size and complexity that they are almost invariably assembled for the first time into a complete unit at the site. Consequently, the showing of such equipment presents many difficulties since it can only be seen either in an incomplete form at the maker's works or at sites widely distributed throughout the country. To overcome these difficulties, Messrs. Babcock and Wilcox, Limited, Farringdon-street, London, E.C.4, have opened a private exhibition hall and cinema in Salisbury House, Salisbury-square, a central point in London and one convenient to their head offices. The hall is equipped for the projection of 16-mm. sound or silent films and provides comfortable seating accommodation for 80 persons. A varied selection of models is also exhibited, the range including an integral-furnace type marine boiler, a radiant-type central-power-station boiler having an evaporative capacity of 515,000 lb. of steam an hour at 1,600 lb. per square inch, and a Cross-type boiler with spreader stoker. These models, however, will be changed from time to time and the facilities of the hall made available to the company's subsidiaries. The display is completed by wall charts, diagrams, etc., which illustrate current production and research methods at their Renfrew works.

SIMPLE METHOD OF COMPARING MANOMETERS.

J. H. Preston, M.A., Ph.D., A.F.R.Ae.S.

It occasionally happens, in measurements connected with fluid flow, that the particular manometer in use is not of a type for which the calibration can be obtained directly in terms of the geometry of the instrument, or it may contain a manometric fluid of unknown density. For instance, the inclined-tube manometer, when used at small angles for increased sensitivity, may be subject to appreciable errors if the tube is not straight or if the bore is not uniform. Again, in manometers of this type, alcohol is frequently used as the manometric fluid because of its relatively low surface tension, but variations in density of the order of 1 per cent. can occur owing to absorption of water from the atmosphere. It is desirable, therefore, to be able to compare the readings of such manometers with readings of a manometer such as the Chattock gauge or other manometer employing a null method of reading, and for which the calibration is known from the geometry of the instrument. To accomplish this, it is necessary to apply the same pressure difference across the arms of each gauge. On first thoughts the idea presents itself of coupling one arm of each gauge to a closed reservoir which can be pumped up to any desired pressure and leaving the other arms open to atmosphere. On trying this, it is found to be impossible to obtain readings owing to large and rapid pressure variations due to temperature changes and the fact that the adjustment of one gauge affects the reading of the other, making the whole system exceedingly "springy."

The only method in practice of which the author is aware is that which makes use of the impact pressure of an open tube, facing as steady a stream of air as it is possible to obtain. This pressure is applied to one arm of each gauge and the other arms are left open to atmosphere or are connected to a common static pressure tapping in the wall of the wind tunnel, if it is of the open-return type. The accuracy of this method is limited by steadiness of the air stream and by the method of controlling the tunnel speed. Moreover, two observers are needed to take simultaneous readings. While the method serves for most practical purposes, it would not enable sensitive gauges to be compared to an accuracy of the order of their sensitivity. Recently, at Cambridge, a manometer of variable sensitivity was constructed. The null method of indication utilised a meniscus in an inclined tube, the inclination of which could be varied, and by low optical magnification a sensitivity of better than 0·005 mm. of alcohol was obtained. The other arm of the manometer was a reservoir which could be raised or lowered by turning an accurately-cut screw of 1 mm. pitch which was connected by gearing to a four-figure Veeder counter, the last figure of which read 0·01 mm. An Askania Minimeter had also been modified by adopting the same method of indication. The Askania instrument had a ground thread of 2 mm. pitch, and the milled head actuating the screw was divided into 200 divisions so that the gauge could be read to 0·01 mm. also.

It was desired to compare the readings of the two manometers to the order of 0·01 mm. of alcohol so that either manometer could subsequently be used as a standard against which simpler and cheaper gauges could be checked. Use of a wind-tunnel stream for this purpose up to dynamic heads of 5 cm. of alcohol was not possible owing to lack of steadiness. The reservoir method of providing a pressure difference was again examined and it was thought that, if an open reservoir were placed in a tank of water with the opening covered by water, some relief from the temperature effects and "springiness" of the closed system might be obtained. This was tried and proved to be the solution to the problem. The measure of relief obtained by means of this device was such that the readings of the two manometers could be compared to about 0·01 mm. of alcohol up to heads of at least 5 cm. This unexpected magnitude of relief was investigated theoretically and an explanation was obtained. This is set out below as well as a description of the apparatus and the method of using it.

Assume that the reservoir, shown diagrammatically below, is cylindrical in form and of cross-sectional area A; and that it is placed in a large tank of water the level of which remains sensibly constant.

The effect of changes in temperature can be determined as follows. Let the original volume of enclosed air be V_0, its pressure P_0 and its absolute temperature T_0. If the temperature rise is t, the new temperature is

$$T = T_0 + t \quad . \quad . \quad . \quad (1)$$

Let the corresponding pressures and volumes be

$$P = P_0 + p \quad . \quad . \quad . \quad (2)$$

and

$$V = V_0 + v \quad . \quad . \quad . \quad (3)$$

Let the corresponding depression of water surface inside the vessel be h. Then

$$v = A\,h \quad . \quad . \quad . \quad (4)$$

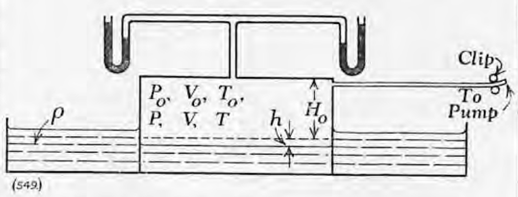
and

$$p = h\,g\,\rho \quad . \quad . \quad . \quad (5)$$

where ρ is the density of water and g is the acceleration due to gravity.

The gas equation is

$$\frac{P_0 V_0}{T_0} = R = \frac{P\,V}{T} \quad . \quad . \quad (6)$$



(549)

Hence, from (4), (5) and (6)

$$P_0 + h\,g\,\rho = \frac{R\,(T_0 + t)}{V_0 + A\,h}$$

or

$$1 + \frac{h\,g\,\rho}{P_0} = \frac{\left(1 + \frac{t}{T_0}\right)}{\left(1 + \frac{A\,h}{V_0}\right)}$$

or

$$\left(1 + \frac{h\,g\,\rho}{P_0}\right)\left(1 + \frac{A\,h}{V_0}\right) = 1 + \frac{t}{T_0} \ . \quad (7)$$

If t and, therefore, h are small,

$$h\left(\frac{g\,\rho}{P_0} + \frac{A}{V_0}\right) \simeq \frac{t}{T_0}$$

hence

$$h = \frac{t}{T_0}\,\frac{1}{\left(\frac{g\,\rho}{P_0} + \frac{A}{V_0}\right)} \quad . \quad . \quad . \quad (8)$$

But, from equation (5),

$$h = \frac{p}{g\,\rho}$$

Hence,

$$\frac{p}{P_0} = \frac{t}{T_0}\,\frac{g\,\rho}{P_0\left(\frac{g\,\rho}{P_0} + \frac{A}{V_0}\right)}$$

$$= \frac{t}{T_0}\,\frac{1}{1 + \frac{A}{V_0}\frac{P_0}{g\,\rho}} \quad . \quad . \quad (9)$$

If H_0 was the original height of the air-space in the reservoir,

$$H_0 = \frac{V_0}{A} \quad . \quad . \quad . \quad (10)$$

and

$$\frac{p}{P_0} = \frac{t}{T_0}\,\frac{1}{1 + \frac{P_0}{g\,\rho\,H_0}} \quad . \quad . \quad (11)$$

It may be noted that, for the completely closed system, where $V = V_0 =$ constant,

$$\frac{p}{P_0} = \frac{t}{T_0} \quad . \quad . \quad . \quad (12)$$

Thus, a rise in temperature of 1 deg. C. at a standard temperature of 15 deg. C. would give rise to a pressure change of

$$p = P_0\,\frac{t}{T_0} = 34 \times 12 \times \frac{1}{288} \text{ in. of water,}$$

$$\simeq 1 \cdot 4 \text{ in. of water.}$$

Hence, it is not surprising that the completely closed system failed to work.

Now, in equation (11), $g\,\rho\,H_0$ is the pressure due to a head of water of height H_0, and, for all practicable purposes, P_0 may be taken as atmospheric pressure, which is approximately the pressure due to a head of 34 ft. of water. Thus, if the reservoir had an air space of height $H_0 = 1$ ft., the change in pressure due to a small change in temperature would be 1/35 that for a closed reservoir. The choice of H_0 is open, and so, if H_0 is made small, a very large measure of relief can be obtained.

The effect of adjusting one gauge will now be considered. Suppose that the water-seal system is adopted. Then, in the action of adjusting one gauge, the volume of air displaced by a movement l of the meniscus is $l\,a$, where a is the area of the tube. If, during the action, the water level in the reservoir is depressed by h, then

$$V = V_0 - l\,a + A\,h \quad . \quad . \quad (13)$$

and $P = P_0 + p$, where $p = h\,g\,\rho$.

The gas equation (6) yields

$$\left(1 + \frac{h\,g\,\rho}{P_0}\right) = \frac{1}{1 - \frac{l\,a}{V_0} + \frac{A\,h}{V_0}} \quad . \quad (14)$$

or

$$\left(1 + \frac{h\,g\,\rho}{P_0}\right)\left(1 - \frac{l\,a}{V_0} + \frac{A\,h}{V_0}\right) = 1$$

or

$$h \simeq \frac{l\,a}{V_0}\,\frac{1}{\frac{g\,\rho}{P_0} + \frac{A}{V_0}} \quad . \quad . \quad (15)$$

Hence, from (5) and (15),

$$\frac{p}{P_0} = \frac{l\,a}{V_0}\,\frac{1}{\left(1 + \frac{A}{V_0}\frac{P_0}{g\,\rho}\right)}$$

or

$$\frac{p}{P_0} = \frac{l\,a}{V_0}\left(\frac{1}{1 + \frac{P_0}{g\,\rho\,H_0}}\right) \quad . \quad . \quad (16)$$

The factor in the brackets is the same as before in equation (11), and, for a given displacement of air by adjustment, $\frac{p}{P_0}$ can also be reduced by increase of V_0. Thus the water-seal system can provide a large measure of relief from temperature and adjusting effects. The ideal reservoir is one of large volume, but with a small height of air-space, and it should be placed in a large tank of water.

The foregoing conclusions were tested as follows. A discarded 5-gallon drum, 1 ft. in diameter and 1 ft. 6 in. high, was fitted with two pressure tappings at its base. The drum was then placed upside down in a dark room sink with the opening at the bottom, and suitable weights were placed on the base end to prevent the drum floating. The sink was then filled with water to a depth of about 4 in., and an arm of each of the manometers to be compared was connected by rubber tubing to a T-piece, and thence to one of the pressure tappings, the other arms being left open to atmosphere. The other pressure tapping was fitted with a piece of rubber tubing carrying a mouthpiece and a clip. The arrangement is shown diagrammatically in the figure on this page. It is important that large-bore tubing should be used and the tube lengths should be kept short.

Before carrying out the tests, the room temperature was allowed to settle down. The clip was left open so that the pressure in the reservoir was atmospheric, and the zero readings on the manometer were noted from time to time. When the values were steady, a small pressure was applied to the reservoir by inflating by mouth and closing the clip. The meniscus of each gauge was adjusted approximately on the sighting line and then a final adjustment was made. In general, two observers can do this very quickly, and one observer can manage it if the gauges are sufficiently close together for quick sighting, as there is generally a very slow creep of the menisci owing to temperature changes in the reservoir. It was found that adjustment of one gauge had no measurable effect on the other. The pressure was then raised and the process repeated, so that two sets of readings covering a range of 5 cm. of alcohol were obtained. The reservoir was then opened to atmosphere and the zeros were checked.

Alternative methods of applying pressure were tried as mouth inflation introduces warm air into the reservoir. For some tests a cycle pump was used and in other tests the pressure was raised by closing the clip and increasing the head of water in the sink by filling from a tap. This method is very convenient, but as cold water is introduced at each stage, temperature creep is still present. Tests were also carried out with the drum cut down to a length of 6 in. and with a depth of water in the sink such that the air-space was about 2 in. high, compared with a height of 12 in. to 15 in. in the early tests. The pressure in these tests was varied by raising the water level in the sink and keeping the clip closed.

The results obtained were as follows: With the manometers filled at the same time from the same bottle of alcohol, the maximum difference in readings did not exceed 0·02 mm. for a range of head of 5 cm. of alcohol. The gauges were designed to read to 0·01 mm. and they had a sensitivity of about half this, so that the water-seal device must be considered very satisfactory. The small differences in readings were found to be due to the effect of temperature changes on the zeros to which this type of manometer is particularly liable. Reduction of the air-space to a height of about 2 in. had a very beneficial effect in reducing the slow creep due to temperature changes, thus qualitatively confirming the theoretical prediction that a shallow reservoir would prove to be best. The main advantage over the reservoir with the greater height of air-space proved to be that the readings could be obtained quickly by one observer. Occasional differences of about 0·01 mm. to 0·02 mm. in readings were traced to creep of the zeros.

In a preliminary test the manometers had been filled from different bottles of alcohol, and one had been in use for some time. It was found that there was about 0·5 per cent. difference in the readings, showing that the densities of the two supplies of alcohol were different. This suggests that well-constructed gauges with accurately cut threads could be used to compare the densities of different manometric fluids. All that would be necessary would be to compare readings with the manometers filled with a common fluid with those in which one manometer was filled with a different fluid. The three different methods of inflation showed that none had any particular advantage over the others in reducing the slow creep due to temperature changes in the reservoir.

The Late Mr. F. M. Selson.—We regret to record the sudden death of Mr. Frederick M. Selson, which occurred on November 6 after a brief illness. Mr. Selson, who was in his 71st year, had been managing director of the Selson Machine Tool Co., Ltd., Cunard Works, Chase-road, North Acton, London, N.10, since 1938.

Development of Wind Power in Israel.—The United Nations Economic and Social Council has asked Mr. E. W. Golding, of the British Electrical and Allied Industries Association, to advise the Government of Israel on the best methods of exploring the potentialities of wind power for the generation of electricity in that country. The Association has granted Mr. Golding leave of absence for the purpose.

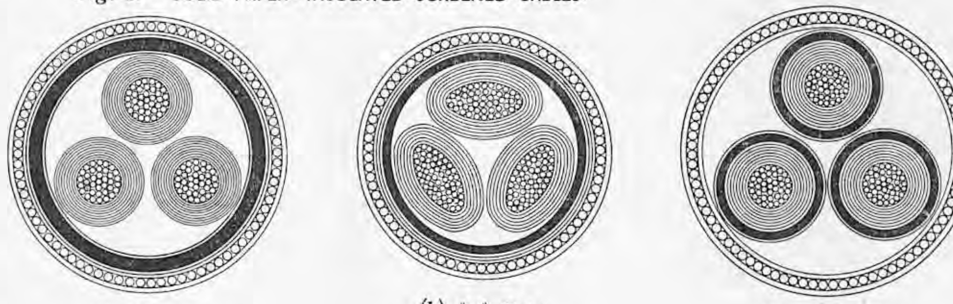
Electrical Developments in Nigeria.—The Electricity Corporation of Nigeria, which has been established by the Government, took over the electricity undertakings of the colony formerly operated by the Government on April 1, 1951, and will shortly absorb those now owned by some of the native administrations. At present both steam and Diesel stations are being operated, but many of these are in isolated towns and are not interconnected. Developments are, however, in hand for the erection of a large power station on the Mamu river close to coal mines, and of a transmission network connecting Lagos, Ibedan, Abeokuta, Oshogbo and other areas in the western provinces. It is also proposed to link up Port Harcourt, Aba and possibly Calabar in the eastern provinces with the new grid and to extend the supply in the direction of Abakaliki to serve lead and other ore mines and a new large cement works. In the northern provinces the existing station at Kano and the distribution system are being extended. At a later date hydro-electric stations will be built at places where water power can be economically developed.

PRESENT-DAY PRACTICE IN PAPER-INSULATED ELECTRIC CABLES.

By C. C. Barnes.

Cables used for the transmission and distribution of electricity consist essentially of conductors which are stranded for flexibility from plain high-conductivity annealed copper wires and are wrapped with oil-impregnated paper tapes. These single or multicore assemblies are then enclosed in an impermeable metal sheath, and, where necessary, depending on installation conditions, are mechanically protected by steel armouring. Impregnated paper as a dielectric was first used by Ferranti in 1891 in a cable designed for the then abnormal voltage of 10 kV to earth; and, although superficially the modern super-voltage power cable is similar to those developed over half a century ago, in that it is still based on the same materials, the continual development of the electrical and mechanical properties of those materials have resulted in certain fundamental improvements.

Fig. 1. SOLID PAPER-INSULATED SCREENED CABLES.

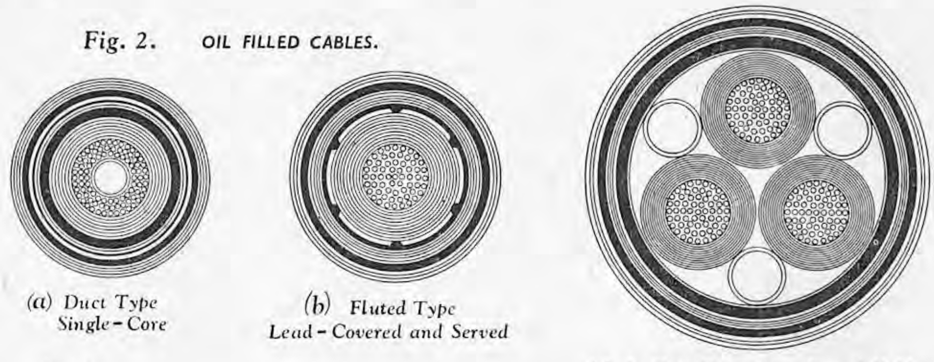


(a) "H" Type Round Conductors (487.A.)

(b) "H" Type Oval Conductors

(c) "HSL" Type Round Conductors

Fig. 2. OIL FILLED CABLES.



(a) Duct Type Single-Core

(b) Fluted Type Lead-Covered and Served

(487.B.)

(c) 3-Core Duct-Type Served Cable

Progress in super-voltage cables can be largely attributed to four main factors: the introduction of the screened (H-type) insulated conductor developed by Martin Hochstädter in 1914; improvements in cable materials, manufacturing and processing techniques, which were developed concurrently; the fluid oil-filled cable introduced by Emanueli in 1917; and the later varieties of gas-pressure cables (self-contained and pipe line constructions). To-day, the stage has been reached where 220-kV* cable installations are a *fait accompli* and a cable for 380 kV has been manufactured.

The current British Standard specification for paper-insulated and lead-sheathed cables (up to and including 22 kV) is B.S.480-1942. Multicore cables of the belted type have given splendid service at these voltages, in spite of the fact that the dielectric within the electric field is non-homogeneous, owing to the fillers, which are necessary to make the cored-up cable circular in cross-section, being of different permittivities. This non-homogeneity leads to distortion of the electric field, and so gives rise to tangential stresses in the cable dielectric. The results are, however, relatively unimportant until the operating voltage is raised above 22 kV. As the operating voltage of the system is increased, however, the electric stresses in the dielectric have also to be increased; otherwise, the thickness of the dielectric and overall dimensions of the cable would become prohibitive, both from the economic and from the manufacturing point of view.

A major step forward in the design of cables for 33 kV and above was the introduction of a screening consisting of a layer of perforated-aluminium paper tape, applied with an overlap (or unperforated aluminium, or copper tape, applied with a slight gap) over each paper-insulated core. Screening the insulated cores in this way results in the voltage gradient being confined to the paper dielectric, and keeps the electric stress in the cores uniformly radial. At the present time, there is no British Standard for 33-kV cables and the inclusion of dielectric, lead, and steel armouring thicknesses for this voltage in a revised version of B.S.480 would be a progressive step.

Table I gives a summary of dielectric thicknesses recommended by members of the Cable Makers Association for modern 33-kV screened solid-type cables.

Table I.—*Minimum Dielectric Thicknesses for 33-kV Screened Cables (Centre-Point Earthed Systems only).*

Nominal Area of Conductor. Sq. In.	Minimum Dielectric Thickness. In.		Maximum Electric Stress (Circular Conductors), kV per cm.	
	Three-Core Screened and Three-Core "HSL" Type Cables.	Single-core Screened-Type Cables.	Three-Core Screened and Three-Core "HSL" Type Cables.	Single-core Screened-Type Cables.
0·10	0·315	0·335	39·0	37·7
0·15	0·300	0·325	37·9	35·9
0·20	0·300	0·325	36·4	34·4
0·25	0·280	0·300	37·0	35·3
0·30	0·280	0·300	36·2	34·3
0·40	0·280	0·300	35·0	33·2
0·50	0·280	0·300	34·5	32·5
0·60	—	0·300	—	31·8
0·75	—	0·300	—	31·0
1·00	—	0·300	—	30·5

At 66 kV, the dimensions and weight of screened three-core cables become excessive. Furthermore, they have to be made in relatively short lengths and wound on large-diameter drums. Screened solid-type cables for this voltage are, therefore, usually of single-core construction, mainly because they can

* "Les Cables à 220-kV de la Région Parisienne." By M. Laborde. Paper 214, Conférence Internationale des Grands Réseaux Electriques à Haute Tension (1950); "The 230-kV Cable System at Génnissiat," *Electrical Times*, vol. 116, page 499 (1949).

be manufactured in longer lengths. Jointing is also simplified. Single-core 66-kV screened solid-type cables usually have a minimum dielectric radial thickness of 0·65 in. for the nominal range of copper sections, i.e., 0·20 sq. in. to 0·75 sq. in. This is equivalent to a conductor stress maximum of 43·9 kV per cm. for 0·20 sq. in. copper section.

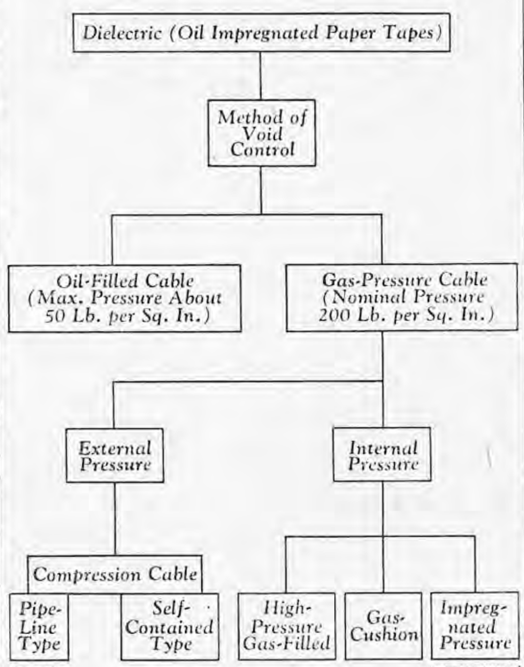
The three main types of solid-type paper-insulated screened cables are illustrated in Fig. 1, opposite. Single-core cables are normally used on installations where armouring is not essential, for example, power-station cabling, or where the conductor section is such that a three-core cable would be inconveniently heavy. The form of cable comprising three laid-up single-core lead-cased cables, known as the "H.S.L." type, is shown on the right in Fig. 1, from which it will be seen that the three lead-sheathed cores are twisted together into a circular formation and steel armoured overall. This design eliminates the heavy magnetic losses which would occur if each core were separately armoured and is very convenient for terminating and jointing. Alternatively, the screened cores can be laid-up and then lead covered, taped and armoured. This construction has the smallest overall diameter for a given copper section, but is not always so convenient to terminate and joint. In hilly country, where there would be a considerable head of oil in a cable, the "H.S.L." cable, with its small-diameter lead sheaths and absence of wormings filled with oil, is technically preferable. Otherwise, there is little to choose between the performance of the two types and the choice is usually a matter of individual preference.

The rapidly increasing demand for electric power has not only made higher working voltages essential but, for economic reasons, has necessitated power cables being operated at lower factors of safety. These objectives have been achieved mainly by steady progress in the selection of the materials used in the cable, together with detailed control of the manufacturing processes. The measure of success has been such that the dimensions of modern 132-kV power cables are of the same order as those of early 11-kV types. Cable-making machinery has also developed from a clumsy collection of parts into precision apparatus designed for the efficient performance of special operations.

In modern multicore cables the shaped or oval conductors shown in the centre of Fig. 1, are pre-spiralled (or pre-twisted) to prevent any tendency of the cores to spring apart when they are cut, and of the paper to wrinkle after application. The registration and tension of the individual paper tapes forming the dielectric are frequently measured to ensure that they "break joint" correctly layer by layer, and are not coincident; otherwise deterioration of the dielectric may occur in service. Control of the drying and impregnating processes has also been established on a scientific basis, with considerable gain in the effectiveness and uniformity of these operations. Many early cable faults were due to the failure of the lead sheath, owing to corrosion arising from inadequate or imperfect servings, or to faults in manufacture. Great care has therefore been paid to the design of the lead-melting pot and to the control of the lead-covering operations, combined with methods for preventing the formation of oxide on the surface of the molten metal. Various methods have also been developed to minimize or eliminate oxidation of the lead during pouring. For instance, carbon dioxide or other gases have been used to flush out the container and to produce an inert atmosphere, while a vacuum-sealed* container, or the Farmer principle, described by Beaver,† has been employed. In this the lead container is sealed by a reservoir or tray of molten lead, thereby eliminating the "human element." In addition, increasing use is being made of the continuous lead extrusion press,‡ the chief claims for which are that opening up for re-charging is not required so that lead is not exposed to oxidation; no longitudinal weld seams or stop marks are produced on the sheath; the exactness of temperature control gives close pipe dimensions and uniform properties; and production and economy are both improved.

It is now generally recognised that screened solid-type cables cannot be used on three-phase systems at voltages above 66 kV since failure occurs owing to ionisation in the voids or gas pockets in the dielectric. The mechanism of deterioration in oil-impregnated cables was summarised in 1936 by Robinson,* as follows:—"When ionisation or glow discharge occurs in voids in dielectrics, the surfaces of the voids are subject to ionic bombardment, some oil is displaced mechanically and some undergoes condensation. The resulting products are a hydrocarbon of higher molecular weight (initially a crystalline wax which is converted by further bombardment into an amorphous wax, and finally the well-known cable wax) and hydrogen, methane, and other gases of lower molecular weight. The glow discharge is most intense near the conductor where some of the gaseous products break-up, forming carbon which spreads transversely between the laminæ in conducting tracks (treeing) until breakdown is complete."

Fig. 3. CLASSIFICATION OF BRITISH SUPER-VOLTAGE POWER CABLES.



Long-term investigations into high-voltage phenomena have resulted in the development of various methods of void control which are now used in cables operating at 66 kV and higher voltages. The suppression of these voids also permits the electric stress to be raised to a much higher value (thereby conserving materials and reducing cable prices) without endangering the performance of the dielectric. The elimination of voids can be achieved by using low-viscosity mineral oil for impregnating the dielectric; and by including oil channels within or adjacent to the insulated cores. It can also be achieved by applying external pressure to a solid type cable, the pressure medium being separated from the oil-impregnated paper dielectric by a flexible impermeable diaphragm of, say, thin lead or polyethylene. Thus, when the cable cools after a heat cycle, the external pressure prevents the formation of voids or low-pressure spaces in the dielectric wall. A third method is to introduce an inert gas at high pressure inside the lead sheath and in direct contact with the dielectric.

The first complete attempt to obviate ionisation under all conditions of load or overload was made by Emanueli, who produced an oil-duct cable in which voids were prevented from forming by keeping the dielectric fed constantly with a fluid oil at a positive pressure, as shown in Fig. 2, opposite. During 1924, a short cable line using this principle and operating at 132 kV was laid at Burghero in Italy, and proved to be the first to be worked successfully at this voltage.

In a paper to the Institution of Electrical Engineers in 1909, Mr. E. A. Watson* gave an account of his work at Liverpool University on the suppression of ionisation by gas pressure. A note in *Nature* in the same year expressed the hope that this principle would soon be applied to electrical equipment. As far as cables were concerned, the belted and/or screened solid type constructions were, however, quite adequate for the distribution systems of that time. The suggested use of gas pressure to suppress ionisation in a cable dielectric was first made in 1925 by Fisher and Atkinson, and in 1926 Hochstädter patented the application of pressure through a flexible diaphragm, which has developed into the compression cable. These developments have resulted in British manufacturers offering various designs of cable using gas under pressure and these are summarised in Fig. 2, opposite. Although the designs dealt with in this illustration were developed primarily for operation at 66 kV, 132 kV, and higher voltages, increasing use is now being made of cables of this kind at 33 kV in view of the economy which results when they are employed on long routes. Table II shows the reduction in the radial thickness of paper insulation obtained by the use of the pressure principle. The main characteristics of the commercial gas-cable designs and oil-filled cable construction are summarised in Table III, on page 648.

TABLE II.—*Comparative Insulation Wall Thicknesses of Supervoltage Cables.*

Operating Voltage kV.	Nominal Area of Conductor. Sq. In.	Minimum Radial Thickness of Insulation (In.).		
		Screened Solid Type Cable.	Oil-Filled Cable.	Gas Filled (I.P.) Cable.
33	0·30	0·28 (Three-Core)	0·16 (Three-Core)*	0·10 (Three-Core)†
66	0·30	0·65 (Single-Core)	0·25 (Three-Core)	0·20 (Three-Core)
132	0·30	—	0·53 (Single-Core) with 0·47-in. internal diameter duct	0·47 (Single- or Three-Core)

* Recently reduced to 0·13 in.
† This very thin dielectric wall is confined at present to a limited number of experimental installations. In general, dielectric thicknesses of 0·13 to 0·16 in. have been used for the limited number (when compared with solid type) of 33-kV gas-filled cable installations in service.

All the British gas cables so far developed operate at a nominal pressure of 200 lb. per square inch; and the resulting permissible increase in the maximum electric stress used for design purposes has the following important advantages; the reduction in the dielectric wall thickness results in a smaller and lighter cable for a specified load (and the sphere of the three-core cable is thus extended); the decreased dielectric thickness reduces the thermal resistance of the cable, thus permitting an increased current loading; and the application of pressure to the dielectric, controls the effect of heating cycles and makes it possible to use a much higher maximum conductor temperature (85 deg. C.) than permissible for screened solid-type cables (i.e., 65 deg. C.). These advantages apply equally to the oil-filled cable, but British cable developments in this field are normally designed for lower (hydrostatic) pressures, the maximum value being about 50 lb. per square inch.

In spite of the advantages of lead and its alloys for cable-sheathing purposes, the use of alternative materials has always received close attention mainly because the weight of lead restricts both the cable dimensions and the drum lengths. Aluminium is an obvious alternative to lead, as abundant supplies are available under normal conditions, the price has not been subject to the same violent fluctuations, and the saving in weight is considerable, as shown in Table IV, page 648.

Over 200 miles of aluminium-sheathed power

* "Vacuum Lead Sheaths as Applied to Power Cables," *Wire and Wire Products*, vol. 2, page 695 (1936).
† "Lead Cable Sheaths." By C. J. Beaver. *Electrical Review*, vol. 136, page 468 (1945).
‡ See ENGINEERING, vol. 167, page 319 (1949).

* *Dielectric Phenomena in High Voltage Cables.* By D. M. Robinson. Chapman and Hall, Limited.

* "The Dielectric Strength of Compressed Air." By E. A. Watson. *Journal of the Institution of Electrical Engineers*, vol. 43, page 113 (1909).

cables for voltages up to and including 11 kV have been supplied and installed by one manufacturer since July, 1948; and the possible increasing use for this type of cable has focused attention on the necessary protective methods. When aluminium-sheathed cables are installed in air, the natural oxide film provides protection in all but strongly corrosive atmospheres. The primary hazard, therefore, is contact with metals which are electro-positive to aluminium, such as copper, brass, and, to a less extent, iron. In general, there is no necessity to provide any form of protective covering for aluminium-sheathed cables in air, except where the sheath is in contact with the above-mentioned metals at joints and bonds. Such contact is avoided by insulating the sheath from each metal, or by plating the contact metal with cadmium or zinc, which are below aluminium in the electro-chemical series.

Long-term experience of the behaviour of aluminium in contact with soils is very limited, and experience on this point is being collated. In a recent paper*, however, Mr. P. M. Hollingsworth summarised the results of his experience as follows: "In normal near-neutral soils, where electrolytic concentrations are low, a high-purity aluminium sheath will not be attacked even if laid bare and under conditions of heavy water-logging. On the other hand, if the soil is so alkaline as to have a pH value greater than 8·5, corrosion by alkaline attack may occur. It is widely accepted that aluminium is readily susceptible to attack by alkalis, but a highly alkaline soil condition is comparatively rare. Acidic conditions do, however, from time to time occur in soil and are known by pH values of 5·0 or less. Aluminium is comparatively immune from attack by organic acids which can have such disastrous effects on lead, and is not readily attacked by sulphur or nitro-acids. In all acidic conditions, attack on aluminium is liable to be accelerated by the action of chlorides, traces of which are often present in soil. Such conditions may occur in very localised areas in a soil the general nature of which is, to casual examination, innocuous, resulting in local attack or pitting."

Various alternative methods of protection have been adopted for buried aluminium-sheathed cables, but a desirable future development would be one overall protection which was sound technically and was also comparatively cheap, so that it could be applied to all aluminium-sheathed cables buried directly in the ground or installed in any position where there was a possibility of corrosion.

TABLE III.—MAIN CHARACTERISTICS OF COMMERCIAL GAS CABLE DESIGNS AND OIL-FILLED CABLE CONSTRUCTION.

Designation.	Normal and Maximum Operating Gas or Oil Pressure, Lb. per Sq. In.	Special Characteristics.	Nominal Dielectric Thermal Resistivity, Deg. C per Watt per Cm.	Maximum Design Stress, kV per Cm.	Types Available.
British Super-voltage Gas-Cable Designs.					
Compression cable (originally termed pressure cable)	200 and 250	The gas is separated from the oil-impregnated dielectric by a diaphragm lead sheath	500	70–110 (depending on service voltage)	33-kV single and three core; 66-kV ditto self-contained or pipe line construction; 132-kV single-core self-contained; 132-kV three-core pipe line.
High-pressure gas-filled cable	200 and 250	(1) Conductors passed through smoothing dies to provide a flat bed for the screening metallised papers applied over the strand. (2) The dielectric is built up from pre-impregnated paper tapes. (3) Nitrogen gas is in contact with the dielectric	700 (recent tests have established a lower nominal value of 550)	Up to 85	33-kV single- and three-core; 66-kV ditto.; 132-kV single core.
Impregnated pressure cable	200 and 250	Nitrogen gas in contact with the dielectric	550	Up to 100	33-kV, 66-kV, 132-kV } Single and three-core.
Gas cushion cable ..	200 and 250	Nitrogen gas in contact with the dielectric	650	Up to 85	33-kV single and three-core; 66-kV ditto.; 132-kV single-core.
British Super-voltage Oil-Filled Cable Design.					
Oil-filled cable ..	50 maximum	(1) Dielectric of greater porosity paper than generally used. (2) Impregnating medium consists of low-viscosity impregnating oil. (3) Longitudinal channels (ducts) are provided in the conductor of single-core cables or in the core interstices of three-core cables	500	Up to about 90	33-kV single- or three core; 66-kV ditto; 132-kV single-core

TABLE IV.—*Lead and Aluminium as Cable-Sheathing Materials.*

—	Lead.		Aluminium.	
	Commercially Refined Lead.	0·85 Per Cent. Antimony (Alloy B–B.S.801-1938).	99·5 Per Cent. Pure.	99·99 Per Cent. Pure.
Weight per cub. ft., lb. ..	710	710	168	168
Tensile strength, tons per sq. in.	0·75–1·0*	1·5*	5·0	2·5
Yield point, tons per sq. in.	0·3–0·4	0·6	2·5	1·2
Elongation, per cent. ..	40	30	4	35
Melting point, deg. C. ..	319	319	658	658
Heating temperature, deg. C.	400	400	750	750
Extrusion temperature, deg. C.	200	200	400–500	400–500
Extrusion pressure, tons per sq. in. ..	1·5	2·5	6	3

* Arbitrary figures; values vary with the rate of loading.

* "Cables Sheathed in Aluminium." By P. M. Hollingsworth. Paper No. 203, Conférence Internationale des Grands Réseaux Electriques (1950).

THE UTILISATION OF PEAT FOR POWER GENERATION.—At a meeting of the British and Irish Peat Society, which was held at the rooms of the Geological Society, London, W.1, on Friday, November 16, Dr. D. S. Shybekay, president of the Industrial Research Council of America, gave an account of work recently undertaken in Minnesota to exploit the 15,000 million ton peat resources of that State. One of the results of this work had been the establishment of a 25-kW power station in which lignite and peat were used as fuel and in which electricity was generated at about one-quarter the cost of the public supply. Peat-burning stations would, in fact, form a useful stand-by to hydro-electric plant now that improved systems of drying had been devised.

THE CYCLE AND MOTOR CYCLE SHOW AT EARL'S COURT.

THE Cycle and Motor Cycle Show, which was held at Earl's Court from Saturday, November 10, to Saturday, November 17, unlike the recent Motor Show, was of more than academic interest to the general public as most of the products on view were purchasable. This was the 26th show of the present series, which began at Olympia in 1910, was followed by three shows in 1911, 1912 and 1913, thirteen from 1919 to 1931, six from 1933 to 1938, and two in 1948 and 1949. At this year's Show the complete ground floor of the main exhibition hall was occupied by 28 exhibitors of bicycles, 33 of motor cycles, 120 of components and accessories, and seven of tyres. A new feature this year was the bicycle-motor section, where 14 exhibitors were showing various forms of equipment used to convert ordinary bicycles to power-driven machines. Every effort was made to make the show attractive and, in addition to the usual features, a 52-minute film dealing with the leading motor-cycle events of the year was shown three times daily in the Warwick Hall, an innovation which proved most popular.

In general, there have been no major changes in the design of bicycles and motor cycles since the last show was held two years ago. As in the case of the motor industry, design and research have been concentrated on the introduction of detailed improvements rather than ambitious novelties and although there are many minor alterations visible to the discerning eye, the basic designs remain very much as before. This state of affairs is to be welcomed as it permits all efforts to be concentrated on production, a very necessary adjunct in times of recurring crises. The contribution made by the bicycle and motor-cycle industries towards the export drive is, perhaps, not generally realised; British manufacturers of bicycles alone are now producing close on 3½ million machines a year, of which nearly 2½ million are exported to over 140 different countries. To maintain these figures, efforts have been directed towards the production of lighter machines without sacrificing strength or reliability and to the holding of prices. In some cases, prices have actually been reduced, a remarkable achievement in these days of mounting material and labour costs and one made possible by the careful selection of specifications to suit specific purposes.

As previously indicated, the general shape and design of bicycles remain much as before, but more attention has been paid to the problem of obtaining the exact angles and proportions to suit each particular purpose. Lighter machines have been made possible by the use of high-grade steel tubing and light-alloy tubing and many machines at the show were built with these materials, weights being down to as little as 16 lb. for track-racing models and 21 lb. for fully-equipped touring machines. Most improvements, however, were to be found in the fittings and accessories; brakes, for example, are lighter and stronger but, at the same time, easier to apply and adjust. Electric dynamos are smaller and neater but give more light, and at least one firm was showing dynamo-lighting equipment which automatically changes over to a battery when the machine is brought to rest. Efforts are being made also to get rid of the annoying little clips and screws by bolting fittings directly to welded or brazed lugs which form an integral part of the frame. Similarly, with wires and cables; these are kept in harmony with the general design and in many cases are kept out of sight by routing them through the tubes.

It seems that a movement has started towards the adoption of spring frames on bicycles, as at least one leading manufacturer of complete machines, namely, Messrs. J. A. Phillips and Company, Limited, was showing a bicycle so equipped. On this machine the seat stay, instead of being bolted to the top of the saddle tube, is connected to a rubber shock absorber installed in the angle formed by the junction of the top and saddle tubes. The seat and chain stays are contiguous and the latter are designed so that they can swivel about the centre line of the bottom, or pedal, bracket, the movement being limited, of course, by the shock absorber. This is arranged to react lightly to minor road shocks with proportionately greater reaction to heavy road shocks. With this design, chain tension remains constant and the position of the rear-brake blocks relative to the wheel rim never alters. There is little doubt that the use of such a frame will reduce materially the road shocks normally transmitted to the rider and, as a consequence, give a more comfortable ride. A sprung frame, however, is not the only way of insulating the rider from road shocks; sprung forks also are quite effective, and several firms were showing equipment of this type suitable for use with auto-cycles, bicycles and tandems, a good example being furnished by the Suparide sprung fork shown by Frank Lawrence Motor Cycles, 125-127, Falcon-road, London, S.W.11. This design is based on the usual arrangement of parallel links joining the moving member to a "fixed" member, but instead of employing a helical spring, the top set of links is connected to the associated pin through a bonded-rubber bush which resists the torsional movement of the links. The same firm were also showing telescopic forks for use with auto-cycles, cycles, etc., the design of which is such that no torsional stresses can be imposed on the vertical members.

One of the outstanding features of the post-war cycling world has been the rapid rise in popularity of the motor-assisted bicycle or "motorised" bicycles, as they are more generally referred to. Ease of handling, combined with low upkeep costs, has led to their wide adoption and it has been estimated that in this country alone there are between 100,000 and 150,000 such units in use. The idea, of course, is not new, and from the earliest days of the internal-combustion engine attempts were made to "motorise" the bicycle. More often than not, however, it was found that the frame was not strong enough to withstand the hammering imposed by the somewhat crude engines of those earlier days. Present-day advances in engineering techniques have improved the design and performance of small motors out of all recognition, and to-day there is a wide range of such units for attachment to bicycles, many of which were displayed at Earl's Court. They varied from friction-drive units arranged to drive either the front or rear wheel through friction rollers to what can best be termed miniature motor-cycle engines, which drive the rear wheel through chains.

In practically all cases, a two-stroke engine is used, the capacity of which varies according to the make from as little as 30 cub. cm. to 50 cub. cm., the latter, apparently, being the maximum size considered safe for use on existing bicycle frames. The most popular position for mounting the friction-drive units appears to be above the rear wheel in the position normally occupied by the parcel carrier, but on at least one friction-drive type the unit was mounted below the pedal bracket, a position that has the advantage of a lower centre of gravity. The positions of the chain-drive units vary considerably, some being situated below the pedal bracket, some beside the rear wheel, and others, such as the Cyclemaster, actually inside the rear wheel.

Only a few of the friction-drive units were provided with clutches, but on some the complete assembly is designed so that it can be moved about a fulcrum point to bring the roller either towards or away from the wheel, this movement being controlled by a lever on the handlebar. Most of the chain-driven models, on the other hand, were fitted with clutches, a most useful feature, as it adds to the convenience of the machine and renders control considerably easier. Although most engines were of the two-stroke type, there was at least one four-stroke unit on view, namely, the Cucciolo, an Italian design, marketed in this country by Britax (London), Limited, 115-129, Carlton-vale, London, N.W.6. This is a particularly interesting unit as, although the capacity is only 48 c.c., it develops over $1\frac{1}{4}$ horse-power and is claimed to be able to travel 300 miles on a gallon of petrol. It is located below the pedal bracket and the drive is transmitted to the rear wheel by a chain, the drive incorporating a two-speed gearbox and a plate-type clutch. Overhead valves are employed and these are operated by pull rods, a method adopted to reduce weight to a minimum. An unusual feature of the unit is the provision of a sump-type lubrication system.

Although the machines in the motor-cycle section were similar in most respects to those exhibited two years ago, many of them have been noticeably modified and most have benefited from detailed improvements in the component parts. This has resulted, for example, in quicker and smoother-running power units, easier and more positive gear changing, better braking and improved lubrication, to mention but a few of the advances made. In the heavyweight class, that is, from 500 c.c. upwards, British machines enjoy a world-wide popularity, the only serious foreign challenger being the German B.M.W. transverse twin. The vertical twin, a British development, was being shown by seven of the largest manufacturers and although all are available in the 500-c.c. size, B.S.A. and Triumph also were showing a 650-c.c. version, the extra capacity of these machines giving a very high maximum speed and rendering them particularly suitable for sidecar work. The most powerful machines in the show were the Vincent-H.R.D. 1,000-c.c. V-twin models and the Ariel four-cylinder machine of similar capacity. These machines are, of course, well-tried favourites, and the Vincent-H.R.D. Black Shadow model, capable of 125 miles an hour, is believed to be the fastest touring machine in the world.

The single-cylinder machine still maintains its popularity; it has a consistent output and is also capable of maintaining high cruising speeds, considerable advances having been made in the last few years towards silent and vibrationless performance. The largest machine of this type on view was the Panther 600-c.c. machine, considered by many as the best motor cycle for use with a sidecar. The popularity of the 350-c.c. models, on the other hand, continues to decline, probably because the relative difference in weight and cost between them and the 500-c.c. models is so very little that most prefer to pay slightly more for the larger machines. Whereas pre-war the 350-c.c. was the most popular of the larger machines, only five firms were showing single-cylinder models of this type and one firm, namely, Douglas, a twin. Douglas still have great faith in the horizontally-opposed twin, and it was noted that a prototype 500-c.c. machine on view for the first time was of this form.

Interest in machines of 250-c.c. capacity has dwindled even more than in the case of the 350-c.c. models, as this type was only represented by two manufacturers. It is difficult to account for this fall in popularity, as not so long ago machines of this class were made by almost every leading firm. Probably the evolution of the two-stroke power unit has been one of the major causes as there is little doubt that this type of machine has gained in popularity an amount commensurate with the loss in prestige of the 250-c.c. four-stroke model. The two-stroke, in fact, has undergone remarkable changes in recent years and the engine, crankcase, gearbox and ancillary equipment are now constructed as a single unit of such small weight and simplicity of design that it has proved possible to make frames for them of remarkably light weight. There were many machines of this class at the show, several of which have performances little short of their 250-c.c. four-stroke counterparts. There is every indication that the demand for them will grow rapidly in the near future; they are reliable little machines, easy to handle and, above all, they provide a cheap and relatively speedy means of personal transport.

Christmas Lecture of the Institution of Electrical Engineers.—The sixth Christmas Lecture of the Institution of Electrical Engineers will be delivered at Savoy-place on Thursday and Friday, January 3 and 4, 1952, by Captain Peter Bressey, a senior pilot of the British Airways Corporation. The subject will be "Electricity in Civil Aviation," and the lecturer will describe electrical services in aircraft—radio communication and navigation aids, and visual aids to approach—from the pilot's point of view. A number of tickets will be available for members' children (for which application should be made before Monday, December 3), but members are asked not to accompany them.

RESEARCH ON FRICTION AND WEAR.*

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

The object of this paper is to outline some of the steps being taken in the laboratories of the Mechanical Engineering Research Organisation to throw further light on the nature of wear and the manner in which it is reduced by the application of lubricants. In the ideal bearing, hydrodynamic forces arising from the viscous nature of the applied lubricant are made to separate the surfaces with the virtual elimination of wear and the reduction of the tangential frictional force to a value which might be as low as one-thousandth of that occurring in the absence of lubrication. Such hydrodynamic forces are, however, only generated when circumstances are favourable and there are many applications in which their achievement is not possible, if only at the moments of starting a mechanism from rest. In such circumstances, it is necessary to rely on specific properties of a lubricant to reduce friction and prevent seizure, and this is described as boundary lubrication.

The purpose of lubrication being to separate surfaces, it is clear that the starting point of any research must be a study of the nature of the surfaces involved. The first and easiest thing to study about a surface is its shape, and fortunately nowadays there are such instruments as the "Talysurf" which are able to determine the profile of the cross-section of a surface. A diamond, finished to a radius of 0·0001 in., is traversed across the surface, its up and down motion being amplified electrically, the result being shown on a diagram with a greatly exaggerated vertical scale. Another way of obtaining this profile is by taper-section technique, wherein a surface is electroplated and then ground and polished on a section inclined at about 10 deg. to the original plane of the surface. Fig. 1, on page 650, shows the profile of a diamond-turned surface as examined by this means. Very great care is necessary in interpreting this form of data, in distinguishing between the periodic rugosities of the surface and its general departure from the plane, cylinder or other ideal form it was intended to represent; for example, it is pointless to obtain a perfectly smooth shaft if it is lobular in shape. The effect of surface finish, in the sense described, is of very great significance in frictional wear problems, though research workers cannot be as definite about its effect as they would like. One great difficulty in studying the subject is that it is virtually impossible to change the roughness of the surface without simultaneously changing other factors, such as hardness. However, there is evidence to show that, in boundary lubrication, it is possible to have too smooth a surface, just as a surface which is very rough is disadvantageous.

The surface profiles revealed by the foregoing methods are, however, on too small a scale to describe the true surface, which must be regarded, in the ultimate, as being made up of atoms. These atoms are related to each other in strict geometrical patterns which determine the true surface-form characteristics of a material, study of which is now possible using the electron microscope. Fig. 2, on page 650, shows an electron micrograph of the surface of a piece of aluminium. Unfortunately, the electron beam is unable to penetrate any great thickness of the material, and reflection is not possible as in ordinary metallurgical microscopy. It is necessary, therefore, to make a replica of the surface, using a material such as "Formvar." Alternatively, an oxide film covering a surface may be removed and used as the replica. The example shown was made in this manner.

Possibly of greater importance than surface profile is the chemical composition of the surface. It is now well known that most metals are covered with a naturally-occurring oxide film. Where this film is stable it is usually not more than a millionth of an inch in thickness and serves to protect the remaining material from further oxidation. Where the oxide is permeable, no protection is afforded and corrosion is continuous, as in the case of the familiar red rust of iron and steel. Oxide films may be removed for chemical study or identification by X-ray powder photographs by dissolving away the substrate metal. They may be identified in place by means of electron diffraction. Fig. 3, on page 650, shows patterns obtained by electron diffraction of two surfaces of aluminium. The lower sample had been exposed to moist air for 24 hours, whereas the upper had been boiled in distilled water for 1 hour. In the first example, the pattern is characteristic of amorphous Al_2O_3, whereas, in the second, Boehmite ($Al_2O_3H_2O$) is present. In the absence of film, metals in contact would weld, but the natural oxide, aided by lubrication, is able to prevent this. The nature of the oxide is important, as indicated in

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

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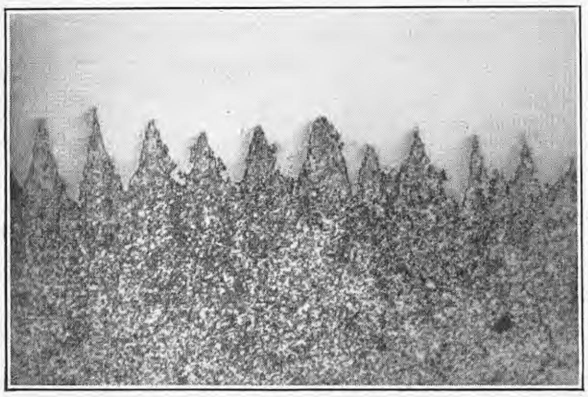


Fig. 1. Taper Section, Diamond-Turned Surface. Vertical, ×1,500; Horizontal, ×150.

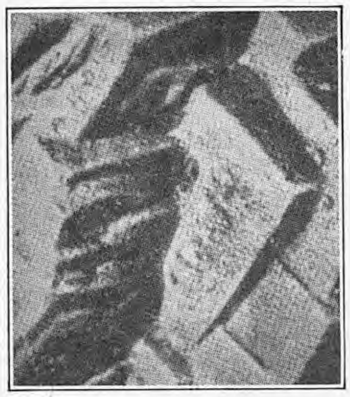


Fig. 2. Electron Micrograph of Aluminium Surface.

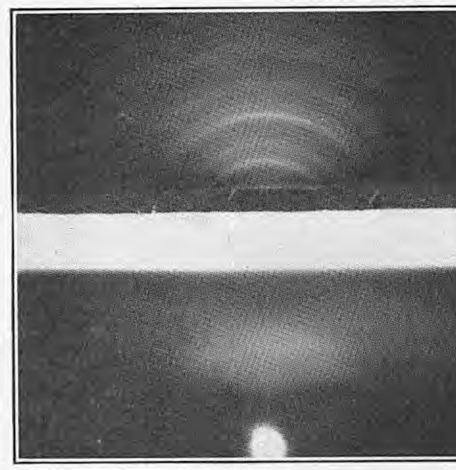
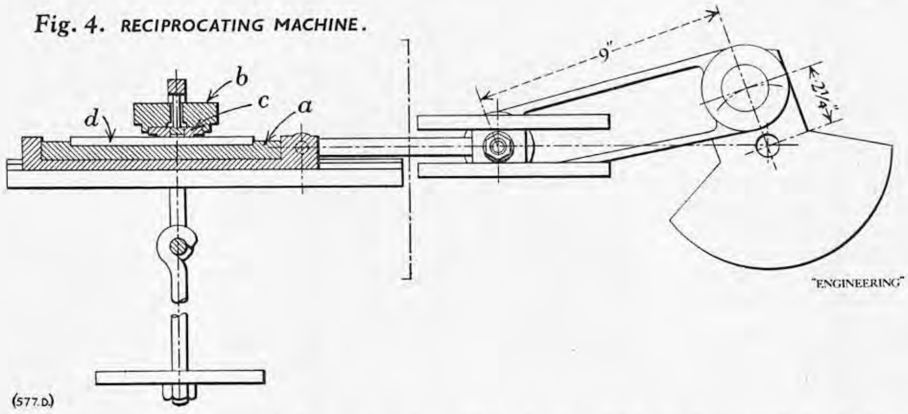


Fig. 3. Electron-Diffraction Patterns of Oxide Films on Aluminium.

Fig. 4. RECIPROCATING MACHINE.



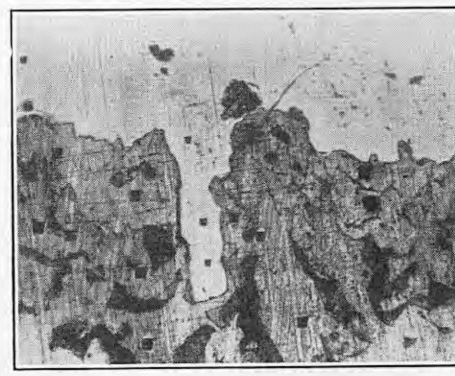


Fig. 5. Brass Adhering to Mild Steel. ×150.

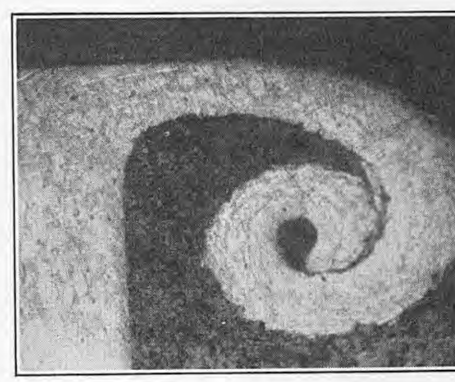


Fig. 6. Plastic Deformation of Worn Specimen (Section).

Table I, whence it will be observed that, even when lubricated, the nature of the oxide affects the magnitude of friction recorded. There is thus a possibility of technological advance to be made by deliberately arranging for rubbing surfaces to be suitably coated.

One such process, which has become increasingly well known, involves the conversion of the surface layer of the material to a phosphate. The process is very simple; the components are simply immersed in an aqueous solution of proprietary reagents and kept at boiling point for a period of 5 to 15 minutes. The surface is considerably roughened, but loosely adhering particles can be removed by vigorous application of a wire brush. The treatment enables wear to be reduced considerably and is particularly effective in preventing local seizure and scuffing. The lubricant is still necessary, but becomes much more effective, partly due to the anti-welding action of the phosphate layer, which prevents or localises seizure, and partly to its porous nature, which provides numerous reservoirs for lubricant. The following experiment will be of interest. The surfaces were rubbed together in reciprocating motion on the machine shown diagrammatically in Fig. 4, herewith. Slider *a* is reciprocated by a simple crank-crosshead mechanism and carries the lower piece *d*. The mating test piece *c* is carried in

Table I.—*Friction of Super-Pure Aluminium (99·99 per cent.), Lubricated with Oleic Acid at 21 deg. C.*

Load 5 kg. Upper surface spherical (radius of curvature 0·5 cm.), sliding on the flat lower surface. The surface was electrolytically polished, washed in alcohol, and then dried in warm air.

Subsequent Treatment.	Nature of Oxide Layer.	Coefficient of Friction.	
		Velocity, 0·01 cm. per Sec.	Velocity, 0·1 cm. per Sec.
Plunged directly into lubricant	Electron-diffraction rings characteristic of aluminium indicating little or no oxide film	0·17	0·17
Exposed to moist air for 24 hours	Amorphous Al_2O_3 ..	0·15	0·15
Boiled in distilled water for 1 hour	Electron-diffraction pattern indicating Boehmite ($Al_2O_3H_2O$)	0·11	0·11
Anodised	Amorphous Al_2O_3	0·10	0·14

block *b*, to which load is applied. This block is restrained from horizontal movement by flexible metal strips to which are attached resistance strain gauges. These enable a continuous indication of friction force to be obtained. Table II, below, shows a comparison of phosphated and untreated surfaces lubricated with paraffin wax.

Table II.—*Effect of Phosphating on Seizure of Mild-Steel Surfaces in Reciprocating Motion.*

Load 6·17 lb. per square inch; stroke 4½ in., speed 120 r.p.m.

Treatment of Lower Surface (Upper Surface Untreated).	Time to Seizure.	Coefficient of Friction (Average).
As ground	Immediate	—
Phosphated	1 hr. 35 min. ..	0·70
As ground; lubricated with paraffin wax	27 hr.	0·24
Phosphated, then lubricated with paraffin wax	Unseized after 50 hr., then ran smoothly under load increased to 268 lb. per square inch.	0·17

Table III.—*Effect of Molybdenum Disulphide on Seizure of Mild-Steel Surfaces in Reciprocating Motion.*

Stroke 4½ in. Stationary specimen, 1½ in. by ½ in.

Treatment of Both Surfaces.	Speed, r.p.m.	Load to Seizure Tests. (Load in lb. per square inch, increased in Increments of 6·7 lb. per square inch at 4-min. Intervals).	Time to Seizure Tests. (Load constant at 6·7 lb. per square inch.) Hrs.
Molybdenum disulphide rubbed on to mild steel	250	6·7	(4 min.)
Molybdenum disulphide bonded to untreated mild steel	250 500 1,000	80 47 33	3 2¾ —
Molybdenum disulphide rubbed on to phosphated steel	250 500 1,000	230 220 87	10 5 —
Molybdenum disulphide bonded to phosphated steel	250 } 500 } 1,000	Ran satisfactorily at 267 lb. per square inch. 230	Unseized after 50 hr. —

In applications where the emphasis is on prevention of wear rather than on minimising friction, such means would often enable the use of a liquid lubricant to be dispensed with. An extension of this method, involving the bonding of molybdenum disulphide with corn syrup, gives even more promising results, as indicated in Table III, herewith.

Wear, which may be defined as the unintentional removal of material from a surface, may take a variety of forms. The simplest concept is that, when the oxide films and the lubricant normally separating two surfaces are removed, the exposed areas bond together and, with continual application of tangential force, one or other of the parts will shear. A taper section in Fig. 5, herewith, shows the effect of brass rubbing on to mild steel. However, even in this particular experiment, all the brass removed from the upper surface was not deposited on the steel; some of it was broken away in the form of loose debris in the oil.

When one of the materials is very much harder than another, or where abrasive particles are present between the surfaces, a form of abrasive wear may occur in which the particles actually cut away material from one or other of them. It is probable that this is one of the most common forms of wear met with in engineering practice. Further, another continuous form of wear may be envisaged whereby the oxide

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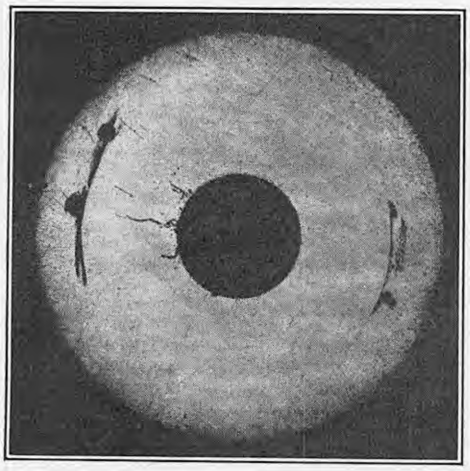

Fig. 7. Abraded Surface After Fretting Corrosion. Steel on Steel.

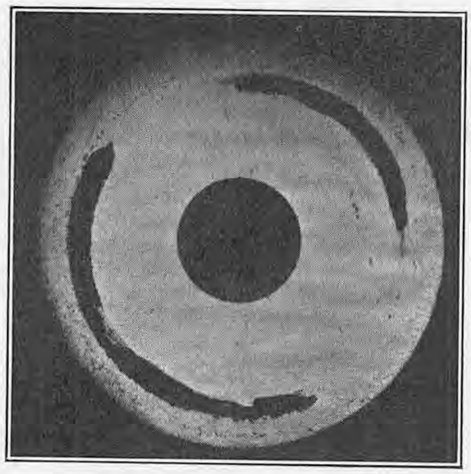

Fig. 8. Steel on Steel; Dry. ×2.

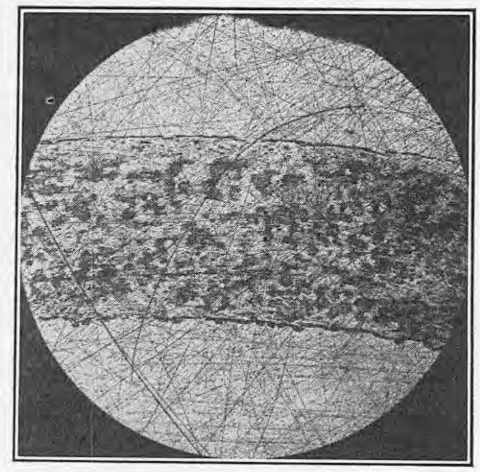

Fig. 9. Phosphated Steel on Steel; Fretting-Corrosion Specimen. ×25.

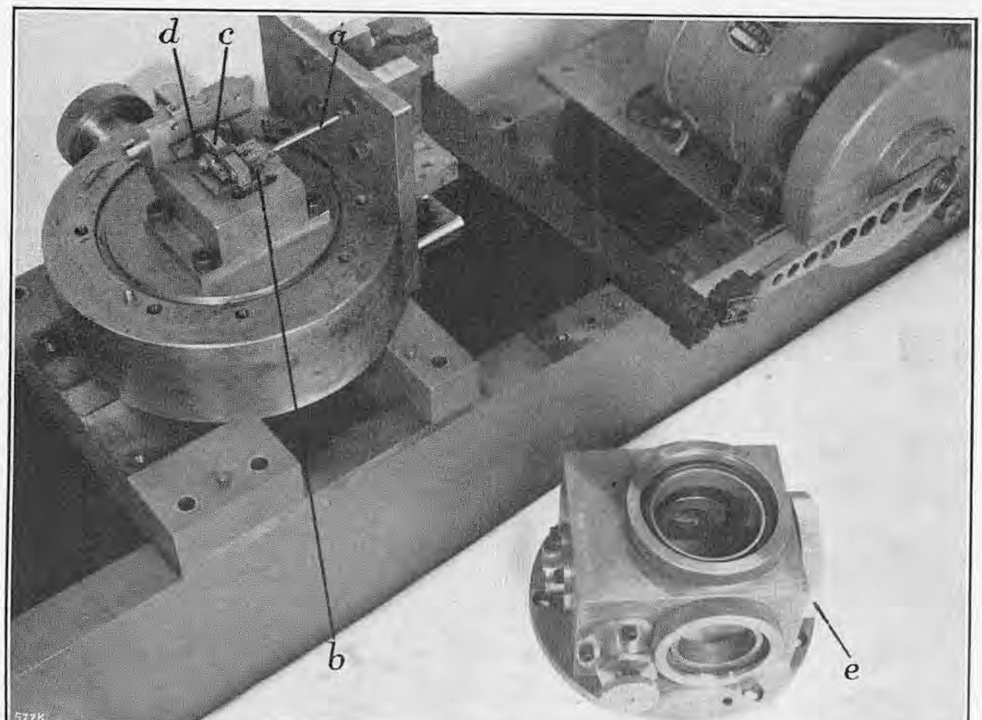

Fig. 10. Fretting-Corrosion Apparatus.

a. Oscillating Drive.
b. Specimen.
c. Loading Yoke.
d. Locating Strips arranged so that Upper Specimen may be drawn clear of Lower Specimen to permit Inspection under Vacuum.
e. Vacuum-tight Housing with Glass Inspection Window.

film of one of the surfaces is continually removed and is replaced by a further film, due to the action of atmospheric oxygen. The author has no convincing evidence that this form of wear is common, but experiments are in progress in an apparatus wherein a pair of specimens may be enclosed in an atmosphere of any desired composition. It is, however, closely analogous to corrosive wear, which occurs in the presence of substances capable of vigorous chemical attack on the surfaces. This form of wear is one of the most urgent problems in internal-combustion engine practice, due to the increasing use of fuels with a high sulphur content.

Wear may sometimes consist of a plastic deformation or flowing of the surface. An extreme example is shown in Fig. 6, opposite, which is a section of the brass specimen which rubbed against the surface illustrated in Fig. 5. The wear which occurs in practice is usually a combination of one or more of the elementary forms. For example, the debris arising from welding wear may easily give rise to abrasive wear.

Scuffing is a particularly difficult form of wear and should be distinguished from seizure. It usually occurs where high loads are met with in association with high speeds. In the circumstances, hydrodynamic effects arising from the high speed afford protection until loading conditions cause a local breakdown. When this occurs, the extreme conditions of speed and load afford potentialities for a rapid supply of energy to the critical surface, resulting in welding, melting and the characteristic severe localised failure of the surface. Sometimes, if speed is increased beyond the point causing scuffing, rapid wear of the surface of a less localised nature occurs, the removed metal being carried away as debris in the oil.

If scuffing is ascribed to inadvertent metallic contact at speed, means tending to limit the possibility of such contact would be expected to have a beneficial effect. This is definitely so. For example, phosphating the surface does provide protection at the instant of breakdown of the lubricant, and phosphated gears may be made to work more intensively than if they were untreated. Another palliative, which is extensively used, is to incorporate chemically active agents in a lubricant so that protective films are formed at the points of weakness. These agents are usually referred to as E.P. (extreme pressure) additives. It is certain that these additives act by attack on the surface; they may even increase the rate of wear. It is not, however, quite so well understood just how they function; for example, do they merely form a barrier to welding? Or do they melt and, in fact, constitute a high-viscosity lubricant at the critical areas?

Another distressing form of wear is known as "fretting corrosion." This is rather a special type, in that it only occurs where components are in contact and subject to very slight relative movement of an oscillatory character. It is now known that the degree of corrosion is affected by the applied load, by the nature of the surrounding atmosphere, etc. A tentative theory accounting for the phenomenon is that the oscillatory motion breaks down any natural protective film carried by the surface, so that metal adheres and is broken away at each oscillation. The presence of lubricant may sometimes prevent the oxidation of these particles, so that a scratching of the surface results, Fig. 7. However, when free access of air and moisture vapour is allowed, the debris may be converted into an abrasive oxide, which causes the severe damage met with in practice, the escaping oxide being often referred to by engineers as "cocoa" because of its brownish-red colour and small particle size. Comparison of Fig. 7, B.P. paraffin lubricant, and Fig. 8, dry, shows the effect of the lubricant. The phenomenon can therefore be regarded primarily as arising from metallic contact, but the entry of oxygen provides a secondary phase which, from the engineering point of view, is much more disastrous. This is borne out by certain experiments; for example, gold, which does not oxidise, suffers damage of a scratching nature, but steel in normal atmosphere produces copious supplies of damaging oxide.

Here again the artificial increase in the natural protection of the surface by phosphating leads to considerable benefit, as shown in Fig. 9, and the presence of oil tends to act as a barrier to oxygen, thereby minimising the rate of attack. The depth of corrosion is reduced from 8×10^{-3} cm. to $2 \cdot 5 \times 10^{-5}$ cm. in the specimens shown. In practice, therefore, it is wise to adopt both methods, that is, phosphating to prevent metallic contact and copious supplies of lubricant to remove debris and to minimise the supply of oxygen to any naked metal which may be exposed by penetration of the thick phosphate layer. Experiments are proceeding on this very intriguing subject and include the use of the apparatus illustrated in Fig. 10, which has been designed so that fretting may be done either in a very high vacuum or in the presence of selected gases in order that the effect of oxygen, moisture, vapour, etc., can be investigated. Such work may provide a basis for the formulation of more highly refined palliatives than the aforementioned.

(To be continued.)

Injuries to Feet.—In a note we have received from Sir Alfred Herbert, he says: "For many years I have been trying to reduce the number of accidents to the feet of workers in engineering workshops. These accidents . . . differ from most other accidents in the fact that a definite preventive is available, viz.: the wearing of safety boots with internal steel toe caps, the use of which will prevent about 80 per cent. of the injuries which are now taking place. In my company's workshops, we have succeeded in reducing foot accidents from 89 in 1943 to 17 in 1950, though during 1951 they have again risen to 33. Our records show that out of 326 foot injuries which have occurred during the past nine years, at least 249 would have been avoided if safety boots had been worn. During this period we have sold to our workers over 6,000 pairs of safety boots, but there are still many who are not wearing them. In order to encourage the further use of these boots we have recently arranged that they may be paid for by small weekly instalments. . . . I believe much can still be done by management and workers alike to encourage the more general use of these invaluable and effective safeguards."

THE GATESHEAD FACTORY OF SIGMUND PUMPS, LIMITED.

Although they were one of the leading Continental manufacturers of pumps for a considerable number of years, it was not until 1938 that Sigmund Pumps, Limited, commenced production of their equipments in the United Kingdom. The pressure of international events, however, soon necessitated radical changes in their original policy and resulted in a rapid expansion of manufacturing capacity to complete large government contracts which the company was called upon to fulfil. At the same time, the original plans of the company had to be left in abeyance and, during the war, only a relatively small number of pumps was supplied to industry, while the conditions then existing precluded the establishment of a proper sales organisation. At the end of the war, two major steps were taken towards the setting up of a peacetime organisation. In the first place, pre-war contacts with the old Czechoslovakian company were renewed in many overseas centres, overseas agents were appointed and the first orders for standard pumps, based on the pre-war range, obtained. Concurrently, it was decided that, in view of the highly competitive conditions in the United Kingdom for standard pumps, the Sigmund range should be extended by including pumps for use in the oil-refining and allied industries.

This decision called for considerable initiative as, hitherto, this type of equipment had been supplied almost solely by the American pump industry, which had built up a large connection and obtained invaluable experience of the conditions peculiar to this application, such as extreme pressures and widely-varying operating temperatures. The decision, therefore, was not taken lightly but only after the matter had been discussed with the Government departments directly concerned and the leading oil companies. As a result of the encouragement received from these quarters, designs were prepared and subsequently orders placed for a new series of Sigmund pumps, which already are operating in the new Shell refineries at Stanlow, Shell Haven, Venezuela, Holland and France, in the new Esso refinery at Fawley and at the Llandarcy refinery of the Anglo-American Oil, to mention but a few. The range of refinery-process and chemical pumps quickly grew and it soon became apparent that the then existing premises in which the company were operating would be inadequate to cope with the envisaged production. It was decided, therefore, to erect a new plant on the Team Valley trading estate, Gateshead-on-Tyne, designed for the production of pumps and with modern production and testing equipment. The Team Valley was chosen as the site of the new factory as it offers excellent transport facilities and has the great advantage of being in an area where there is an abundance of skilled labour. Although the factory first started production about two years ago, the installation of new machinery and the addition of extra staff has only recently been completed.

The new plant covers an area of approximately 140,000 sq. ft., but sufficient spare ground is available to permit the factory to be doubled in size. It comprises a main factory, a large administration block, covered loading and storage spaces, a transformer station, a boiler house and the usual facilities such as canteens, etc. The main factory consists of a series of bays which can be subdivided by partitions to suit any layout. The smaller bays form the light shops, which include machining, fitting, assembly, hardening, inspection and service shops; and two larger bays, which are illustrated in Figs. 5 and 6, on page 656, form the heavy shops where bedplate, etc., are fabricated, and mounting, lining up and testing of components and complete pumps are carried out. In the heavy shops there are two overhead cranes, one of 5 tons and the other of $7\frac{1}{2}$ tons capacity, the latter being arranged to serve the loading and dispatch bay as well. In the light shops several fixed-jib cranes with a capacity of 1 ton have been installed and, in addition, there are a number of electric hoists for lifting the work into and out of the various machine tools. All production processes are carried out in this one building, the work flowing in an orderly sequence through the machine shops, fabrication and assembly departments to the test and dispatch sections at the other end of the factory. By adopting this procedure, handling is reduced to a minimum and a close watch maintained at all stages of production.

The machine shop, which is illustrated in Figs. 1 and 2, on this page, covers several bays and is equipped with a wide range of modern machine tools such as horizontal and vertical borers, capstan and turret lathes, shapers, plano-millers, etc. In addition, there are several special-purpose machine tools which have been designed to deal with certain components peculiar to pumps; a good example is provided by a grinding machine arranged to handle shafts of exceptional length. The machine shop is supplied with the necessary jigs and tools by a modern toolroom, which incorporates a special section devoted to the maintenance of tools and gauges so as to ensure all equipment of this nature is kept in good condition. This is an important feature, as all components are produced to close tolerances, so that spare parts can be replaced and interchanged in the field without difficulty. As a consequence, a considerable number of gauges are employed in the factory. Other facilities provided include a fully-equipped heat-treatment shop and a section for the hard-facing of special components in a variety of metals. There is also a large pattern shop, though the firm do not produce their own castings; in view of the wide variety of metals used, this is nor surprising.

Particular attention has been paid to the design and layout of the testing facilities. The main test tank is built below ground level and has a total capacity of 100,000 gallons, being built up from four interconnected compartments. There is also a well 35 ft. deep for testing vertical-spindle and submersible pumps. Capacities are measured by two channels provided with several weirs of the usual form, one channel being designed for capacities up to 6,000 gallons per minute and the other for capacities up to approximately 40,000 gallons per minute. Surface tanks, together with venturi tubes, nozzles, etc., are also available for dealing with smaller pumps. For testing electrically-driven pumps, points are provided for different voltages of both direct and alternating current, the complete switchgear together with the transformers, etc., being installed on a separate platform arranged over the test bay. This arrangement can be seen in the photograph of the test area reproduced in Fig. 8, on page 656. A large variety of small calibrated electric motors is available in the test area and, in addition, there is a 300-h.p. electric motor having a speed of 3,000 r.p.m., also a 500-h.p. motor operating at 1,450 r.p.m., the higher-speed motor having been installed for the testing of refinery pumps, for which 3,000 r.p.m. is the normal operating speed.

THE SIGMUND PUMP FACTORY, GATESHEAD.

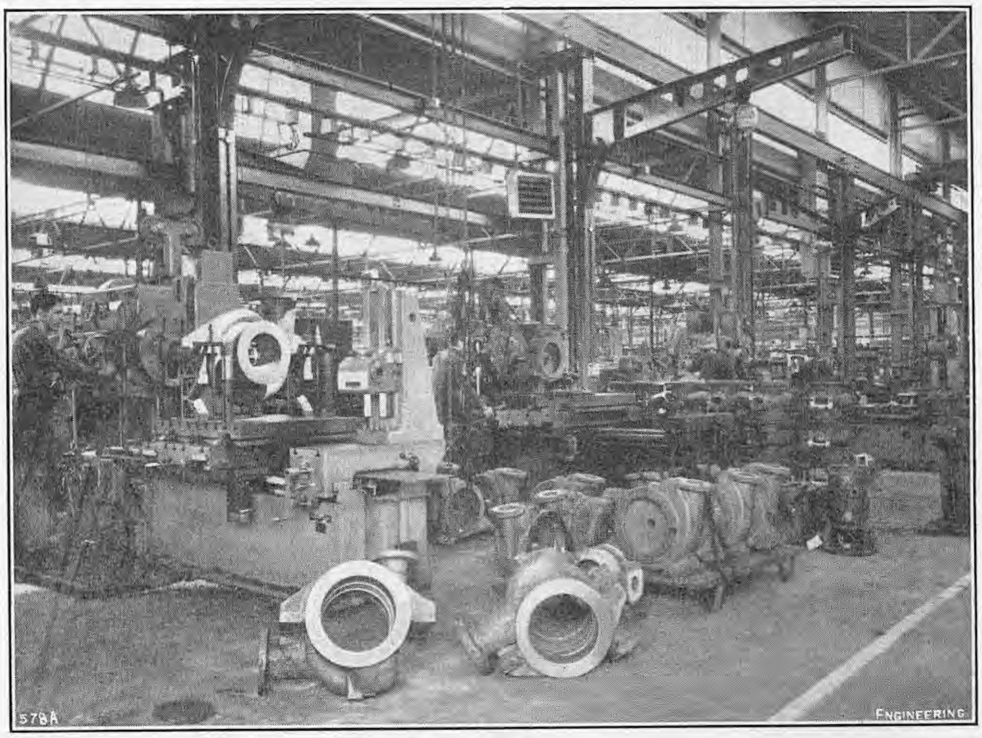

Fig. 1.

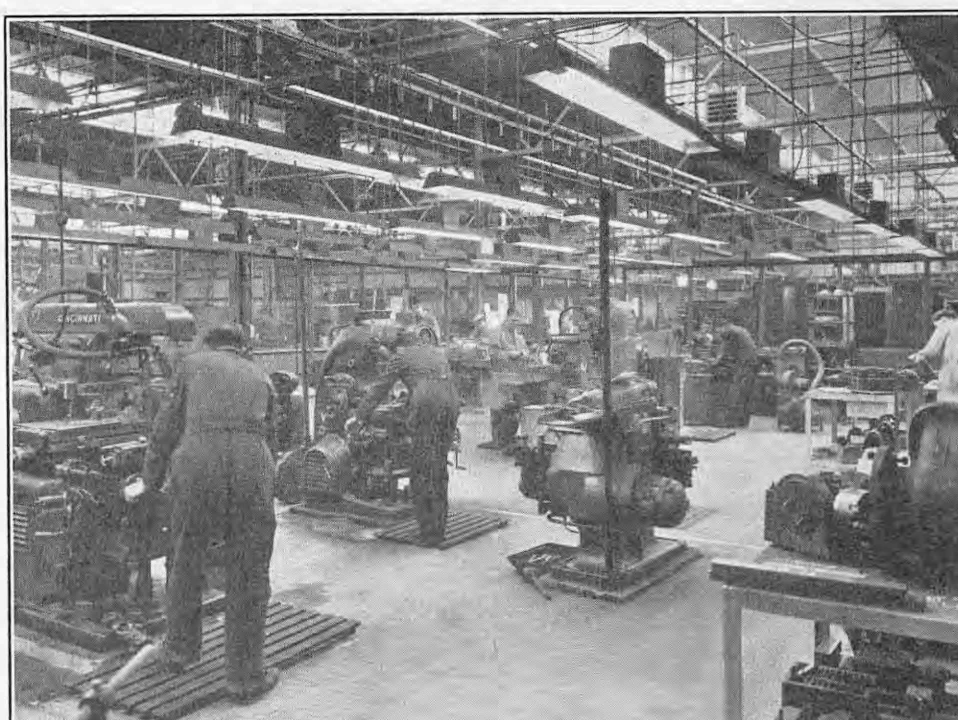

Fig. 2.

Figs. 1 and 2. Machine Shop.

PROCESS PUMPS FOR OIL-REFINING DUTIES.

SIGMUND PUMPS, LIMITED, GATESHEAD.

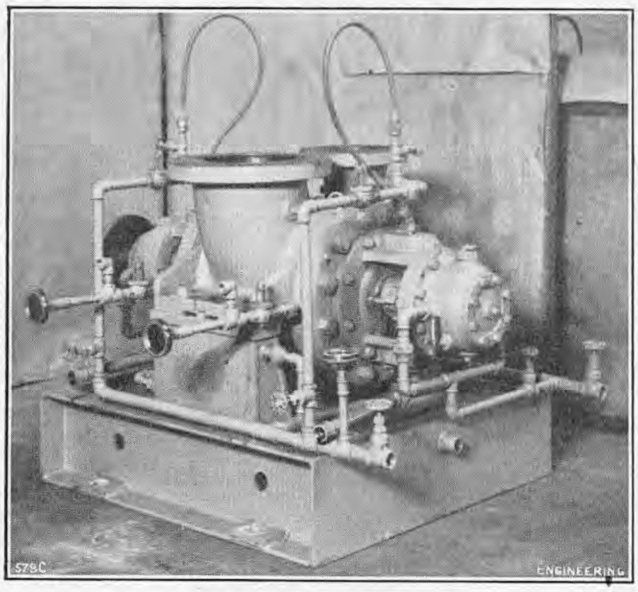

Fig. 3. Double-Entry Single-Impeller Pump.

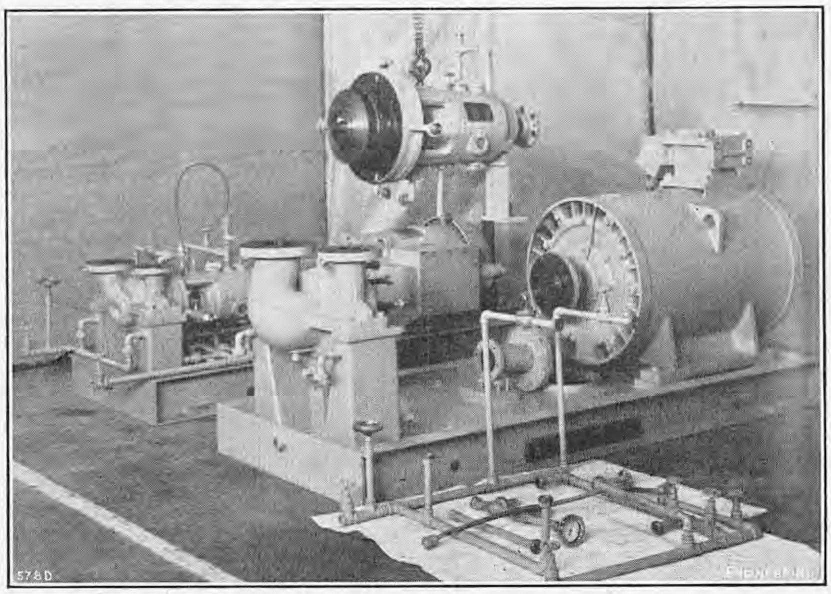

Fig. 4. Single-Stage Single-Entry Impeller Pumps.

A speed-increasing gear is also available, use of which enables speeds of 3,600 r.p.m. to be obtained. Testing of small steam-turbine driven pumps is carried out by using steam from the main boiler house, the maximum pressure available being 450 lb. per square inch. The efficiencies of the smaller pumps are determined by means of torsional dynamometers, a number of which are installed in the test area. As far as possible, all instruments in the area are mounted on panels.

As previously mentioned, Sigmund Pumps, Limited, are now producing an extensive range of units for the oil-refining and allied industries. The design of such units differs somewhat from usual practice, as the fire and explosion risks are extremely high, particularly where liquids such as high-octane petrol, propane, naptha, etc., are being handled. These liquids are frequently pumped through the refinery area at temperatures well above flash-point; the number of joints is therefore kept to a minimum and coolant is fed to the bearings and glands. Selection of materials is also important and many different alloys are used, according to the duty undertaken. In many instances, the working life of these pumps is extended by incorporating the shaft sleeves casing, and impeller wear-rings manufactured from high-duty steels and hardened by means of Stellite or Colmonoy deposits fused to the parent metal and then super-finished. With this method, hardnesses of the order of 1000 Brinell have been obtained. Care has also to be taken at the design stage to ensure easy maintenance and quick replacement of worn parts. Consequently, all pumps are made so that, when inspection of the rotating parts proves necessary, the complete impeller and shaft assembly can be withdrawn without breaking any joints in the pipelines and without affecting the alignment of the pump and its prime mover. To ease maintenance further, extremely high speeds are used, so as to reduce to a minimum the number of parts in each pump.

A photograph showing a selection of typical Sigmund process pumps, part of a contract completed recently for the new Shell refinery in Venezuela, is reproduced in Fig. 7, on page 656. Two of these pumps are shown separately in Figs. 3 and 4, herewith, Fig. 3 showing a single-stage double-entry centrifugal pump and Fig. 4 two single-stage single-entry pumps, one assembled and the other partially dismantled. The double-entry pump is manufactured from stainless steel and is intended to pump 1,460 U.S. gallons per minute of crude-oil product at 570 deg. F. against a pressure of 590 ft. when operating at 3,550 r.p.m. Both the suction and discharge branches are incorporated in the main casing and the design is such that it may be dismantled without breaking any pipe joints. The stuffing boxes are provided with external water cooling, further cooling being effected by the sealing liquid circulating through the lantern spaces. The shaft is protected against wear in the stuffing-box portions by sleeves, the surfaces of which are hardened by means of deposits fused to the parent metal, a process referred to previously. Ball and roller bearings are used to support the shaft, the bearing at the driving end being of the heavy roller type, while that at the opposite end is of the double-row double-thrust ball type. Both bearings are water-cooled and are lubricated by rings. One high-pressure joint is used at each side of the pump, sealing being effected by metallic gaskets in circular recesses.

The two pumps illustrated in Fig. 4 have been constructed to handle gas-oil products at temperatures up to 480 deg. F. They are of the single-stage overhung impeller type and, like the double-entry pump just described, have been designed so that they can be dismantled without breaking any pipe joints other than those used in the cooling and gland-sealing systems. The ease with which the impeller and associated parts can be removed will be apparent from a study of the partially-stripped pump shown in the foreground of Fig. 4. In general, the same design principles are used in these pumps as for the double-entry pump, the suction and discharge branches being cast integrally with the body, the shafts protected by sleeves with hardened surfaces and the high-pressure joints, of which there is only one for each pump, sealed by metallic rings. The shafts are supported by double-row ball bearings, the thrust being taken by angular-contact ball bearings located at the tail end of each pump. Lubrication is by means of oiling rings and, in accordance with the firm's standard practice, the bearings are water-cooled. Gear-type flexible couplings are employed to transmit the drive to the impeller, the design being such that each coupling can be dismantled and the rotating element withdrawn without disturbing the alignment of the pump casing and the driving motor.

CONTRACTS.

Barclay, Curle and Co., Ltd., Glasgow, are to build two single-screw turbine cargo steamers, each having a gross tonnage of 8,800, a deadweight capacity of 10,000 tons, and a speed of 16·5 knots, to the order of the British India Steam Navigation Co., Ltd., 122, Leadenhall-street, London, E.C.3. A third ship of identical dimensions will be built for these owners by Scotts' Shipbuilding and Engineering Co., Ltd., Greenock, and a fourth by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne.

Head, Wrightson & Co., Ltd., Thornaby-on-Tees, have received an order from the Appleby-Frodingham Steel Co., Scunthorpe, Lincolnshire, a branch of the United Steel Cos., Ltd., for a new iron-ore-preparation plant. This will comprise screening, fine-crushing and sintering equipment and will be capable of treating 3,750,000 tons of low-grade Lincolnshire and Northamptonshire iron ores per annum.

The English Electric Co., Ltd., Queen's House, Kingsway, London, W.C.2, have received an order, as stated on page 668, for a 60-MW turbo-alternator for the J. Clark Keith generating station at Windsor, Ontario. This power station is being constructed by the Hydro-Electric Power Commission of Ontario. Three similar turbo-alternators for the same station have already been ordered by the Commission from the English Electric Co. This fourth set will bring the station's total capacity to 240,000 kW. Each of the four sets will run at 3,000 r.p.m., and the turbines are designed to operate with steam at a pressure of 850 lb. per square inch, and a temperature of 900 deg. F. The turbines are of two-cylinder impulse-reaction design, and the alternators supply current at 13,800 volts, three-phase, 50 cycles.

CENTRAL HEATING FROM ATOMIC PILE.

Since last Monday, November 19, a building containing 80 offices has been drawing its heat direct from Bepo, the large experimental atomic pile at the Ministry of Supply Atomic Energy Research Establishment, Harwell. Eventually, two, and perhaps three, more buildings will be heated in this way, and the Ministry's coal consumption will be cut by at least 1,000 tons a year. After counting all incidental expenses, the saving in cash is estimated at 2,650*l*. a year. Costs of the installation amount to 15,000*l*. The hot water is obtained by placing a heat-exchanger in the outlet air duct of the pile's air cooling system. Here there is a by-pass fitted with a damper which can be adjusted to vary the proportion of the air flow passing through the heat-exchanger. Hot water from the exchanger is then circulated in a closed circuit by a small pump to a secondary water-to-water heat-exchanger. This supplies hot water for space heating and domestic hot-water supplies.

At present the air temperature at the primary heat-exchanger is 135 deg. F., and the water itself is heated to 130 deg. In 1952, when modifications to the pile have been completed, these temperatures will be substantially increased. There is, of course, no danger from radioactivity and the water can safely be used for washing. The heat output designed for the first building is 1,000,000 B.Th.U. per hour, but for the final installation the maximum output will be 7,000,000 B.Th.U. per hour. The total floor area now being heated is 32,000 sq. ft. and the space is 330,000 cub. ft. When the system is extended to include other buildings, no other heat-exchanging apparatus will be required, and it will only be necessary to connect the piping. The installation was carried out by the Ministry of Works in collaboration with the Engineering Division of the A.E.R.E. The heat exchanger, measuring 10 ft. by 10 ft. by 2 ft. 6 in., weighs 8 tons.

British Association Appointments.—The Council of the British Association announce the following appointments for the forthcoming year, which will include the annual meeting at Belfast, from September 3 to 10, 1952: President, Professor A. V. Hill, C.H., O.B.E., F.R.S.; general treasurer, Mr. M. G. Bennett; general secretaries, Sir Richard Southwell, F.R.S., and Dr. George Taylor. The presidents of certain sections will be as follows: A (Mathematics and Physics), Professor A. M. Tyndall, C.B.E., F.R.S.; B (Chemistry), Professor W. Wardlaw, C.B.E.; C (Geology), Dr. J. E. Richey, F.R.S.; G (Engineering), Sir Ben Lockspeiser, K.C.B., F.R.S.; and L (Education), Mr. A. L. Binns, C.B.E., M.C.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND

Iron and Steel Production.—Production of steel ingots and castings in Scotland during October was equivalent to an annual rate of 2,147,800 tons, compared with 2,114,200 tons in September. The corresponding rate in October last year was 2,574,100 tons. The output of pig iron represented 847,700 tons per annum, in contrast to 852,900 tons in September and 861,000 tons in October last year.

Coal for Coke and Gas Manufacture.—The estimated overall deficiency of coking coal in Scotland by 1960 would be 1,056,000 tons, according to Dr. E. A. C. Chamberlain, chief scientist to the Scottish division of the National Coal Board, who addressed the Mining Institute of Scotland in Glasgow on November 14, on "The Utilisation of Coal." It was clear, he said, that coking coal would have to be reserved for the production of metallurgical coke, and the gas industry must be prepared to make use of non-coking coals. The consumption of coal for gas manufacture in Scotland in 1950 was 2,381,000 tons; by adopting processes of complete gasification, this output could be maintained for a non-coking coal consumption of 730,000 tons, a saving of 1,651,000 tons.

Scottish Peat Resources.—The establishment of a National Peat Board with powers to develop an estimated 2,000,000 acres of Scottish peat, in an attempt to meet the fuel and food crisis, has been advocated in a letter sent by the Scottish Peat and Land Development Association to Mr. James Stuart, Secretary of State for Scotland. They state that if Scotland's peat resources were utilised, as in all other European countries with large deposits, there would be no cause for anxiety over the supply of fuel and power.

Electricity Tariffs.—New electricity tariffs for industrial consumers are to be brought into operation by the South-West Scotland Electricity Board on December 15. The Board have decided that there will be a block tariff (available to all industrial consumers) on the basis of the first 100 units per quarter at 2*d.* a unit, and the balance at 1·65*d.* a unit. Consumers whose demand is 20 kW or more will have the alternative of a tariff based on their maximum demand, with a sliding charge adjusted to their actual consumption and with an additional sum for all units charged. The unit charge will be subject to variations in the price of coal.

The Trade of Leith.—Despite a heavy decrease in scrap-iron imports and no improvement in coal exports, the overall total of imports and exports at Leith was higher during the first nine months of this year than in the corresponding period of 1950, stated Mr. George Veitch, representative of the Edinburgh Chamber of Commerce and of the manufacturers on Leith Harbour Commission, at the quarterly general meeting of members on November 15. Shortages of dock labour, he added, had been very marked in recent months.

The Tay Ferry "Dundee."—The old Tay Ferry paddle steamer Dundee, which has been docked at Burntisland since February of last year, has been towed to Charlestown, Fife, to be broken up by Metal Industries, Ltd. The vessel was built in 1875 by William Simons & Co., Ltd., Renfrew, and registered at Granton.

CLEVELAND AND THE NORTHERN COUNTIES.

The Position in the Iron-Steel Industry.—No surprise was expressed in North-East Coast commercial circles at the Government's decision to postpone re-imposition of the tonnage allocation scheme. There is general agreement that some system of sharing distributable tonnage of iron and steel is necessary, and the delay in the re-introduction of a system is understood to be to afford an opportunity to devise a more flexible method than that employed during the war. Thus, until February 4 next, supplies will be distributed as at present. Shortages of commodities urgently needed in large quantities are probably accentuated by buyers endeavouring to place orders with several different sellers.

Decline in Coal Exports.—During the first ten months of the present year, ended October 31, shipments of coal and coke from the River Tyne declined by upwards of 800,000 tons as compared with those of the corresponding period of 1950. The total was less by 3,000,000 tons than that for 1938.

Drift from Agriculture to the Collieries.—At a recent meeting of the Yorkshire North Riding and South Durham County branch of the National Farmers' Union, held in Darlington, it was reported that many young men employed in agriculture in County Durham were leaving this work to enter collieries in the district. After some discussion, it was decided to request the headquarters of the Union to investigate the matter and, if possible, to supply data regarding the drift from the land to the pits in other colliery districts.

LANCASHIRE AND SOUTH YORKSHIRE.

Man-power in the Mines.—Experience has shown that the winter period has been a good time for the recruitment of man-power at the collieries. In the Yorkshire coalfield, there was a gain last winter of 200 men and it is noteworthy that, this year so far, the fall in man-power has been arrested. Gains are now replacing losses, but there seems no hope, at present, of reaching the desired strength of 139,500 by the end of the year. The total is now about 4,000 fewer than this figure. By the end of the first nine months of this year, however, the number employed had increased by 1,600 in the North-Eastern Division.

Steel Denationalisation.—Leaders in the steel industry at Sheffield have welcomed the initial steps taken towards denationalisation. The Master Cutler, Mr. G. M. Flather, in expressing satisfaction, emphasised that his view was not expressed as a political opinion, but was based on his knowledge of the industry and its economics. In Sheffield, he said, many independent steel users, not themselves nationalised, had expressed fears that there might be discrimination in the allocation of supplies; these fears had now been allayed.

Peak-Load Economy.—The Sheffield Electricity Peak Load Economy Committee has been formed with the object of explaining to commercial and domestic users how to regulate their consumption at peak periods without interfering with routine. Speakers who address meetings arranged by the Committee will make a point of explaining the power consumption of different appliances.

Cutlery Imports.—The imposition of a restriction upon the import of cutlery has given satisfaction to Sheffield manufacturers. In point of fact, in September, before the restriction came into force, there was a considerable fall in the import of German and Italian cutlery. This is attributed, in part, to the closing of the Festival of Britain functions, which had attracted souvenir types of foreign pocket knives and scissors.

THE MIDLANDS.

Water Pipes and the Metal Shortage.—At a meeting of the Midland branch of the Association of Waterworks Officers, held at Wolverhampton on November 9, the question of alternative materials for water pipes was among the items discussed. Mr. T. G. Griffin, water engineer to the Corporation of Leicester, said that waterworks undertakings had looked to the plastics industry for an alternative to metal pipes for a long time. In the present shortage of metals of all kinds, the use of plastics might be extended. Plastic pipes had many advantages, and, in particular, they could be used where the water was corrosive.

The Late Mr. Joseph Payton.—The death has occurred, on November 16, of Mr. Joseph Payton, of Solihull, Warwickshire. Mr. Payton, who was 79, was a director of the District Iron & Steel Co. Ltd., Smethwick, and the New Cransley Iron & Steel Co., Ltd., Kettering, until the nationalisation of those companies. He was president of the Staffordshire Iron and Steel Institute in 1921.

New Lightweight Cycle Power Unit.—Tube Investments, Ltd., Birmingham, have developed an entirely new lightweight petrol engine for attachment to pedal bicycles. It is a two-stroke rotary engine, mounted in a special rear wheel, and is claimed to be the first rotary engine designed for this application.

Gas Supplies.—Mr. G. le B. Diamond, chairman of the West Midlands Gas Board, in a report to the Gas Consultative Council, published on November 12, said that it has been necessary to refuse extra supplies of gas to industrial consumers because of shortage of coal and gas plant. The total demand refused amounted to 9,300 million cubic feet yearly—more than the combined sales of Wolverhampton and Coventry.

Plans for an Old Canal.—The Town Council of Halesowen, Worcestershire, have under consideration the question of taking over 2,000 yards of a canal between Mucklow Hill and Lapal tunnel. The canal was built to provide communication between the Dudley canal, in the south-western part of the Black Country, and the Worcester and Birmingham canal near Birmingham. The section from Halesowen has not been used for commercial traffic since 1917, when a portion of the Lapal tunnel collapsed; this tunnel was opened in 1793, and is the third longest in the country (3,795 yards). There is an alternative route via Netherton tunnel, which is much more modern. The line of canal in question was used for pleasure boating until the recent war, but has since become choked with weeds. Halesowen Council are considering either clearing the canal and making it available once more for pleasure boating, or filling it in and making a public walk along its course.

Midland Flooding.—The heavy rains of the past two weeks have caused much flooding in the Severn and other Midland river valleys. An unusual feature has been the stoppage of Hereford's water supply. The water is drawn from the river Wye, and the intakes were choked by flood water and debris. Temporary arrangements were made by the fire brigade to deliver water in 500-gallon tenders to central points, where the city's population of 32,000 could collect it.

The Samson Stripper in the Midlands.—A Samson stripper is now working successfully at the Lipstone Colliery, near Mansfield, in the National Coal Board's East Midlands Division. It is operating on a face 200 yards long, with Dowty hydraulic pit props for roof support, and has enabled the output per man-shift to be raised to ten tons. The next two Samson strippers to be installed in the Midlands will be at Kingsbury Colliery, near Tamworth, and at the Deep Pit, near Hanley, both in the West Midlands Division. The Kingsbury machine is expected to be delivered soon, and that at Hanley before the end of next year.

SOUTH-WEST ENGLAND AND SOUTH WALES.

Traffic at South Wales Ports.—A total trade of 17,170,191 tons was handled at the South Wales group of ports from January 1 to November 4 this year, this being an increase of over 1¼ million tons over the figure for the corresponding period of 1950. Imports rose from 6,036,650 tons to 7,884,756 tons, but there was a small decline in exports. The rapid growth of the oil trade to nearly 6,000,000 tons, compared with just over 4,000,000 tons a year ago, was the chief feature. Swansea, which handles most of the oil, did almost as much trade as all the other ports together. Newport, Barry, and Penarth docks showed small improvements, but Cardiff, Port Talbot and Briton Ferry had less trade than a year ago.

Petroleum Gas in Town Mains.—An experimental plant for the storage of liquid petroleum gas, to be distributed through the town's gas mains, is being installed at Whitland, Carmarthenshire. Mr. T. Mervyn Jones, chairman of the Wales Gas Board, made the announcement at the annual dinner of the South Wales branch of the Institution of Mechanical Engineers. The experiment is in the nature of a pilot plant for the whole of Great Britain, he said, and the chief credit for it was due to a member of the branch, Mr. E. M. Edwards. Alternative systems of using a butane-air mixture, one American and one French, would shortly be tried out.

Wind Recording on Suspension Bridge Site.—Specially-designed wind-recording apparatus has been made by the Meteorological Office for the Ministry of Transport, to provide information concerning wind strengths and directions in the locality of the proposed new suspension bridge over the Severn, near Chepstow. Several problems had to be overcome in the design of the instruments, to meet the special requirements of the bridge engineers. Chief among these was the measurement of winds inclined to the horizontal which persist for periods of half a minute or more. Six instruments have been provided, each of which will automatically record data on the behaviour of the wind from all directions.

Unemployment in Wales.—A total of 24,743 adults and juveniles were registered as unemployed in Wales on October 15, 8,189 less than at the same time last year. Compared with September, however, there was an increase in unemployed—928 men, 1,414 women and 173 girls. There was a decrease of 92 in the number of boys out of work.

Reconstruction of Swansea Centre.—A preliminary scheme for the next stage of reconstruction work in the centre of Swansea, which was largely destroyed during the war, has been discussed by the local borough Parliamentary Committee. It was agreed that officials should confer with the Ministry of Housing and Town Planning and the Ministry of Transport on the matter.

Cardiff Municipal Airport.—Questions on the future of Cardiff's municipal airport, consequent upon the fact that an aerodrome at Rhoose in the Vale of Glamorgan is likely to become the air terminal for South Wales next year, are to be addressed by the City Council to the Ministry of Civil Aviation. The Cardiff Airport has been requisitioned since 1939.

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.

Institution of Electrical Engineers.—*Radio Section:* Monday, November 26, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "Should Broadcasting be Superseded by Wire Distribution?" opened by Mr. P. P. Eckersley. *North-Eastern Centre:* Monday, November 26, 6.15 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. "The Dimming of Low-Pressure Discharge Lamps," by Mr. C. E. Williams, B.Sc. *London Students' Section:* Tuesday, November 27, 7 p.m., Victoria-embankment, W.C.2. "Use of Working Scale Models in the Development of Broadcasting Aerials," by Mr. T. R. Boys. *South Midland Centre:* Tuesday, November 27, 7.15 p.m., Works Institute, Hylton Road Power Station, Worcester. "Surge Diverters for the Protection of Alternating-Current Systems," by Mr. T. F. Monahan. *Supply Section:* Wednesday, November 28, 5.30 p.m., Victoria-embankment, W.C.2. "A Statistical Approach to Problems in Electricity Supply," by Mr. R. B. Rowson. *Scottish Centre:* Thursday, November 29, 7 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Use of Saturable Reactors as Discharge Devices for Pulse Generators," by Mr. W. S. Melville. *Institution:* Monday, December 3, 5.30 p.m., Victoria-embankment, W.C.2. Informal Meeting. Discussion on "Are Sales Representatives Necessary?" opened by Commander R. B. Fairthorne.

Illuminating Engineering Society.—*Leeds Centre:* Monday, November 26, 7 p.m., Lighting Service Bureau, 24, Aire-street, Leeds, 1. "Hospital Lighting," by Mr. J. K. Frisby. *London:* Wednesday, November 28, 6 p.m., Lighting Service Bureau, 2, Savoy-hill, W.C.2. Discussion on "The Recent Meeting of the International Commission on Illumination at Stockholm."

Institution of Production Engineers.—*Southern Section:* Monday, November 26, 7 p.m., Municipal College, Portsmouth. "Thread Production and Inspection," by Mr. F. Hodgkins. *Luton Section:* Tuesday, November 27, 7.15 p.m., Town Hall, Luton. "Difficulties and Developments in Deep Drawing and Pressing," by Dr. J. D. Jevons. *Coventry Section:* Wednesday, November 28, 7 p.m., Geisha Café, Hertford-street, Coventry. "Preservation and Packing," by Mr. F. Chapman. *Lincoln Section:* Wednesday, November 28, 7.30 p.m., Blue Bell Hotel, Scunthorpe. "Time and Work Studies in Heavy Industry," by Mr. J. R. Widdowson. *Shrewsbury Section:* Wednesday, November 28, 7.30 p.m., Technical College, Shrewsbury. "Craftsmanship of Output as Applied to American Brassfoundry Work," by Mr. F. E. Rattlidge. *South Wales and Monmouthshire Section:* Thursday, November 29, 6.45 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Productivity and the Machine Tool," by Mr. N. Stubbs.

Institution of Works Managers.—*Glasgow Branch:* Monday, November 26, 7.15 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Spoken Communication in Industry," by Mr. A. C. Leyton.

Junior Institution of Engineers.—*Sheffield Section:* Monday, November 26, 7.30 p.m., 201, Napier-street, Sheffield. Presidential Address on "Vulcanalia," by Professor F. J. Sarjant. *Institution:* Friday, November 30, 6.30 p.m., 39, Victoria-street, S.W.1. "Some American Windmills," by Mr. Rex Wailes.

Institute of Marine Engineers.—Tuesday, November 27, 5.30 p.m., 85, The Minories, E.C.3. "Automatic Combustion Controls for Marine Boilers," by Mr. B. Taylor. Friday, November 30, 7.30 p.m., Technical College, Barrow-in-Furness. "The Construction of Oil Tankers," by Mr. H. Armstrong.

Institution of Civil Engineers.—*Structural and Building Division:* Tuesday, November 27, 5.30 p.m., Great George-street, S.W.1. "Rapid Calculation of the Plastic Collapse Load for a Framed Structure," by Mr. B. G. Neal and Mr. P. S. Symonds. *Midlands Association:* Wednesday, November 28, 7 p.m., Loughborough College, Loughborough. "Water Supply," by Mr. Norman J. Pugh. *Yorkshire Association:* Friday, November 30, 6.30 p.m., Blue Bell Hotel, High-street, Scunthorpe. "Civil-Engineering Aspects of Major Plant Developments at the Appleby-Frodingham Steel Company," by Mr. K. Paterson.

Institution of Mechanical Engineers.—*South Wales Branch:* Tuesday, November 27, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Mechanical Engineering Features at Nantgarw Colliery," by Mr. T. G. Dash and Mr. J. Petit. *Yorkshire Branch:* Wednesday, November 28, 7 p.m., Mappin Hall, The University, Sheffield. "Engineering Possibilities of Afghanistan," by Dr. W. Abbott. *Institution (Applied Mechanics Group):* Friday, November 30, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Cup Drawing from a Flat Blank: An Experimental Investigation," by Dr. S. Y. Chung and Professor H. W. Swift. *Scottish Branch:* Friday, November 30, 7.30 p.m., Robert Gordon's College, Aberdeen. "Some Milestones in a Hundred Years of Marine Engineering," by Mr. Edward L. Denny. Automobile Division.—*Birmingham Centre:* Tuesday, November 27, 6.45 p.m., James Watt Memorial Institute, Birmingham. "Design and Development of Very Large Road-Haulage Vehicles," by Mr. C. E. Burton.

Institution of Heating and Ventilating Engineers.—*Scottish Branch:* Tuesday, November 27, 6.30 p.m., 351, Sauchiehall-street, Glasgow, C.2. Discussion on "Pneumatic Conveying and Dust Exhausting."

Sheffield Metallurgical Association.—Tuesday, November 27, 7 p.m., Grand Hotel, Sheffield. "Vermiculite as a Fuel Saver," by Mr. K. W. Cowling.

Royal Aeronautical Society.—*Section Meeting:* Tuesday, November 27, 7 p.m., 4, Hamilton-place, W.1. "Is It Possible to Simplify Aircraft and Retain Their Efficiency?" by Mr. W. S. Farren. *Society:* Thursday, November 29, 6 p.m., Institution of Civil Engineers, Great George-street, S.W.1. "Structural Problems in Advanced Aircraft," by Mr. H. H. Gardner.

British Institution of Radio Engineers.—*West Midlands Section:* Tuesday, November 27, 7 p.m., Wolverhampton and South Staffs Technical College, Wolverhampton. Discussion Evening.

Royal Society of Arts.—Wednesday, November 28, 2.30 p.m., John Adam-street, Adelphi, W.C.2. "The Whaling Industry," by Dr. Edward Hindle, F.R.S.

Liverpool Engineering Society.—Wednesday, November 28, 6 p.m., 9, The Temple, 24, Dale-street, Liverpool. "The Manufacture and Application of Mineral Wool," by Mr. A. M. MacGregor.

Institution of Structural Engineers.—*Wales and Monmouthshire Branch:* Wednesday, November 28, 6.30 p.m., Mackworth Hotel, Swansea. Discussion on "Structural Engineering Problems."

Royal Statistical Society.—*Industrial Applications Section:* Wednesday, November 28, 6.45 p.m., Chamber of Commerce, 95, New-street, Birmingham, 2. "A Comparison of Different Methods of Inspection," by Mr. B. H. P. Rivett. Thursday, November 29, 6.30 p.m., Grand Hotel, Sheffield. "Elementary Statistical Methods as an Aid to Foundry-Production Control," by Mr. W. G. A. Jenkins.

North East Coast Institution of Engineers and Shipbuilders.—*Student Section:* Wednesday, November 28, 6.45 p.m., Bolbec Hall, Newcastle-upon-Tyne. Lecture on "The Development of Mining Machinery," by Mr. T. Thompson.

Institute of Petroleum.—Thursday, November 29, 5.30 p.m., 26, Portland-place, W.1. "Methods for Expressing the Viscosity-Temperature Relationship of Lubricating Oils," by Mr. F. T. Blott and Mr. C. G. Verver.

Association of Supervising Electrical Engineers.—*Luton Branch:* Thursday, November 29, 8 p.m., George Hotel, Luton. "Oil-Switchgear Failures and Their Causes," by Mr. N. Elliott.

Royal Society.—Friday, November 30, 2.30 p.m., Burlington House, Piccadilly, W.1. Anniversary Meeting.

Manchester Association of Engineers.—Friday, November 30, 6.45 p.m., Engineers' Club, Albert-square, Manchester, 2. Open Discussion Meeting. (Paper on "Tubular Structures" postponed to March 7, 1952.)

Institute of Economic Engineering.—*Glasgow Branch:* Saturday, December 1, 10.30 a.m., 70, Bothwell-street, Glasgow. "Manufacturing Cost Standards and the Benefit to Works Management," by Mr. R. I. Campbell. *Birmingham Branch:* Saturday, December 1, 2.30 p.m., Chamber of Commerce, 95, New-street, Birmingham, 2. Annual Meeting, to be followed by a display of films.

Institution of Chemical Engineers.—*North-Western Branch:* Saturday, December 1, 2.30 p.m., Radiant House, Bold-street, Liverpool. "Study of Carbide-Furnace Operation," by Mr. R. B. Peacock.

Institute of British Foundrymen.—*Wales and Monmouthshire Branch:* Saturday, December 1, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Patternmaking for General Engineering Castings," by Mr. H. S. W. Brittain.

Institute of Metals.—*South Wales Local Section:* Tuesday, December 4, 6.30 p.m., University College, Singleton Park, Swansea. "The Solidification of Castings," by Mr. R. W. Ruddle.

Incorporated Plant Engineers.—Tuesday, December 4, 7 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. "Soil Mechanics," by Mr. A. Wilson. *South Wales Branch:* Tuesday, December 4, 7.15 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Design, Construction and Maintenance of Modern Concrete Mixers," by Mr. R. Morris-Prosser.

PERSONAL.

Sir Robert Micklem, C.B.E., R.N., chairman of Vickers-Armstrongs Ltd., and Sir James Reid Young, director of finance and administration of that company, have been appointed joint managing directors of Vickers Ltd., Vickers House, Broadway, London, S.W.1.

Lord Woolton, P.C., C.H., D.L., has resigned from the board of the Birmingham Small Arms Co., Ltd.

The Council of the Royal Society have awarded the Davy Medal to Sir Eric Rideal, M.B.E., F.R.S., and the Hughes Medal to Professor H. A. Kramers.

Mr. J. C. Carr, C.B.E., has been appointed to the Board of Thomas Summerson & Sons, Ltd., Darlington, and their subsidiary companies on his retirement as principal assistant secretary in the Ministry of Supply.

Mr. W. H. C. Pilling, B.A. (Cantab.), M.I.E.E., generation engineer (construction) of the southern group of power stations, Yorkshire Division, British Electricity Authority, has been appointed chief generation engineer (construction), Merseyside and North Wales Division.

Mr. M. Gaughan, B.Eng., A.M.I.E.E., has been appointed to the government and railways department of the British Thomson-Houston Company's lamp and lighting department, at Mazda House, Fitzroy-road, London, N.W.1.

Mr. C. T. Roberts, B.Sc. (Eng.), M.I.Mech.E., M.I.Loco.E., hitherto locomotive works manager, Western Region, British Railways, has been appointed carriage and wagon engineer, Western Region.

Mr. W. R. Mosby, M.I.R.S.E., indoor assistant to signal and telecommunications engineer, North Eastern Region, British Railways, has been made assistant signal engineer, signal and telecommunications engineer's office, North Eastern Region, York.

Mr. James Cleland has been appointed engineer-in-charge of the B.B.C. television transmitting station now being built at Kirk o'Shotts, between Glasgow and Edinburgh. His assistant will be Mr. W. L. Nicoll.

For reasons of health, Mr. B. Th. W. van Hasselt is relinquishing his positions as director-general of the Royal Dutch Petroleum Co., and as managing director of the operating companies of the Royal Dutch Shell Group, to take effect on December 31. In consequence, Mr. L. Schepers has been appointed managing director of the Anglo-Saxon Petroleum Co., Ltd., the Shell Petroleum Co., Ltd., and the N.V. de Bataafsche Petroleum Maatschappij, as from January 1, 1952.

Mr. W. R. Jones has been appointed chief engineer of Nevelin Electric Co., Ltd., a subsidiary company of Lancashire Dynamo Holdings Ltd.

Mr. Ion Earle, secretary of the Midland region of the Federation of British Industries, is to be transferred to the Federation's London office, as from January 1, 1952. He will be succeeded in Birmingham by Mr. S. W. Gregory-Meakin, at present assistant secretary.

Mr. A. McEwan, M.I.Struct.E., who is in charge of the structural division at Chamberlain Industries Ltd., Staffa Works, Leyton, London, E.10, has been appointed a director of the company.

Mr. S. A. Scadding, hitherto in charge of the sales and sales promotion departments, J. and H. McClaren Ltd., Leeds, has now succeeded Major T. Rhind as publicity officer and Press relations officer.

J. H. Fenner & Co., Ltd., have opened an additional branch at 32, Dewsbury-road, Leeds, 11, under the management of Mr. F. Grindlay.

As from December 1, the head-office address of the British Aluminium Co., Ltd., will be Norfolk House, St. James's-square, London, S.W.1. (Telephone: WHItehall 7868.)

C. C. Wakefield & Co., Ltd., have now organised their industrial lubrication service on regional lines. Mr. C. W. Page has been appointed sales manager of the eastern region in succession to Mr. B. S. Davis, who has resigned from the company. Mr. Page joins Mr. J. E. S. Elwell and Mr. D. S. Kirkpatrick, northern and western regional sales managers, respectively.

The Institute of Road Transport Engineers has been incorporated under Section 19 of the Companies Act, 1948. The Institute's headquarters have now been transferred from 174, Palace Chambers, Bridge-street, to 69, Victoria-street, London, S.W.1. (Telephone: ABBey 6248.)

The Glacier Metal Co., Ltd., London and Kilmarnock, have taken over a 15,000-sq. ft. factory at Carfin Industrial Estate, Lanarkshire, where they hope to begin production in February.

High Duty Alloys Ltd., Slough, Buckinghamshire, announce that the new address of their northern area sales office is Colwyn Chambers, 24, Mosley-street, Manchester, 2. (Telephone: Manchester Central 2758.)

From December 1, the address of the London office of Rose, Downs and Thompson, Ltd., Old Foundry, Hull, will be changed from No. 28 to 39, Victoria-street, S.W.1. Mr. A. Cockram continues as London office manager.

THE GATESHEAD WORKS OF SIGMUND PUMPS, LIMITED.

(*For Description, see page* 652.)

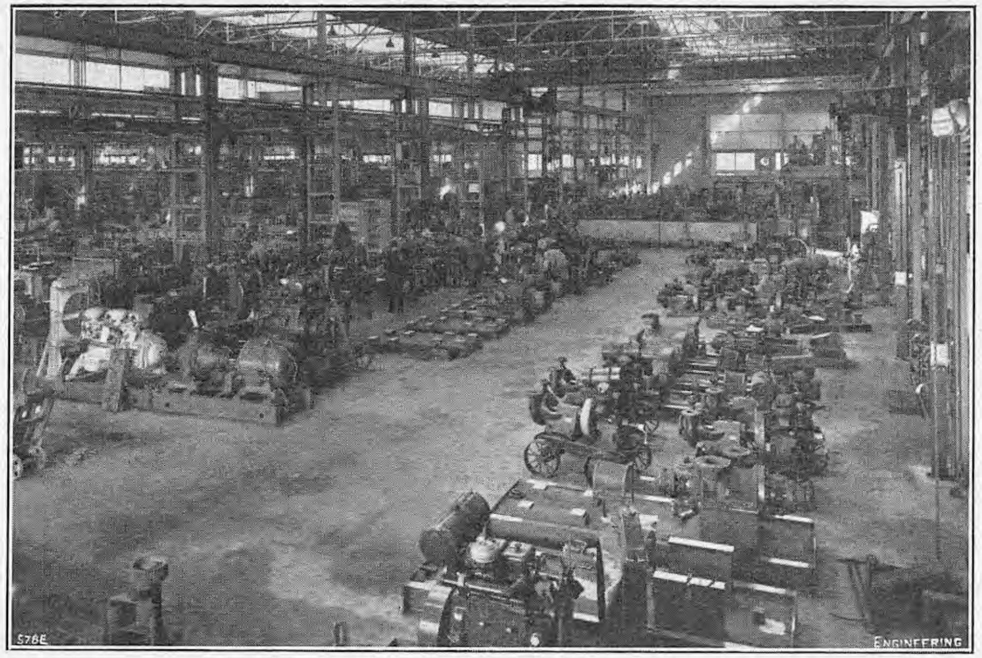

Fig. 5. Heavy-Assembly Bay with Test Bay in Background.

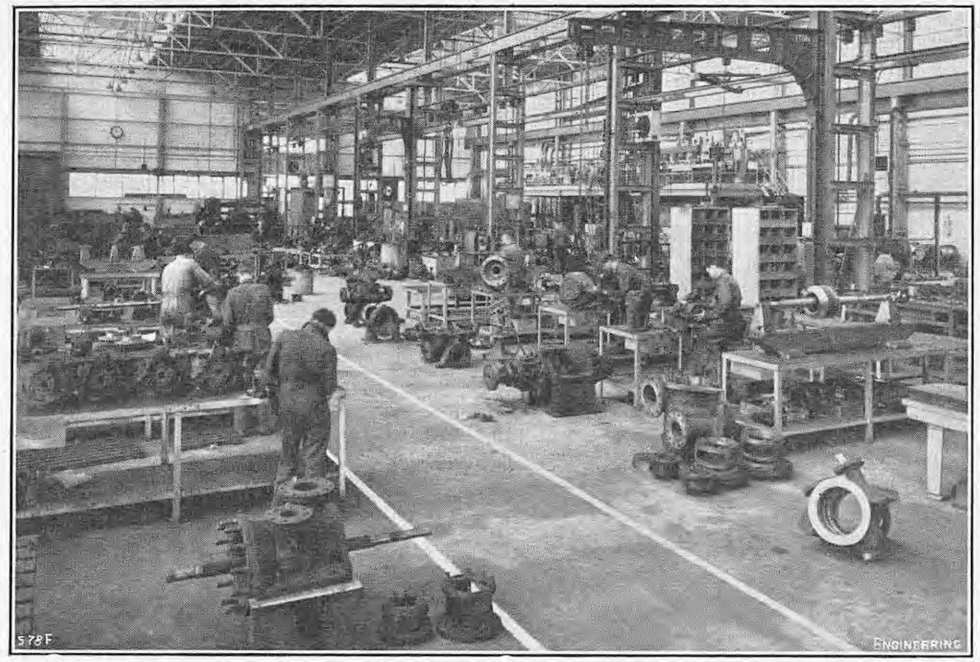

Fig. 6. Main Pump-Assembly Bay.

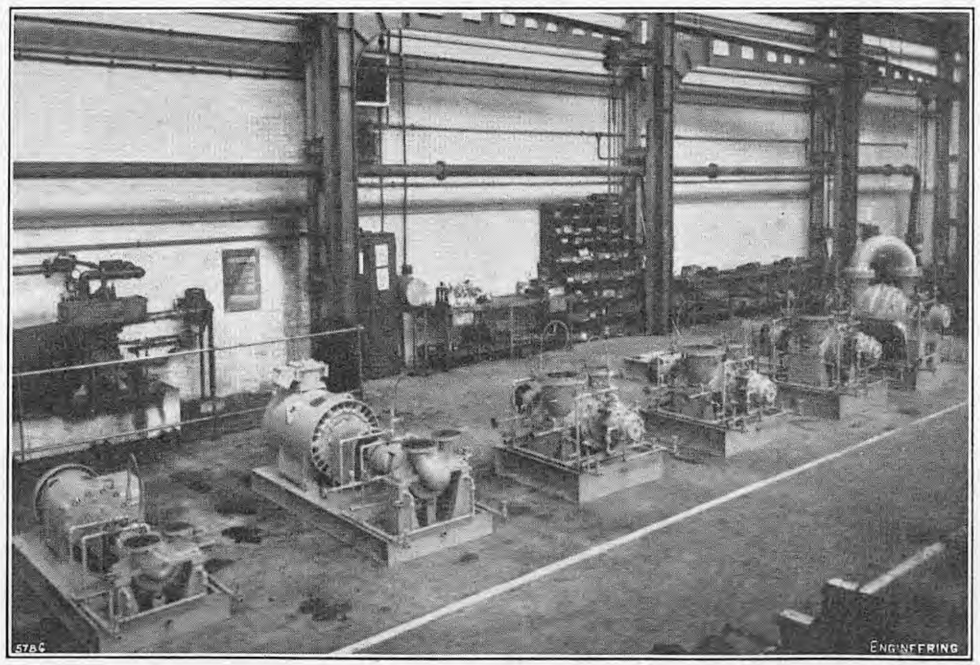

Fig. 7. Batch of Process Pumps in Heavy-Assembly Bay.

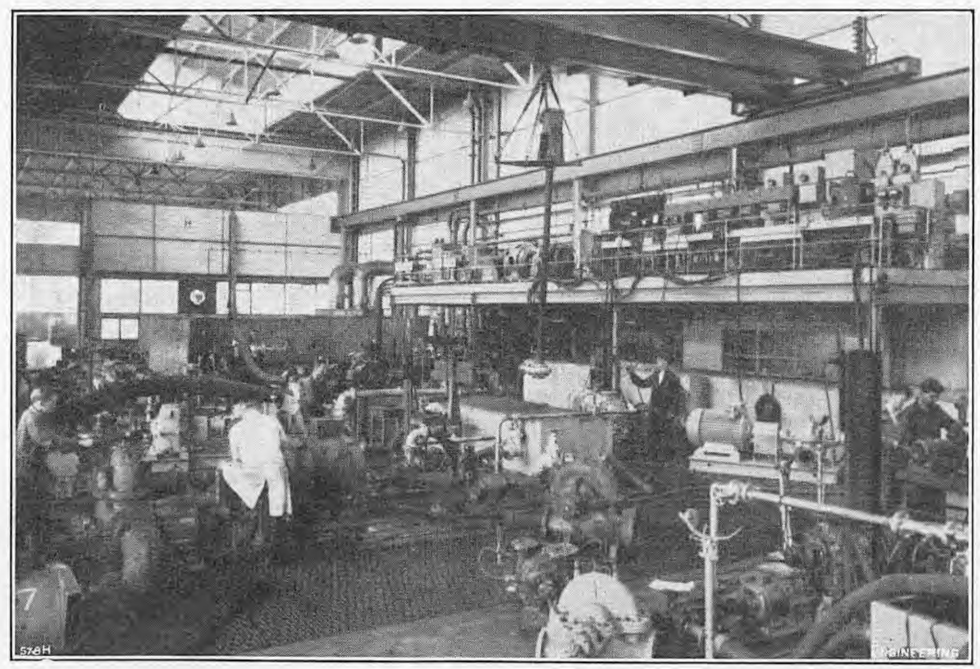

Fig. 8. Pump-Testing Bay.

ENGINEERING,

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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.

Telegraphic Address :
"ENGINEERING," LESQUARE, LONDON.

Telephone Numbers :
TEMPLE BAR 3663 and 3664.

All editorial correspondence should be addressed to the Editor and all other correspondence to the Manager.

Accounts are payable to "ENGINEERING" Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

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ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for insets, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 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 10s. for the first four lines or under, and 2s. 6d. per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30s. per inch. If use is made of a box number the extra charge is 1s. per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates :—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 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.

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ENGINEERING

FRIDAY, NOVEMBER 23, 1951.

Vol. 172. No. 4478.

POST-WAR FUEL RESEARCH.

For reasons of security, and no doubt because staffs were engaged on matters of more immediate importance, the research stations of the Department of Scientific and Industrial Research suspended publication of their various annual reports during the war. After the termination of hostilities, the interregnum was, in most cases, covered by a general report dealing with th war period. In the case of the Fuel Research Station, the matter was dealt with by a report covering the work carried out from 1939 to 1946. This was published about twelve months ago and some account of it will be found in our issue of December 15, 1950. Some of the stations resumed publication of their annual reports after the appearance of their review of war activities, but the Fuel Research Station has followed their 1936-1946 review with another report* covering the three years from April 1, 1946, to March 31, 1949. It is, however, stated by Engineer Vice-Admiral Sir Harold Brown, the chairman of the Fuel Research Board, in his introductory section of the report, that in future the earlier practice of presenting an annual report will be reverted to. The earlier report was largely concerned with *ad hoc* war-time activities ; this new one covers a period in which it was possible once again to turn to long-term researches.

* *Report of the Fuel Research Board with the Report of the Director of Fuel Research for the Period 1st April, 1946 to 31st March,* 1949. H.M. Stationery Office. [Price 3s. net.]

The document naturally covers a considerable range of work and some of the subjects dealt with cannot even be mentioned here. Among matters of wide general interest about which something may be said, however, are the work on domestic heating, on the development of combustion chambers for coal-fired gas turbines, on various aspects of boiler performance and on atmospheric pollution. It may appear to some mechanical engineers that domestic heating is not of sufficient interest or technical importance to stand at the head of this list, but in view of the enormous numbers of domestic boilers and fires in use, their individual efficiency has a serious bearing on the whole fuel situation. We believe it was Sir Harry Ricardo who, many years ago, pointed out that although the efficiency of a motor-car engine might not be of moment to the individual owner, in view of the petrol consumption of the total number of cars in the country, the efficiency of the engines was just as important as that of the largest power-station generating set. The same thing, from the point of view of fuel consumption, applies to domestic solid-fuel appliances. There is some reason to believe that an increasing proportion of householders are realising this, not because they have any interest in combustion efficiency as a general subject, but as they cannot obtain adequate supplies of coal or coke, they are beginning to understand that they must make the best use of what they can get.

It was towards the end of the war that the Fuel Research Station started investigations on the performance of domestic fires and stoves, and as a result of those investigations and the work of other bodies, such as the British Coal Utilisation Research Association, various models have been approved and a list of improved solid-fuel appliances recommended to local authorities has been circulated by the Ministry of Health. As about half the grates and stoves used in Great Britain to burn solid fuel are made in Scotland, a Scottish Branch of the Fuel Research Station has been established at Thorntonhall, near Glasgow, in order to permit close contact to be maintained with manufacturers. Probably the most intractable problem in the domestic-heating field is concerned with the heating of a room by a stove or open fire. This method of heating seems likely to be retained in this country for a long time and it cannot be said that there are any important signs of the adoption of the central-heating methods commonly used in America even in the smallest houses.

The work on gas turbines, up till the end of the period dealt with in the report, was confined to the development of combustion chambers for coal firing. It is remarked that for relatively small power-producing units, the gas turbine would be more efficient than the conventional steam plant and accordingly work has been started on the use of pulverised coal for such installations. The application of powdered-fuel firing to open-cycle gas turbines involves the development of a combustion chamber and burners to work at a pressure of about four atmospheres as well as auxiliary apparatus, including pulverising plant and feeders. When these various items of the installation have been developed it will be necessary, as the report remarks, "to examine the amount and type of ash that can be tolerated in the hot gas supplied to the turbines and to devise means for cleaning this gas if necessary." This sentence refers to what may be difficult problems. Some years ago, a good deal was heard of a German internal-combustion engine using pulverised coal, but nothing seems to have come of the matter. It may well have been found that no type of piston engine could operate for any long periods with gases carrying fine ash, but possibly a gas turbine would prove more amenable.

Two types of combustion chamber have been designed and built ; each burns about 500 lb. of coal an hour at atmospheric pressure. Operating under higher pressures, it is considered that combustion chambers of the same dimensions would be able to deal with about 2,000 lb. of coal an hour and serve a 2,000-h.p. turbine. It is stated that a third experimental combustion chamber has been constructed by the British Coal Utilisation Research Association. One of the Fuel Research Station combustion chambers is of the vortex type, consisting of a shallow cylindrical vessel 3 ft. 3 in. in diameter and 12 to 18 in. deep. It is fixed with the axis vertical and the pulverised fuel is carried into it by the primary air which enters from above through nozzles spaced around a circle having a diameter about two-thirds that of the chamber. The main supply of air for combustion enters tangentially through 16 long narrow brick nozzles situated around the periphery. The products of combustion pass downwards through a central opening. The other combustion chamber is of the straight-through type, consisting of a vertical brick-lined cylinder 6 ft. high and 2 ft. 6 in. in external diameter. The primary air and fuel enter from above, combustion air being supplied through ports arranged around the body of the cylinder.

The section of the report relating to what is called above "various aspects of boiler performance" deals, among other matters, with the "smoke eliminators" which were devised by the Fuel Research Station to improve the efficiency of coal-fired boilers. Some information about this matter was given in our previous article. The present report records that a "typical merchant ship" with boilers equipped with these eliminators during a voyage from England to West Africa and back showed an average fuel saving of about 5 per cent. when the smoke eliminators were in use. Other boiler work referred to includes the up-grading of inferior fuels by the addition of fuel oil or tar. The conclusion arrived at was that the improved performance obtained was more than offset by the extra labour involved in preparing the fuel. Work in connection with deposits on the external heating surfaces of water-tube boilers has been continued in collaboration with the Boiler Availability Committee and the important conclusion has been reached that there is urgent need for a redistribution of coals to generating stations so that the different types of coal shall be sent to installations where the boilers are best suited for burning them.

Another boiler problem dealt with in the report is a factor in the broad question of atmospheric pollution, a subject on which the Fuel Research Station has collaborated with the National Physical Laboratory and other bodies. The particular boiler problem referred to is the removal of sulphur compounds from the flue gases. At Battersea the British Electricity Authority has adopted a process of washing the flue gas with water containing an alkali, and, as mentioned on page 624 of our issue of last week, the same system is to be adopted at Bankside. As large and expensive plants are necessary for the removal of sulphur compounds in this way, the Fuel Research Station is investigating the possibility of developing a cheaper method. One process is the addition of oxidation catalysts to the scrubber liquor, so increasing the rate of absorption of sulphur dioxide. Salts of chromium, copper, vanadium and aluminium have been tried, vanadium being the only one to give promising results. The suggestion has been made that in view of the expense of the gas-washing process, the matter might be dealt with by injecting dry alkaline absorbent powders into the flues leading from the boilers. Experiment showed, however, that the reaction was negligible at temperatures lower than about 600 deg. C., and as in practice the gas temperature is not usually higher than 150 deg. C., the process would be quite ineffective. Another method is the removal of sulphur dioxide by oxidation in an electrical discharge, the sulphur trioxide formed being removed by electrostatic precipitation.

ABRASION AND WEAR.

In deciding to inaugurate their new premises by holding an International Symposium on Abrasion and Wear, the directorate of the Rubber Stichting at Delft—the Dutch research organisation which, in collaboration with the British Rubber Producers' Research Association and the Institut Français du Caoutchouc, seeks to promote the wider and more efficient use of rubber—made a notably appropriate choice; for, of all the engineering materials which confront designers and users with problems of wear, rubber presents features that are, perhaps, the most complex and individual, and the least generally understood. Engineers certainly have paid much more attention to rubber, and have studied more closely its peculiar physical and chemical properties, since the discovery and widespread adoption of methods of bonding rubber to metal; but their familiarity with it is still tinged with a certain degree of uncertainty, and much of the knowledge that chemists and physicists have now accumulated by painstaking investigation is by no means common knowledge in the field of engineering manufacture. By taking as their theme the broader subjects of abrasion and wear in general, however, the organisers of the Symposium were able to bring into personal contact a considerable number of research workers experienced in the problems of practical engineering as well as in the narrower field of rubber technology; and there can be no doubt that the exchanges of views and the expert summaries of recent and highly specialised researd which occupied the four sessions on Wednesday and Thursday of last week, November 14 and 15, will bear fruit in a number of directions, not always obviously related to each other. Dr. Ir. R. Houwink, the Director-General of the Rubber Stichting, and Dr. H. C. J. de Decker, the Director of Research, together with their colleagues on the Board of Management, are to be congratulated on the success of their arrangements.

As we have announced previously, the eight papers which constituted the main programme of the Symposium will be printed in Engineering in the near future; and it is our intention to publish a general report of the proceedings, as has been done with various other specialised conferences in recent years. As an introduction to these reports, however, it may be useful to outline the general scope of the facilities now available, under the co-ordinating supervision of the International Rubber Research Board and the associated organisation, the International Rubber Development Committee. The stimulus to set up this machinery for the co-ordination of rubber research and the investigation into the further and more effective use of rubber came from the unsettled state of the world rubber market before the war, which led to an international agreement to restrict the production of rubber. This restriction was intended to be merely temporary, as it was recognised that what was really needed was a heavier and a steadier demand. It was for this purpose that British, French and Dutch producers set up their respective research establishments. There are, in addition, affiliated bodies in Malaya, Indo-China and Indonesia, these being, respectively, the Rubber Research Institute of Malaya at Kuala Lumpur, the Institut des Recherches du Caoutchouc en Indochine, and the Indonesisch Instituut voor Rubberonderzoek at Buitenzorg, Java; and there are associated bodies in various other European countries, and in the United States, Australia, South Africa and Japan.

The endeavours of these several organisations to discover and apply new uses for rubber had produced considerable results even before the war. During the war, of course, the problem of absorbing the available output no longer existed, but the problems of promoting its most efficient use became of paramount importance. Since the war, economic conditions have necessitated an even more intense concentration on both the extent and the efficiency of use, thus bringing the rubber physicist and the rubber technologist into closer contact with a variety of other branches of technology. Their problems may be widely different in detail, but they have much in common and, to some extent, their investigation involves the use of similar apparatus. This connection was very apparent during the recent Symposium, when, in the intervals between the sessions, the delegates turned their attention to the exhibition of testing and other equipment that had been arranged for their benefit. Many of the instruments and machines were evidently familiar to many members whose uses of them were notably different.

It is probable that comparatively few of the 158 participants in the Symposium had had occasion to consider abrasion and wear in other than a sectional and limited way, or to attempt to formulate, for their individual guidance, anything approaching a comprehensive philosophy of the subject. Most wear is undesired and undesirable, but, as Professor H. Blok, of Delft, pointed out in his paper, there are some forms of wear (as, for instance, in the running-in of new machinery) which are not merely desirable, but necessary, unless and until manufacturing methods can be improved to the extent that such deliberate wear is no longer needed as a finishing process. Obviously, the elimination of such a method of finishing, which can hardly be brought under precise control, is highly desirable, and its persistence does not weaken the general principle that wear, whether caused by abrasion or by changes that are fundamentally chemical, is something to be avoided or, at least, minimised wherever possible.

The aggregate economic consequences of wear are enormous and practically incalculable. Taking a short-term view, it is easy to see that the elimination of wear in any considerable field where it occurs could have disturbing results on employment and might, indirectly, lead to material changes in the means of livelihood of large sections of the community; to take a single example, the production of a virtually indestructible material for boot soles would reduce greatly the need for the services of cobblers, and, after a probable sudden upward surge in market demand, to a permanent reduction in the sales of new footwear. On the other hand, and taking a longer view, any improvement in the wearing properties of materials which reduces the rate at which the world's natural resources are being consumed should tend to improve, or at least to maintain, the average standard of living of the rapidly increasing population of the world by diverting, to production that is literally vital in that life cannot be sustained without it, much of the labour and energy now engaged on continual and not always economic maintenance and replacement.

Hitherto, the equipment and maintenance requirements of the growing world population have been met largely by an intensified exploitation of natural resources, the utilisation of previously undeveloped areas of the Earth's surface, and, to some extent, by the discovery of new synthesised products; but there are obvious limits to the first and second of these methods, and the third, though its possibilities are far from being exhausted, cannot be expected alone to provide an assured solution to the problems of the future. Neither can the avoidance of wear, however successfully that aim may be pursued; but every advance that can be made in this direction is a material contribution to the expectation of life of modern civilisation and, indeed, the continuance of the human race on a superior level of existence, compared with that of the beasts that perish, that it is so apt to regard as a birthright but which, in fact, is nothing of the sort.

NOTES.

Nobel Prize for Physics.

The winners of the Nobel Prize for Physics for 1951 are Sir John Cockcroft, C.B.E., F.R.S. M.I.E.E., director of the Atomic Energy Research Establishment, Harwell, and Professor E. T. S. Walton, M.A., M.Sc., Ph.D., who occupies the Erasmus Smith Chair of Natural and Experimental Philosophy at the University of Dublin. Sir John and Professor Walton, who will share the prize of 11,560*l.*, have received the award for their researches on atomic physics. Sir John, who is 54 years of age, went to school at Todmorden, Lancashire, and received his technical education at the University of Manchester and at St. John's College, Cambridge. He was Jacksonian Professor of Natural Philosophy in the University of Cambridge from 1939 until 1946 and also chief superintendent of the Air Defence Research and Development Establishment of the Ministry of Supply from 1941 until 1944. From 1944 until 1946, he was director, Atomic Energy Division, National Research Council of Canada, after which he was appointed to Harwell. Professor Walton is 48 years of age and was educated at the Methodist College, Belfast, and at Trinity College, Dublin, and the University of Cambridge. He has been a Fellow of Trinity College, Dublin, since 1934 and was awarded the Hughes Medal by the Royal Society in 1938. He became Professor of Philosophy at Dublin in 1946.

The Thomas Hawksley Lecture.

As chief scientist to the Ministry of Fuel and Power, Dr. H. Roxbee Cox was able to give a most impressive review of gas-turbine and other developments in this country when he delivered the 38th Thomas Hawksley Lecture at the Institution of Mechanical Engineers on Friday, November 16. His subject was "Some Fuel and Power Projects," which included, apart from gas-turbine work, the performance of the heat pump at the Royal Festival Hall, the gasification of coal, the use of peat, the development of compressors, and the utilisation of wind power. A large programme of research and development is organised and sponsored by the Ministry, and it is the policy of the Ministry, Dr. Cox said, to provide the means for long running, under practical conditions, of gas turbines which, though necessarily experimental, are designed for industrial duty and are of sizes sufficient to provide reliable design and cost data. For the development of open-cycle internal-combustion coal-burning gas turbines, large-scale laboratory combustion experiments are being undertaken; Messrs. C. A. Parsons and Company, Limited, have adapted their 500-h.p. open-cycle gas turbine to burn coal; and the English Electric Company, Limited, are responsible for the design and construction of a 2,000-kW coal-burning engine. To enable high-ash coal to be used, two-stage internal combustion in an open-cycle turbine is the responsibility of the Metropolitan-Vickers Electrical Company, and of the Incandescent Heat Company and Messrs. Joseph Lucas (Gas Turbine Equipment), Limited, the two latter firms jointly designing a pressurised gas-producer, which may have other useful applications. For locomotive use, attention is being directed to an open-cycle external-combustion gas turbine, on which Messrs. C. A. Parsons and the North British Locomotive Company are working. With the object of utilising the firedamp in mines, the English Electric Company are working on a gas turbine which will burn firedamp and an auxiliary fuel.

Capital Resources of Industry.

The Federation of British Industries have this week produced evidence to show that a deplorable effect of the changing value of money is to render depreciation funds, normally set aside by firms, insufficient even to maintain the real value of capital assets. So far from being enabled to increase the capital assets per employee—a ratio which is a fair guide to the productivity of industry—firms are not allowed sufficient tax-free depreciation allowances to replace their worn-out machinery by machinery of the same real value. This situation has arisen because, during a long period of rising prices, accounting methods and the Inland Revenue system of taxing profits have continued on the assumption that prices are remaining stable. The accounting convention is that, in calculating profit, it is sufficient to put aside a sum equal to the cost of the asset whenever it was bought, despite the fact that the replacement will actually cost much more. Likewise, the tax-free depreciation allowance permitted by the Inland Revenue is normally sufficient to provide for the renewal or replacement of the fixed asset at its original cost, but if the new asset costs more than the old—as it invariably does to-day—the depreciation funds are inadequate. Thus, if a firm intends to maintain intact the volume of its assets it will have to use part of its taxed profits, or look elsewhere for finance—for which it must pay a price in dividends or interest. This is exactly what firms are having to do, as the F.B.I. booklet, *The Effects of Inflation on Industrial Capital Resources*, shows. The Federation have quoted the assets, etc., of 80 representative firms which, in 1949, employed over 600,000 persons and possessed total assets (book value) of over 1,000,000,000*l.* From 1938 to 1949 the total assets of these companies increased by 362,000,000*l.*; only 199,000,000*l.*, however, came from "profits" retained in the business, the remaining 163,000,000*l.* being obtained from share issues, borrowing, etc. As the booklet states: "The extent to which these 80 firms have been forced to seek funds from outside demonstrates clearly the inadequacy of profits after taxation." Any suggestion that the companies could have avoided seeking outside finance by reducing the amount of distributed profit is countered by the fact that, between 1945 and 1949, the proportion of total profits distributed fell from 27 per cent. to 22½ per cent. According to the booklet, the total number of employees of the 80 firms rose by about a third from 1938 to 1949. This may indicate that the firms were not a representative sample of industry; nevertheless, the Federation's general thesis appears to be indisputable, and if productivity is to rise—as rise it must—the financial environment must be made more conducive to an increase in the capital equipment per employee.

The Iron and Steel Institute.

The autumn general meeting of the Iron and Steel Institute was held in London on Wednesday and Thursday, November 21 and 22. The President, Mr. R. Mather, occupied the chair, and, among other announcements, stated that the "Symposium on the Corrosion of Buried Metals," organised by the Institute in conjunction with the British Iron and Steel Research Association and the Corrosion Group of the Society of Chemical Industry, would now be held in the lecture theatre of the Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2, at the same date and time, namely, Wednesday, December 12, commencing at 10 a.m. The British Government had announced that the date of the official end of the war with Germany was July 9, 1951, and persons of German nationality were henceforth once again available for membership. The reciprocal arrangement which had previously existed with the Verein deutscher Eisenhüttenleute would be resumed and details included in the Institute's *Journal*. The Council had nominated Captain H. Leighton Davies to be the next President; he had joined the Institute in 1918 and had served on the Council for the past 20 years. Mr. R. Elsdon, librarian of the Institute, was to retire on December 31 after 47½ years of service, and the Council had arranged that, as from January 1, 1952, Mr. A. E. Chattin, assistant secretary since 1925, should be assistant secretary and librarian, and Mr. A. Post, who joined the staff in 1946, should be joint assistant secretary. On being called upon by the President, the secretary stated that since the last general meeting in May, 1951, the Council had nominated Professor J. H. Andrew, Sir Arthur Matthews, O.B.E., and Dr. J. Oberegger to be honorary vice-president; Mr. I. F. L. Elliott and Mr. N. H. Rollason to be vice-presidents; and Mr. H. Boot, Mr. E. T. Judge and Mr. Samuel Thomson to be members of Council. The following members were due to retire at the next annual general meeting but were eligible for re-election. They comprised three vice-presidents: Mr. G. H. Latham, Mr. J. Sinclair Kerr and Mr. H. H. Burton, and five members of Council, namely, Dr. J. W. Jenkin, Mr. W. F. Cartwright, Mr. F. Saniter, Mr. T. Jolly and Mr. R. A. Hacking, O.B.E. The secretary's final announcement before the meeting passed on to the discussion of papers, was that Mr. J. Burke, of Liverpool University, had received a second Andrew Carnegie Scholarship grant of 50*l.* and that Mr. M. J. Olney, of Cambridge University, had received a grant of 250*l.* from the same fund.

Intra-European Industrial Co-operation.

Last week (on page 619, *ante*), we referred, under the heading "The Organisation of Research," to the proceedings at a four-day symposium held in London under the auspices of the Department of Scientific and Industrial Research. The symposium was attended by a large number of delegates from Europe and elsewhere, some of whom had been studying the organisation of scientific and industrial research in several Western European countries as members of a mission sponsored by the Organisation for European Economic Co-operation, and were concluding their tour by a visit to England. No attempt was made to secure the acceptance of any formal resolutions during the meetings, but the mission will submit a report to O.E.E.C. which will be published in due course. At a Press conference last Friday, Dr. Alexander King, of the D.S.I.R., summed up the aims and gave details of the work of the O.E.E.C. Committee on Scientific and Technical Matters, of which he is chairman. The advantages of co-operation between states in industrial research were considerable, he said—a point which, as reported earlier, was made during the symposium by the Lord President of the Council, when he said that the western European countries were at a great disadvantage compared with large politically-integrated units like the United States and the U.S.S.R. because, in the latter countries, one experimental investigation and one pilot plant could serve the needs of all, whereas, without collaboration between small nations, each country must work out its own solution. It is obvious, therefore, that international collaboration on industrial research, when it can be secured opens the way to great economies, but the subjects to be studied require careful selection. Dr. King explained how the choice was made by an international committee composed of industrialists, economists and technicians meeting in Paris. Once a list had been drawn up, it was submitted to the various governments concerned, who were free to accept it wholly or in part, or to reject it. Except where the industries involved were nationalised it was customary for government to ascertain the wishes of industry and for the latter to provide the necessary financial backing for any proposal which interested them. The amounts to be paid into the common fund were the subject of international agreement, as was also the location of the work. So far, said Dr. King, the scheme had worked well. Nine countries having steel industries, but lacking adequate supplies of metallurgical coke, were collaborating in a 250,000*l.* project in which oxygen-enriched air would be employed in low-shaft blast furnaces. It was hoped that in this way it would be possible to treat ores of poor quality successfully. An international board of management had been formed to run the undertaking on strictly commercial lines, and plant was in course of erection near Liége, this location having been selected partly because an oxygen-manufacturing company, able to supply 50 tons of oxygen per day to the undertaking, was situated there. The scheme had become economic because oxygen was now cheaper. 621·3

Single-Phase Electric Traction at 50 Cycles.

British Railways are to carry out trials of the single-phase system of electric traction at 50 cycles on the Lancaster-Morecambe-Heysham line, in the London Midland Region. By arrangement with the principal electrical manufacturers, various types of equipment will be tested at voltages from 6·6 kV to 20 kV. It may be recalled that this section of the then Midland Railway, which consists of 21 miles of track with a number of sharp curves and low bridges, was equipped on the single-phase system as long ago as 1908, in order to obtain data which could be applied on a large scale. Single-phase current for operation was obtained from a power station at Heysham, belonging to the railway company, and was supplied to the overhead contact wire at a voltage of 6·6 kV and a frequency of 25 cycles. The overhead system consisted of two steel catenaries from which a steel auxiliary wire was suspended and, in turn, carried a copper contact wire of figure-8 section. To begin with, a tensioning device was fitted to the contact wire, but this was afterwards abandoned; and a number of other modifications were made before electrical operation ceased in February, 1950. The traffic was carried in three trains, each consisting of a motor car and two trailers. Two of the motor cars were equipped with 180-h.p. motors and one with a 150-h.p. motor, which were supplied at a mean terminal voltage of 250 volts from a transformer with six tappings on the low-tension side. The experiment will be watched with great interest, particularly in relation to the recent trials in France, which we reported on pages 521, 545 and 583, *ante*, and in view of the recommendation in the recent report of the British Transport Commission that the single-phase system at 50 cycles should be considered for use on secondary lines. Its advantages are a lighter overhead system, fewer and simpler sub-stations, and the absence of power cables along the track.

Bi-Centenary of George Graham.

An excellent account of the life and work of George Graham was given in a paper delivered by Mr. H. Alan Lloyd, M.B.E., at the Royal Society of Arts during a joint meeting with the British Horological Institute, on Wednesday, November 14, 1951. The meeting was held to celebrate the bi-centenary of the death of Graham, who was certainly the foremost horologist and astronomical-instrument maker of his time. The date of Graham's birth cannot be fixed with certainty, but the inscription on his tombstone in Westminster Abbey indicates that he died on November 16, 1751, in his 78th year. Even more uncertainty seems to exist regarding his birthplace, which is variously stated to have been Gratwick, Horsegills and Rigg, all in Cumberland. It is clear, however, that he came to London in 1688 and was apprenticed to Henry Aske, with whom he served for seven years, after which he entered Tompion's workshops, where he remained until the death of Tompion in 1713. Also in Tompion's employ when Graham joined him was Edward Banger, who was afterwards taken into partnership by Tompion; there are several fine clocks in existence bearing the names Tompion and Banger. The partnership appears, however, to have been dissolved, because in the later years of Tompion's life, while Banger was still living, many pieces of work, including a planetarium, were produced bearing the names Tompion and Graham. Graham, moreover, was made Tompion's executor and the successor to his business. Graham's main contributions to clockmaking were the dead-beat escapement and the mercury pendulum. The former appeared about 1715 and was adopted almost universally for astronomical clocks. The mercury pendulum was introduced in a paper read by Graham before the Royal Society in 1726, although his experiments were commenced several years earlier. Graham was elected a Fellow of the Royal Society in 1721, and was appointed to the Council in the following year. His chief contribution to watchmaking was the cylinder escapement, which he invented about 1725. It is probable that Graham's interest in astronomy commenced with the design and construction of the planetarium mentioned above, which occupied him from 1705 to 1710. One of his earliest and most important contributions to astronomy, however, was the 8-ft. mural quadrant which he made for Halley in 1725. This instrument was in use at Greenwich until 1750, when it was replaced by a quadrant supplied by John Bird. Other important astronomical instruments he made were a $24\frac{1}{4}$-ft. zenith sector constructed in 1725 for Sir Sam Molyneux, of Kew, and a $12\frac{1}{2}$-ft. instrument of the same type made two years later for Bradley, who afterwards became Astronomer Royal. In addition to zenith sectors, he made transit instruments, an equatorial sector, and micrometers for use in transit observations. As previously indicated, his remains were interred in Westminster Abbey, and it may be added that they were placed in the same grave as those of his employer Tompion.

LETTERS TO THE EDITOR.

PRELIMINARY INVESTIGATION OF HYDRAULIC LOCK.

To the Editor of Engineering.

Sir,—In your issues of October 26 and November 9 (pages 513 and 580) you publish an article by Dr. D. C. Sweeney describing some interesting and valuable work on this subject which has been carried out at Birmingham University. Hydraulic lock is a prolific source of difficulties for many hydraulic engineers, and it seems to me that laboratory experiments on this subject are of particular interest as it is difficult to co-relate data from actual practice because friction of this type may arise from (*a*) distortion of the parts; (*b*) the filtering out of solid particles during the passage of the liquid through the clearances; and (*c*) hydraulic lock pure and simple. In practical installations, all these effects may be present together, but under laboratory conditions it should be possible largely to eliminate (*a*) and (*b*) and obtain a clearer picture of the hydraulic-lock phenomenon itself.

The experimental piston and cylinder described by Dr. Sweeney are robust and symmetrical and should eliminate the possibility of shape distortion, but no details are given as to the efficiency of the filtering arrangements. Trapping of dirt in the clearances may not only give rise to direct friction but also alter the hydraulic gradients and superimpose a time effect of its own. I venture to suggest that the filtering means adopted should be sufficiently good to prevent any solid particles of sizes down to the limit of visibility (say 4 micro-inches) from reaching the piston and cylinder.

The experiments so far described are for quite small pressures, whereas the most serious effects of hydraulic lock in practice usually occur at pressures over 2,000 lb. per square inch. Practical difficulties lead one to suspect that at some point the pressure-friction relationship ceases to be linear and the friction commences to rise at an increasing rate. There is also evidence that at these higher pressures the increased friction may have some cause other than that of unequal gradients through the clearance. Viscosity has an important bearing on the matter, at least as regards time effects, and, as many high-pressure installations now use oil somewhat thinner than the grade used in the experiments, it would be of interest if the effect of viscosity could be investigated.

The title of the article infers that some further work on this subject is contemplated and I would urge that it is very useful work indeed and likely to lead to results of immediate practical value, and that if possible it should be extended to higher pressures (to 3,000 and if possible to 6,000 lb. per square inch) and also to oils of lower viscosities (say, down to 4 centipoises).

Yours faithfully,
T. E. Beacham.

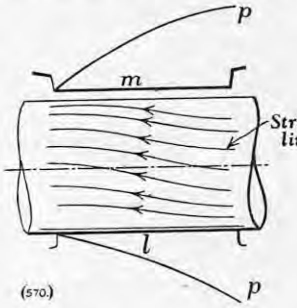
57, St. Mary Abbot's Court,
London, W.14.
November 19, 1951.

To the Editor of Engineering.

Sir,—Dr. Sweeney is to be congratulated both on his experiments and on his theoretical treatment. It may be doubted, however, if the latter is complete, and I should like to suggest that the phenomenon can occur even with mathematically perfect surfaces, whereas Dr. Sweeney rather gives the impression (without saying so explicitly) that irregularities are not only the sufficient but also the necessary cause.

Consider a perfectly cylindrical piston in a perfectly cylindrical bore, and assume, for the sake of argument, that the system is in neutral equilibrium, apart from gravity forces (if the axis is horizontal) or hydrodynamic forces due to minute irregularities, which will be assumed to be insufficient to set up appreciable friction forces. Due to one or both of the above effects, the piston will eventually touch the bore along one of the generators of the cylindrical surfaces; call this l, and let m be a generator diametrally opposite, as shown in the accompanying drawing. The piston is now fully eccentric, and the clearance varies sinusoidally from zero at l to a maximum at m. Under such conditions there is no *a priori* reason to believe that flow is truly axial; on the contrary, it seems probable that streamlines will diverge from the low-clearance to the high-clearance region, as shown; if this does happen, then pressure drop is no longer linear, and along m pressure will drop at an increasing rate, while along l it will drop at a decreasing rate, i.e., the pressure-distribution curve will be convex on the high-clearance side and concave on the low-clearance side, as shown. There will then be a net load tending to press the piston on to its contact line.

The magnitude of the load due to the above effect should be calculable by solving the two-dimensional flow equations—an undertaking beyond the writer's skill, but no doubt Dr. Sweeney could tackle it. It seems likely that the load will be $k\,p\,D^2\left(\frac{l}{D}\right)^n$, where k is a constant, p is the pressure, D the diameter, and l the length of the leakage path: n is



an exponent which I suspect to be 2 or thereabouts; if it is 2, then load should vary inversely as the number of circumferential grooves in Dr. Sweeney's experiments, which is very roughly the case. If analytical methods of solution of the flow equations are not feasible, numerical solutions for say three or four values of l should give the values of k and n.

If this theory is correct, a perfectly cylindrical piston-cylinder arrangement is unstable, and it is not even necessary to postulate gravity or micro-irregularity effects to account for the piston eventually moving to touch the cylinder. If loads calculated on the basis of the above theory are of the same order of magnitude as those measured by Dr. Sweeney, they may be regarded as "expected loads," while Dr. Sweeney's analysis of the effect of taper would account for the high degree of scatter observed.

It would be interesting to have Dr. Sweeney's comments on this.

Yours faithfully,
R. Hadekel.

36, Evelyn-gardens,
London, S.W.7.
November 14, 1951.

"THE WHITWORTH REGISTER."

To the Editor of Engineering.

Sir,—A quarter of a century having elapsed since *The Whitworth Book* was published, the Whitworth Society are now engaged in the preparation of a new edition, to be known as *The Whitworth Register*, 1951.

This is intended to comprise an account of the careers of all Whitworth Scholars and Exhibitioners from the inception of the scheme by Sir Joseph Whitworth to the present day. The Whitworth Awards are regarded by the past beneficiaries as being of continuing value and it is hoped that, by indicating some of the contributions made to the development of British engineering by former Scholars and Exhibitioners, the *Register* will be a source of encouragement to the present and future generations.

While a large proportion of Whitworth men are in touch with the Society, there remain a number whose present addresses are unknown, and we wish, through your columns, to invite them to communicate with us so that we may ensure that

RUBBER MODEL FOR COMBINED BENDING AND TORSION TESTS.

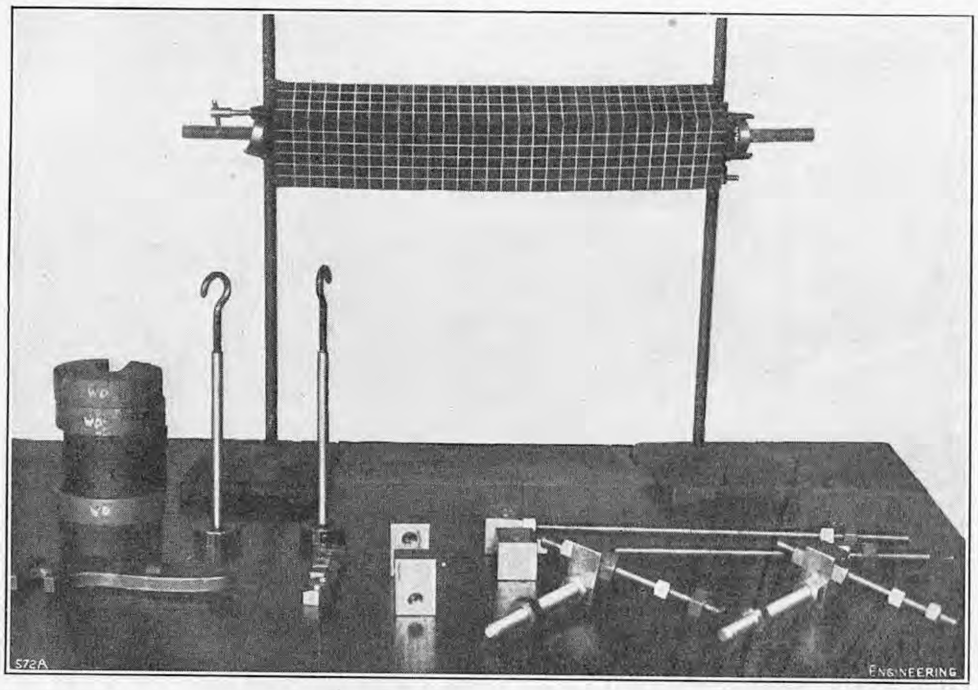


FIG. 1. PARTS OF APPARATUS.

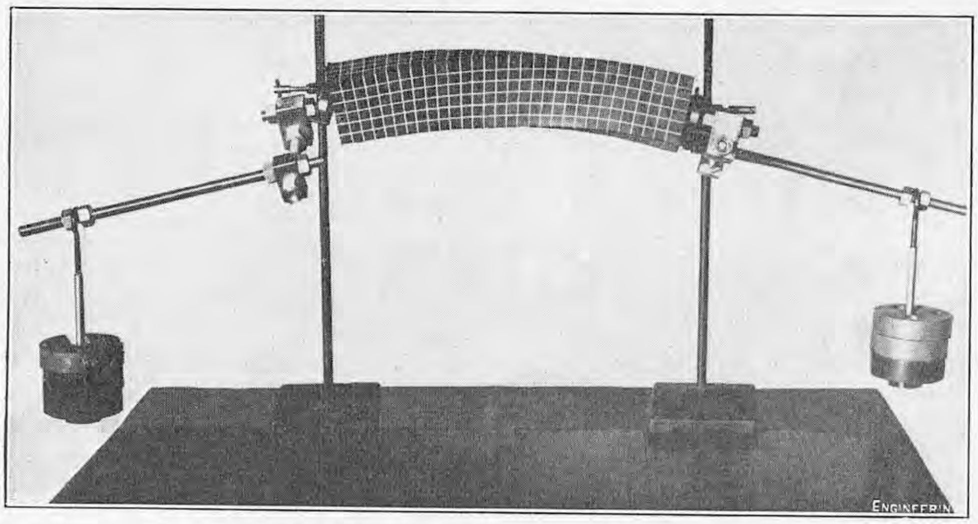


FIG. 2. RUBBER BLOCK UNDER COMBINED BENDING AND TORSION.

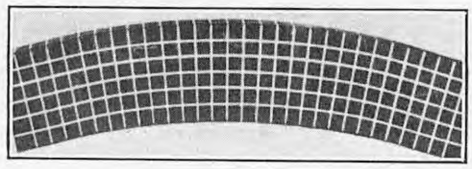


FIG. 3. PURE BENDING.

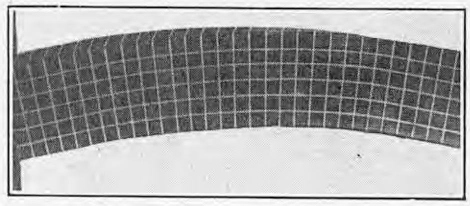


FIG. 4. BENDING MOMENT : TWISTING MOMENT = 6.

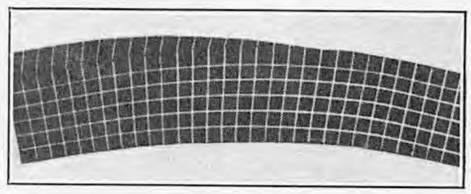


FIG. 5. BENDING MOMENT : TWISTING MOMENT = 2.

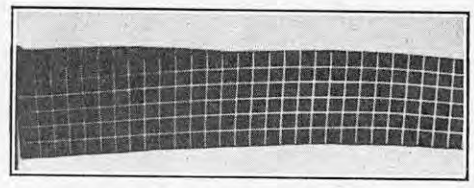


FIG. 6. BENDING MOMENT : TWISTING MOMENT = 1.

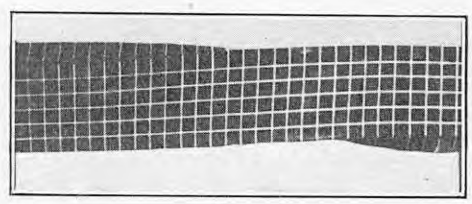


FIG. 7. PURE TORSION.

particulars inserted against their names in the *Register* shall be as up to date as possible.

Yours faithfully.

S. F. DOREY,
President.

F. T. BARWELL,
Hon. Secretary.

c/o The Institution of Mechanical Engineers,
Storey's-gate, St. James's Park,
London, S.W.1,
November 19, 1951.

RUBBER MODEL FOR COMBINED BENDING AND TORSION TESTS.

TO THE EDITOR OF ENGINEERING.

SIR,—The elastic deformation of rectangular sections in combined bending and torsion is complex, and not easily visualised in its three-dimensional form. The problem of the torsion of a rectangular beam is complicated by the warping of the cross-section during twist. The addition of bending further deflects the section in a vertical plane. Though the deformations due to both bending and torsion are linear, and, therefore, can be compounded by superposition, this joint effect is not readily appreciated in space.

As an aid to an investigation on the strength of reinforced concrete in combined bending and torsion, a rubber model has been constructed by Mr. S. Armstrong, B.Sc., and the writer to demonstrate the deformations in the gradual transition from pure bending to pure torsion. The model consists of a rectangular block of soft black indiarubber into which a bolt, $\frac{1}{2}$ in. in diameter, is moulded at each end. The dimensions of the rubber block, 2 in. by 3 in., are proportional to those of the test specimens. The deformations are brought out by a rectangular grid drawn on the surface of the model in white ink. The block is mounted in self-aligning ball bearings, and is carried on two retort stands (Fig. 1). The load is applied by two pairs of threaded rods, connected at right angles through a junction block; these can be adjusted so as to vary the ratio of bending moment to twisting moment (Fig. 2).

The gradual transition from the simple circular shape in pure bending to the three-dimensional deformation in pure torsion is illustrated in Figs. 3 to 7. Fig. 3 shows pure bending and Fig. 7, pure torsion. In Figs. 4, 5 and 6, the ratios of bending moment to twisting moment are 6, 2 and 1, respectively. As the amount of torsion increases, the originally straight vertical lines of the grid become more and more curved. With decrease in bending, the angle between the vertical lines of the grid is proportionately reduced. Though the front views of Figs. 3 to 7 do not show the anticlastic curvature of the model in bending, this is readily observed during the experiment.

Yours faithfully,

H. J. COWAN, M.Sc.

Department of Applied Science,
University of Sheffield.
November 8, 1951.

SAFE MEANS OF ACCESS.

TO THE EDITOR OF ENGINEERING.

SIR,—With regard to the question of providing workmen with "safe means of access" to their work, which was discussed in your article on page 594, *ante*, it may be further illustrated by a very recent case (*McCarthy* v. *Coldair, Limited*) which was reported in *The Times* of November 2; a case which serves to show how difficult it may be to decide whether a particular means of access is "safe" or not. In this instance, an electrician had to use a ladder to reach electric wiring which required attention; so the chargehand obtained a 10-ft. ladder and set it up at the proper angle. While the electrician was on the ladder, it slipped. He fell to the ground, sustained injuries, and, therefore, brought an action for damages.

Mr. Justice Jones, who tried the case, found that the ladder, as such, was safe, and that it had been inclined at the correct angle; but, it transpired, the floor was what he described as "semi-glazed." The surface, though not in itself dangerous, was smooth to the extent that a ladder might slip on it. In these circumstances, he came to the conclusion that a "safe" means of access had not been provided, found the employers liable, and awarded the plaintiff 2,750*l*. damages. When the case came before the Court of Appeal, Lord Justice Denning said: "The nature of the floor distinguishes this case from the ordinary case. I do not wish it to be thought that the law places upon the employers the duty to post a man at the foot of a 10-ft. ladder on an ordinary floor; but here the Judge had evidence on which he could find that the floor was a smooth one, on which a ladder might have a tendency to slip. The chargehand could have called someone to stand at the foot of the ladder while the plaintiff climbed it, or could have placed something heavy against it." In these circumstances, as the question was one of fact, upon which a Court of Appeal is reluctant to disturb the finding of a judge, the appeal failed; but the damages were reduced to 1,250*l*.—a fact which rather tends to show that the Lords Justices did not wholly approve the decision.

With all respect to the learned judge who found for the plaintiff, it appears that he placed upon an employer a wholly unreasonable burden of responsibility. Everyone of full age and reasonable intelligence must be assumed to know that a ladder is an implement which must be used with caution. Is it to be presumed that an experienced electrician, who is probably using ladders every day in the course of his work, is wholly devoid of common sense? If a jury had been summoned to decide this question of fact, I venture to think that their decision would have been different. An eminent engineer (the late Mr. J. S. Highfield) once said that "A jury is the best tribunal to decide a question of fact; there is generally one man among the twelve who can convince the others that their decision must be based on common sense."

Yours faithfully,
W. Valentine Ball.

18, Holland-street,
London, W.8.
November 12, 1951.

"FORDSON-MAJOR" AGRICULTURAL TRACTOR.

FORD MOTOR COMPANY, LIMITED, DAGENHAM.

(For Description see Opposite Page.)

Fig. 1. Tractor Fitted with Ford-Ransome Mounted Plough.

HIGHER TECHNOLOGICAL EDUCATION.

To the Editor of Engineering.

Sir,—In a leading article on page 401, *ante*, in your issue of September 28, on the subject of the Higher Technological University, you dwelt somewhat on the fact that no such institution could be founded for a good many years owing to financial stringency, and that, therefore, there was no need to bother about the proposal.

I would suggest, Sir, that this is not the proper way to deal with an idea which seems to a substantial number, probably to the considerable majority, of engineers to be a thoroughly bad one. If an idea is bad, it should be killed, and not allowed to "lie on the table" until its opponents have forgotten about it, when its protagonists can rush it through before effective opposition can be organised.

"Technological University" is, in itself, a contradiction in terms, for an institution cannot be universal that is devoted to the pursuit of a limited branch of knowledge. Apart from this ridiculous nomenclature, the idea that would-be engineers should be herded together in some sort of concentration camp called a "Technological University" is abhorrent not only, as I said above, to large numbers of practising engineers, but to practically the whole of the engineering faculties in the existing universities of the United Kingdom. A technological institution, pure and simple, can be nothing beyond a somewhat superior trade school, and will relegate the engineer (or "technologist") to a permanently inferior position as a very expensive tool whose cost is somewhere between a good lathe and a cyclotron.

Engineers suffer in status and remuneration from the fact that they are too specialised already. To increase this specialisation, to cut them off yet more from their fellow students of other branches of knowledge, would be a blow to the profession that would drive the best of the younger men to other careers. In a comparatively few years, engineers would be left with even less consideration than they receive now.

The ideal schooling for any professional man is a general education in the humanities until he is about 19 or 20. The humanities to-day must include an acquaintance with the fundamental principles of science, both mechanical and biological, as well as with the humanities proper. Outside his lecture rooms and laboratories, the undergraduate must mix with the diverse students of all branches of knowledge in all their activities. This is an essential feature of a university education and cannot be replaced by devoting an hour a day in the curriculum to lectures on the history of science, elementary economics, etc. A young man so trained will have no difficulty in learning the essential fundamentals of any branch of engineering to which he decides to devote himself, and will then become a civil engineer, or mechanical engineer, or an electrical engineer, as the case may be. He will not become, until later in life, a specialist in tidal equations, or turbine blades, in soil mechanics or three-phase motors, etc., etc. What is more, he will be able to bring his trained mind and basic knowledge to bear on any of a vast number of problems that will come to him in his own branch—his scope will be vastly increased. Such a training will mean, of course, that a young man does not leave college until he is about 22 or 23, some three years older than is at present the common average, I believe. Other professions, medicine and law, which are acknowledged to be senior in esteem to engineering, face an even longer period of training, and there is no reason why those people with a scientific bent of mind who decide to follow the profession of engineering and to reach the higher ranks, should hesitate at a similar length of education.

All such teaching should be done in the appropriate faculties, expanded above their present size if necessary, of the existing universities, up to the point where a young man gets his degree of B.Sc. (Engineering) or the like. Thereafter, research of two kinds can be undertaken. The first in the public eye, though the less valuable in the long view, is on "technology," which can be defined to cover everything from better beer to more isotopes. Such courses can best be undertaken at special institutions only remotely connected with the universities, where the facilities for research are available and up to date. To equip a laboratory of a university with an expensive quantity of large machines or apparatus to teach the techniques that are in force at the time the laboratory is made, means nothing but a waste of money in providing obsolescent models and machinery for the students to study. One thing is certain; that, as long as engineering progress continues in Great Britain, any models or machines provided for study in a university will be out of date even before the first postgraduate students begin to study them.

It is obvious that research by postgraduate students on technology, pure and simple, should be carried out in conjunction with the actual factories where the products are being made. There is no difficulty in this nowadays, because of the research associations maintained by many branches of engineering and industry, and by many of the great corporations, which are still limited liability companies. Many of the latter now take the best of the graduates from the engineering colleges and put them through courses where they are both learning and doing useful work at the same time, and pay them adequately while so engaged. Normally speaking, an undergraduate who is successful in taking a good degree need not expect to have to pay for postgraduate study, but rather to be paid while carrying it out.

The second, but more important, branch of postgraduate study is academic research on the science of engineering, which can, and must, be carried out in research laboratories attached to the existing universities. That many of such laboratories are too small and out of date is common knowledge, but a comparatively small sum expended on improving these will bring far more good to Great Britain than vast millions spent on a technical concentration camp known as a "Technological University."

What can engineers do to kill the "Technological University" idea? They should, individually, on every possible occasion, voice their objections in letters to the technical Press and to ordinary newspapers and periodicals, trade journals, local papers, the "high-brow" weeklies, etc., and generally carry on an agitation against this poisonous idea, strong, long and steady enough to kill it and not merely to let it "lie on the table."

I am bringing this up again so many weeks after your leader appeared because the menace of the "Technological University" has become greater in the last week or two, for reasons well known to all interested in this matter.

Yours faithfully,
F. Newhouse, M.I.C.E.

The Athenæum,
Pall Mall, London, S.W.1.
November 7, 1951.

"FORDSON-MAJOR" AGRICULTURAL TRACTOR.

FORD MOTOR COMPANY, LIMITED, DAGENHAM.

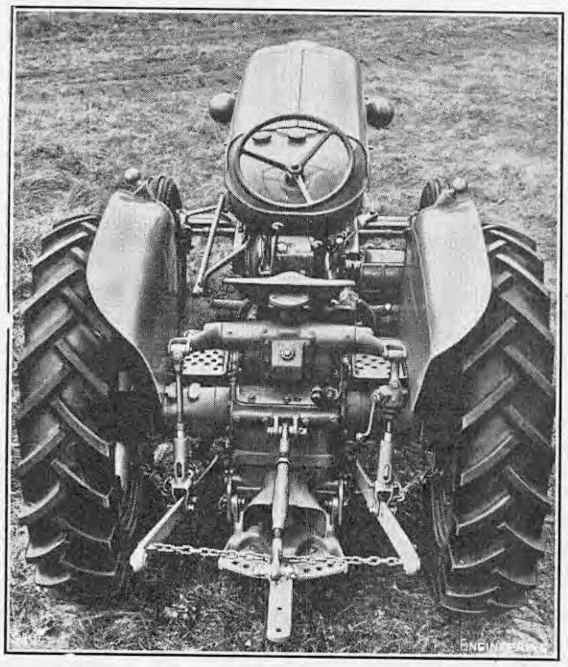


FIG. 2. REAR-IMPLEMENT LINKAGE.

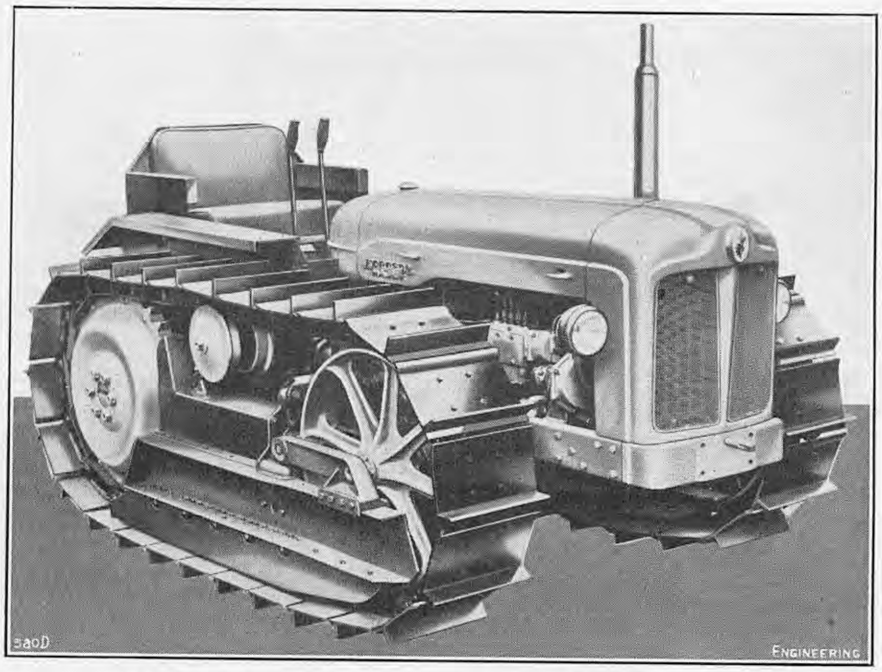


FIG. 3. TRACTOR FITTED WITH "COUNTY" FULL TRACKS.

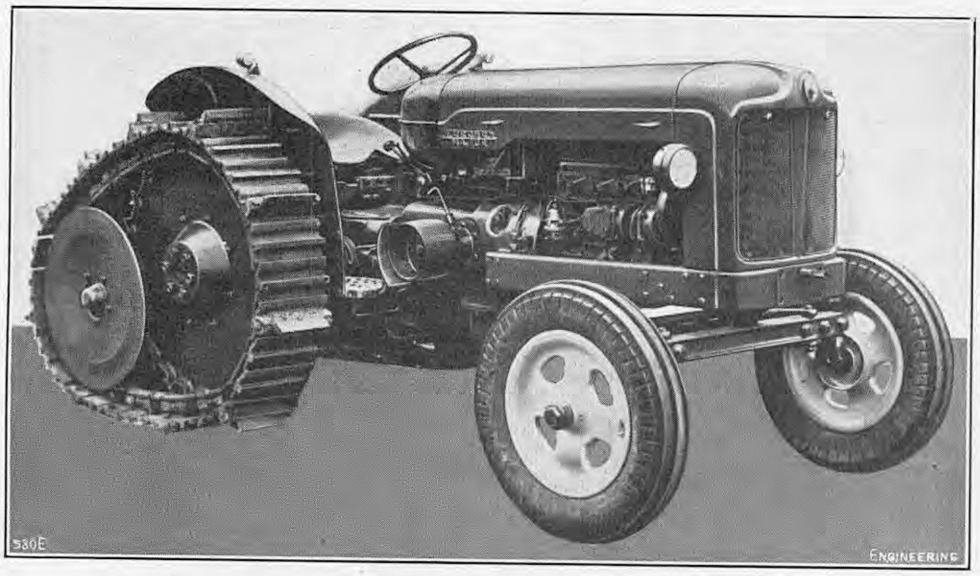


FIG. 4. TRACTOR FITTED WITH "ROADLESS" HALF-TRACKS.

THE "FORDSON-MAJOR" AGRICULTURAL TRACTOR.

At the forthcoming Smithfield Show the Ford Motor Company, Dagenham, Essex, will be exhibiting a new Fordson-Major tractor designed so that it may be fitted with a petrol, Diesel or vaporising-oil engine. The tractor is illustrated in Fig. 1, opposite, where it is shown fitted with the Ford-Ransome three-furrow mounted plough. It will be noted that the tractor bears little resemblance to its predecessor, having a modern styling and a lower overall height without, however, impairing the ground clearance. The three types of engine have four cylinders and overhead valves, and are of Ford design and manufacture throughout.

In general, the three engines are similar, many components, such as the cylinder block, crankshaft, timing gears, etc., being common. The bore and stroke for the Diesel and vaporising-oil engines are the same, namely, 100 mm. and 115 mm., respectively, but the petrol engine differs; the bore in this case is reduced to 95 mm. The main difference between the engines is in the design of the cylinder heads, the Diesel engine having a flat roof to the combustion chambers whereas those used on the vaporising-oil and petrol engines have larger combustion spaces to give the necessary reduction in compression ratio. The pistons also vary considerably, those for the Diesel engine being recessed at the top to form the combustion chambers. Nevertheless, most of the parts are interchangeable, with the result that manufacturing costs are reduced considerably and servicing arrangements simplified. Quality, however, has not been sacrificed in this standardisation, as all the common parts are designed to the highest specification required in any of the three engines.

Apart from detailed improvements, the general design of the engines follows standard practice. The cylinder block, which is identical for all three engines, is cast in one piece from a high-grade iron and is fitted with replaceable wet-type liners. A five-bearing crankshaft is used, the bearings comprising steel shells lined with anti-friction metal. The use of a five-bearing crankshaft on four-cylinder petrol and vaporising-oil engines is, of course, uncommon, and should do much to increase the effective life of these units. In accordance with modern practice, the crankshaft is statically and dynamically balanced and is drilled for conveying oil under pressure to the big-end bearings. An aluminium alloy having a low expansion coefficient is used for the pistons, which are ground to give a "barrel" shape. For the Diesel and vaporising-oil engines, three pressure rings and two scraper rings are fitted, but on the petrol engine only two pressure rings are installed; the number of scraper rings is the same. Steel connecting rods with bronze-bushed little ends and replaceable steel-backed metal-lined big-ends are used on all three engines. The valve gear follows established practice, consisting of a camshaft driven from the forward end of the crankshaft through helical gearing, and arranged to operate the valves through push rods and rocking levers, the levers being provided with means for adjusting the clearance. Oil for the forced-feed lubrication system is supplied under pressure by a gear-type pump the suction of which is protected by a strainer. Cooling is on the thermo-syphon principle, assisted by a centrifugal pump, the complete system being maintained under a slight pressure to minimise evaporation losses and obtain a more efficient working temperature. Cooling is aided by an 18-in. diameter fan, belt-driven from the crankshaft, and the operating temperature is controlled by a thermostat installed in the cylinder head.

On the Diesel engine, the fuel is drawn from a 15-gallon tank through a sediment bulk by a standard diaphragm-type fuel pump. From the pump the fuel passes through a Micronic paper filter to a gauze filter which is in the body of the Simms injection pump before entering the pump gallery. The injectors are of the four-hole type and any spillage is led back by a system of pipes to the fuel tank. On the vaporising-oil engine, separate carburetters are provided, one for petrol for use during starting and the other for vaporising oil, the change-over from petrol when the engine is warm being accomplished by means of a simple control on the instrument panel. Ignition on the petrol and vaporising-oil engines is provided by a 12-volt coil and a distributor which incorporates an automatic advance-and-retard mechanism. Governors are installed on all three types of engine, that for the Diesel engine being operated pneumatically and those for the petrol and vaporising-oil models centrifugally, the speed range being 400 r.p.m. to 1,700 r.p.m.

The outputs from the three engines are remarkably close, both the Diesel and petrol engines developing 32·8 belt horse-power at 1,400 r.p.m. and 35·8 h.p. and 34·9 belt horse-power, respectively, at 1,600 r.p.m. The vaporising engine develops slightly less power, the outputs being 32 belt horse-power and 34 belt horse-power at 1,400 r.p.m. and 1,600 r.p.m., respectively. The drawbar horse-power at 1,600 r.p.m. for the Diesel engine is 29·75, for the petrol engine, 29·0, and for the vaporising-oil engine, 28·25, these figures corresponding to road speeds of 3·4 miles an hour, 3·42 miles an hour and 3·44 miles an hour, respectively, on a tar-macadam surface. It should be added that the performance figures quoted were obtained with prototype machines, but the company intend to submit production models for testing by the National Institute of Agricultural Engineering.

Several improvements have been made to the transmission assembly which, of course, is the same regardless of the type of engine fitted. The clutch, which is incorporated with the flywheel, is an 11-in. diameter single dry-plate unit having a total friction area of 123·75 sq. in. It is connected directly to the input shaft of the gearbox, which is of the constant-mesh type and designed to give six forward speeds and two reverse speeds. Twin selector-control levers are used, the primary lever giving a high and low gear and the main lever three forward ratios and a single reverse ratio in both the high and low gears. The final drive consists of a bevel-pinion and crown-wheel assembly arranged to drive the half shafts through two separate spur-gear reduction units, one for each shaft, a differential gear of the bevel-pinion type being incorporated in the crown wheel. Brakes of the internal-expanding type are provided for the rear wheels, applied either independently to assist steering or together for use on the road, provision being made for locking them in the applied position when parking. The front axle is of the beam type with central-pivot mounting and the steering gear is of the recirculatory-ball pattern.

The total weight of the tractor varies according to the type of engine fitted, being 4,420 lb., 4,380 lb. and 4,360 lb. for the Diesel, vaporising-oil and petrol models, respectively, these figures including fuels, oil and water but excluding extra equipments such as power take-offs, hydraulic pump, electric lighting, etc. The wheelbase is 6 ft. 8 in., the overall length 10 ft. $10\frac{1}{2}$ in., and the maximum width, i.e., with the wheels set at the widest track, 7 ft. 1 in. Conversely, the minimum width is 5 ft. 5 in. The ground clearances are exceptionally good, being $19\frac{1}{2}$ in. under the front axle, 23 in. under the rear-axle housings, 16 in. under the forward transmission housing and slightly over 13 in. under the drawbar. As previously indicated, the wheel tracks are adjustable, the front track between the limits of 4 ft. $1\frac{3}{4}$ in. and 6 ft. $1\frac{3}{4}$ in. by increments of 4 in. and the rear track between 4 ft. 4 in. and 6 ft. by the same increments.

The Ford Company have designed a range of attachments for use with the new tractor; these include a hydraulic lift and associated linkage, belt-pulley and rear power take-offs, a safety clutch for use with mounted implements, and electric-lighting equipment. Oil under pressure for operating the hydraulic lift is supplied by a gear-type pump now located in the rear transmission housing and driven from the power take-off. It operates at a speed of 745 r.p.m., giving an output of 3·67 gallons per minute at 2,000 lb. per square inch when the engine is rotating at 1,400 r.p.m. The piston which actuates the linkage is designed to allow the implements free vertical movement when at work, thus permitting the depth-control wheels to follow accurately the contour of the ground and maintain constant depth. The layout of the linkage, which is illustrated in Fig. 2, on page 663, is much the same as on earlier models, the right-hand lifting rod incorporating a levelling box which can be operated easily from the tractor seat and the top link designed so that it can be replaced by a special link fitted with a hydraulic device for throwing out the clutch should any implement in use strike an obstruction such as a tree root. The belt pulley is fitted to the off-side of the tractor, as heretofore; it is provided with an $8\frac{1}{2}$-in. diameter pulley which can be run at two speeds, namely, 1,400 r.p.m. and 779 r.p.m., at a constant engine speed of 1,400 r.p.m., the corresponding belt speeds being 3,115 ft. per minute and 1,734 ft. per minute, respectively. The rear power take-off is fitted with a centrally-located shaft having six splines and designed to turn at 542 r.p.m. at an engine speed of 1,200 r.p.m. The shaft is $1\frac{3}{8}$ in. in diameter and the complete fitment conforms with B.S.I. and S.A.E. requirements. A swinging-type drawbar is fitted as standard to all tractors; this has a free lateral movement of 12 in. each side of the centre line and can be adjusted to give heights of 12 in., $14\frac{3}{4}$ in. and $17\frac{3}{4}$ in. above the ground.

Like its predecessor, the new Fordson Major can be fitted with either County full-track equipment or Roadless half-track equipment. A tractor fitted with the full-track equipment, which is manufactured by County Commercial Cars, Limited, Fleet, Hampshire, is shown in Fig. 3, on page 663, from which it will be seen that the conversion is particularly neat. When so equipped, the tractor will haul a four-furrow or six-furrow plough and similar heavy implements. Three widths of track plate are available, namely, 12 in., 14 in. and 16 in., the corresponding ground pressures being $4\frac{1}{2}$ lb. per square inch, 4 lb. per square inch and $3\frac{1}{2}$ lb. per square inch, respectively. These pressures are exceptionally low and enable the machine to be used on boggy ground not normally accessible to tractors. A tractor fitted with the half-track equipment, made by Roadless Traction, Limited, Gunnersbury House, London-road, Hounslow, Middlesex, is illustrated in Fig. 4. The track can easily be replaced by pneumatic tyres. It is of the girder type, being "locked" to a predetermined curvature, and is driven by sprockets fitted in place of the rear wheels. It will be appreciated that with this design, the track plates and associated linkage are in compression when under load, a factor which adds materially to the life. A safety device is incorporated so as to prevent damage to the tracks by stones or other bodies which may get trapped between the tracks and sprockets. The drawbar-pull is increased considerably and a tractor so equipped is suitable for four-, five- or even six-furrow ploughing.

LABOUR NOTES

Engineering wage claims were discussed for several hours at a joint meeting between leaders of the engineering trade unions represented on the Confederation of Shipbuilding and Engineering Unions and officials of the Engineering and Allied Employers' National Federation, which meeting took place in London on November 14. The negotiations terminated in an offer being made by the employers to increase the wages of all adult male employees by 11*s*. for a 44-hour week and to grant an additional week's holiday with pay. This offer was made in reply to claims by the Confederation, which included a demand for an all-round increase of 20*s*. a week for all men engaged in the industry and was based on a 44-hour week. The Confederation requested, when presenting its demands, that all merit, craft and district differentials should be maintained at their existing levels. The trade-union leaders informed the Federation officials that their proposals would have to be placed before the next meeting of the general council of the Confederation, to be held at York on November 21.

A joint statement issued after the London meeting on November 14 announced that it was understood by the representatives of the two sides that "the accumulation of payments in respect of next year's additional holiday would begin from the time when an agreement was reached." This stipulation appears to mean that the employers would not consider themselves bound to commence paying weekly sums into their holiday funds until such time as the agreement between the two parties had actually been signed. It is believed that the engineering unions had not expected an offer of a second week's paid holiday to be made at this time and it was, no doubt, the more welcome on that account. The acceptance of the Federation's offer would increase the wage bill for the engineering industry by between sixty and seventy million pounds annually, as, in addition to the main offer, it is understood that advances for juveniles and other employees would be incorporated in the final agreement. In all, nearly 2,500,000 engineering workpeople would benefit.

Similar offers, including a general increase in wages of 11*s*. a week for all adult male employees and, subject to certain conditions, an extra week's holiday with pay, were made in respect of some 250,000 operatives in the shipbuilding and ship-repairing industry at a meeting between representatives of both sides of the industry held in London on November 16. As in the case of the engineering industry, the men's demands were for an all-round increase of 20*s*. a week. The claim was submitted in mid-September and the negotiations which ensued were adjourned, like those in respect of the engineers, to enable the employers' local organisations to consider the position. The joint meeting on November 16 was attended by officials of the Shipbuilding Employers' Federation and of the Confederation of Shipbuilding and Engineering Unions and it was announced afterwards that this offer also would be submitted to the meeting of the general council of the Confederation at York on November 21.

A special meeting of the national committee of the Amalgamated Engineering Union was held in London on Sunday last, to consider what attitude should be adopted by the union to the offers of the Engineering and Allied Employers' National Federation and the Shipbuilding Employers' Federation respecting wage increases in the engineering and shipbuilding industries. It was announced subsequently that the national committee had decided by 32 votes to 20 to recommend the Confederation at its meeting on November 21 to accept the offers of the two federations.

It is understood that, at an earlier stage in the meeting of the national committee, efforts were made to secure the rejection of the employers' offers as being "totally unsatisfactory." The committee decided to press for the payment of the second week's holiday in 1952 to be made at the full rate, and not in proportion to the time when the agreements between the two sides of the respective industries are signed. In this connection, it may be noted that the rate for a week's holiday is reckoned as one-fiftieth of fifty weeks' earnings. It was considered that the federations should themselves make up the amounts set aside weekly by individual firms to what was required to ensure that the extra week's holiday in 1952 was accompanied in each case by a full week's pay.

The Amalgamated Engineering Union, with a membership of more than 700,000, possesses the largest voting strength of any of the 38 unions affiliated to the Confederation and the decision of the union's national committee to recommend the acceptance of the employers' offers no doubt exercised considerable influence at the meeting of the Confederation's general council on Wednesday last. The voting support of but one other union of average size, or, alternatively, of a few unions with small memberships, being all that was required to secure the acceptance of the employers' offers by all the unions affiliated to the Confederation. It was announced late on Wednesday night that these offers had, in fact, been accepted all on a show of hands.

The recommendations of the Railway Staff National Tribunal for all-round wage increases for some 442,000 railwaymen were accepted by the Railway Executive, according to an announcement made by the Executive, on November 14. The three principal railway unions had indicated separately during the preceding week-end that they were willing to accept the terms of the Tribunal's award. This provided for an increase of 8 per cent., against the 5 per cent. offered by the Executive and the 10 per cent. requested by the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen, and the Transport Salaried Staffs' Association in their joint claim. It was estimated by the Executive that its acceptance of the Tribunal's award would increase the wage bill of British Railways by about 14,200,000*l*. annually. The new rates will apply to wages and salaries as from the week commencing on November 26.

As there was no possibility of the money required to meet this additional charge on the railway service being raised "by further economies or other means," the Executive announced that it had no alternative but to apply to the Minister of Transport for further increases in freight charges. An application to that effect had accordingly been made by the British Transport Commission on behalf of the Executive. It seems certain that the acceptance by the Executive of the Tribunal's award will affect other railway-wage claims which are at present under negotiation, the most important of which are those put forward, on behalf of the railway shopmen, by the Confederation of Shipbuilding and Engineering Unions. As some 120,000 employees are affected by that demand, it may well be that the present round of wage claims will increase the Executive's wage bill by some 19,000,000*l*. in a full year.

An offer for an all-round wage increase of 8 per cent. was made by the London Transport Executive on November 16, in answer to the demands of the three principal railway unions for an all-round advance of 10 per cent. in respect of the Executive's railway staffs. The request of the three unions for the increase was presented jointly, and was, in effect, a claim parallel to that presented to the Railway Executive. There are some 20,000 employees in the salaried and conciliation grades of the Executive's railway services who are likely to benefit from this offer, if it is implemented. The representatives of the unions concerned informed the Executive that its offer would be considered by the unions separately and their decisions communicated to the Executive at an early date.

Disagreement with the policy of the Trades Union Congress for co-operation with the Government was expressed at a meeting of the executive committee of the Scottish area of the National Union of Mineworkers in Edinburgh on November 19. The matter arose out of a resolution to the same effect, which was put forward by the Valleyfield, Fife, branch of the N.U.M. The area committee decided to give this resolution its unanimous support, according to Mr. Abe Moffat, the union's local President, and it was decided that the resolution should be placed on the agenda of the union's Scottish delegate meeting in Edinburgh on December 17.

Criticisms of the attitude of the Scottish divisional coal board, respecting the wage rates paid to Scottish miners, were also expressed by Mr. Moffat. He stated that the Scottish board had been asked to take immediate action to close the gap which existed between the average wages paid to miners in Scotland and those obtaining in other parts of Britain. This gap was steadily widening and its existence was attributable, in Mr. Moffat's opinion, to the policy of the Scottish coal board, by which colliery managers were not permitted to fix piece rates. Furthermore, colliery agents, when fixing piece rates, were obliged to do so on the basis of existing earnings at their respective collieries.

Mr. Moffat said that his executive had also passed a resolution requesting the National Coal Board to concede without delay the demands recently put forward by the National Union of Mineworkers for increased remuneration. These demands included an increase in wages and two weeks' summer holiday with full pay. Referring to the resentment felt by Scottish miners at the fact that their wages lagged behind those paid elsewhere, he expressed the view that the Scottish coal board must change its policy or accept responsibility for any developments which might occur.

POWER-OPERATED CONTROLS FOR AIRCRAFT.

WEIGHT COMPARISON BETWEEN HYDRAULIC AND ELECTRIC POWER TRANSMISSION.

Fig. 1.
HYDRAULIC SCHEME: 4 PUMPS.

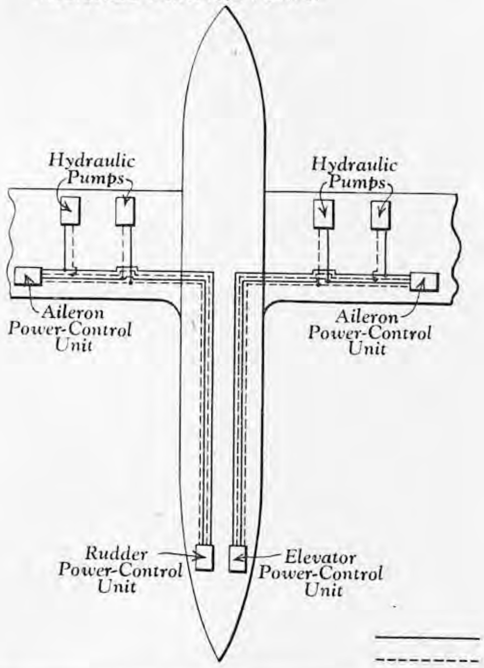
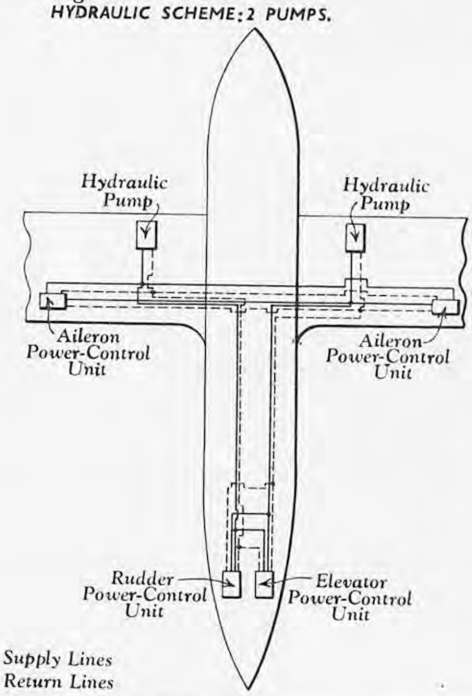


Fig. 2.
HYDRAULIC SCHEME: 2 PUMPS.



Scheme	Electric Motors	Cooling Ducts	Electric Cables	Generator System Share	Hydraulic Pipes	Fluid in Pipes	Pipe Clipping, Etc.	Pump Drives	Hydraulic Pipe Lagging	Total Weight
Electrical Transmission	180 lb.	40 lb.	35 lb.	200 lb.	—	—	—	—	—	455 lb.
Hydraulic Transmission Scheme of Fig. 1.	—	—	—	—	295 lb.	70 lb.	45 lb.	80 lb.	15 lb.	505 lb.
Hydraulic Transmission Scheme of Fig. 2.	—	—	—	—	215 lb.	55 lb.	30 lb.	50 lb.	10 lb.	360 lb.

(550.B)

POWER-OPERATED CONTROLS FOR AIRCRAFT.*

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

In applying power-operated flying controls to aircraft, the most important question is whether the controls should be operated only by a powered system, or whether manual control should be used in an emergency. The latter arrangement is limited by aircraft size and speed. Table I shows the estimated variations in payload, and their value in overall revenue during the life of the aircraft, for nine different systems for operating the flying controls of a hypothetical long-range aeroplane of about 100,000 lb. all-up weight. The life of the aircraft is assumed to be seven years, and the revenue for every additional pound of payload carried is assumed to be 27*l*. per annum (a standard value agreed by the Society of British Aircraft Constructors). The take-off weight, range, cruising speed and height have been assumed constant in each case.

The first, which is taken as the standard for comparison, is an ideal all-electric irreversible system, with miniature pilot's controls, no mass balancing, no aerodynamic balancing and such a high degree of reliability that no duplication is required. Such a system is not available to-day. The last system shown in the table is normal manual control which, although perhaps not feasible on a high-speed aircraft, has been included for the purpose of payload comparison. Between these two extremes are systems showing various stages of compromise.

Compared with a manually-operated flying-control system, the additional payload possible with scheme 3, probably the most advanced system which could be contemplated at present, is worth 106,000*l*. more in first cost. Thus, on an order for, say, 10 civil aircraft, an advanced system of powered controls may well pay for its development in earning capacity. Splitting the control surfaces and operating each part with a single actuator, as in scheme 6, makes for reliability, but tends to be heavy and limits the basic layout of the aircraft, e.g., it can hardly be adopted when the "elevator" is in the form of an all-moving tailplane. The advantage of manual emergency controls over the "all-power" control system is, again, reliability. As a last resort, the pilot exercises some measure of manual control which may, however, be embarrassing if the main power fails when the control-surface actuator is supporting a large hinge-moment. A method of overcoming this problem is to provide continuous automatic trimming by means of a separate power-operated follow-up tab. The usual practice is to return the trimmer to neutral after failure of the main actuator, and to carry on manually. In order to cater for a runaway failure of the powered trimmer, the main actuator must be powerful enough to support the increased hinge moment with the trimmer in its most adverse position.

The main engines, or perhaps in some cases auxiliary power plants, provide the power source. With an all-power system, it may be necessary to provide electrical or hydraulic accumulators for descent and landing in the event of complete failure of the main source. On single-engined aircraft, the provision of reserve energy is essential unless manual emergency controls are used. Power transmission from the engines to the control-surface actuators can be electrical, hydraulic or pneumatic, although the latter has not so far been used on aircraft. Electrical power transmission can be used with any type of actuator, but hydraulic and pneumatic systems can only be applied to actuators employing similar media.

Electrical transmission is more reliable than a piped system, since pipe fractures due to movement of the aircraft structure, vibration, etc., are more likely than breakages of electrical wiring. When used with hydraulic actuators, however, electrical transmission introduces the aircraft generating system, together with electric motors, into the chain of items which may go wrong. Thus, the reliability "balance" lies between electrical power generation and transmission, with electric motors, and long, large-bore pipes under constant pressure, which may have to be heated. Electrical transmission is less vulnerable and is more easily installed and maintained. Probably the electrical system is preferable for large aircraft and hydraulic transmission for small aircraft.

Figs. 1 and 2 show two hydraulic power-transmission systems for a hypothetical 100,000-lb. aircraft; their weights are compared in the Table below Figs. 1 and 2, with an electrical transmisson used to drive fully-duplicated electro-hydraulic actuators. With the hydraulic system of Fig. 2, a two-engine failure could put the whole system out of action. When compared with that of Fig. 1, electrical-power transmission is probably lighter than hydraulic for this size of aircraft. On smaller aircraft, engine-driven hydraulic pumps would show to better advantage.

Control-surface actuators may be divided into three broad classes: piston jacks, screw jacks, or skew-roller jacks. The piston-jack actuator, which is the lightest and simplest, is confined to use with hydraulic or air systems, whereas screw and skew-roller jacks can be driven by electric, hydraulic or air motors. When using piston jacks, it is doubtful whether the stiffness in the link between the control surface and the aircraft structure is sufficiently high to ensure freedom from flutter unless the control surfaces are mass-balanced. This relative lack of stiffness is due to the elasticity of the cylinder walls, to the elasticity of the fluid, or to aeration, i.e., the presence of air bubbles in the fluid. The last case, probably the most serious and certainly the most unpredictable, can be almost entirely eliminated by pressurising the fluid on each side of the piston to about 500 lb. per square inch. Actuators using piston jacks are probably the best solution for a system on which the control surfaces are mass-balanced and, particularly, when manual emergency controls are employed.

The simple screw jack has a high stiffness and offers the best chance of eliminating mass balance; in order to afford static irreversibility, however, an efficiency of less than 50 per cent. is demanded. Nevertheless, the damping effect of a jack with an efficiency up to about

TABLE I.—Power Control Systems: Comparison of Weights, Payload and Overall Revenue.

Item.	Type.	Description.	Total Weight, Lb.	Overall Relative Variation in Payload, Lb.	Overall Loss in Revenue $\left(\frac{£}{1,000}\right)$ Over Period of 7 Years.
1	All-power electric. No standby. Miniature pilot's controls.	Electric actuator, with remote electric signalling control, driving screw-jacks. No aero- or mass-balancing or feel.	940	0	0
2	All-power electric. No standby.	As (1), but with normal pilot's controls and artificial feel.	1,102	−162	31
3	All-power electric. Full duplication of controls.	As (2), but with all-powered components fully duplicated.	1,332	−392	74
4	All-power mechanical. Full duplication of controls.	As (3), but with non-duplicated mechanical signalling system. Electro-hydraulic actuators.	1,417	−477	90
5	All-power mechanical. Full duplication of controls.	As (4), but with full mass-balancing.	2,002	−1,062	200
6	All-power mechanical. "Split" control surfaces.	Each control surface split into three sections, each controlled by a single actuator. Mechanical signalling with artificial feel. No mass balancing.	1,917	−977	185
7	All-power with automatic follow-up trim.	Main actuator operating main surface. Separate actuator operating follow-up tab. Mechanical signalling with artificial feel. Aero- and mass-balancing.	2,113	−1,173	222
8	Power-boosted controls	Single actuator with proportional feed-back. Aero- and mass-balancing.	1,925	−985	186
9	Manual controls	Normal mechanical control system with spring tabs. Aero- and mass-balancing.	1,895	−955	180

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

POWER-OPERATED CONTROLS FOR AIRCRAFT.

Fig. 3. SKEW ROLLER JACK.

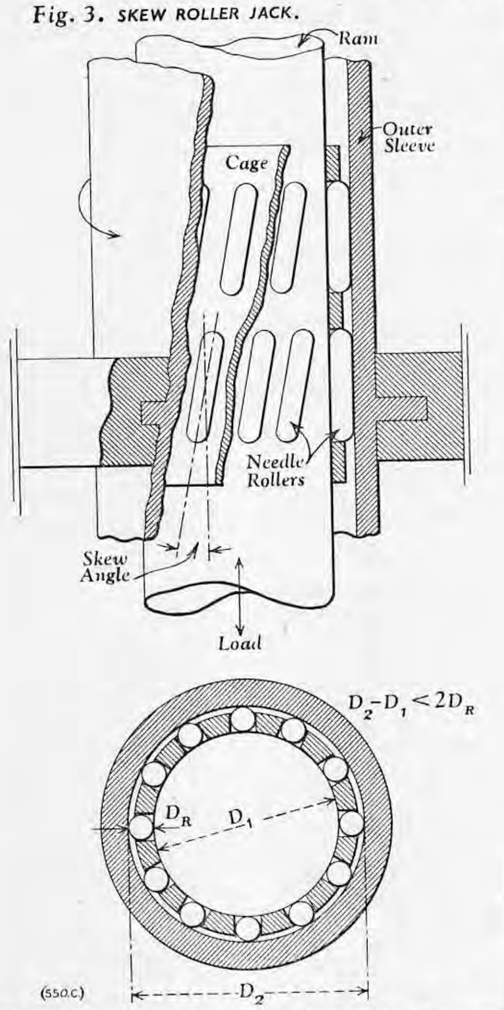


Fig. 4. REQUIRED PUMP CHARACTERISTIC.

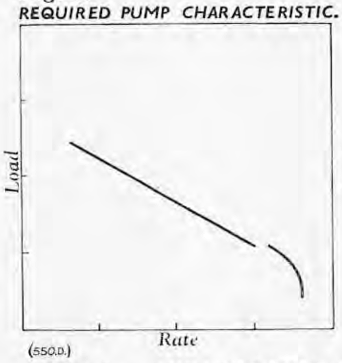


Fig. 5. CONSTANT -DISPLACEMENT PUMP CHARACTERISTIC.

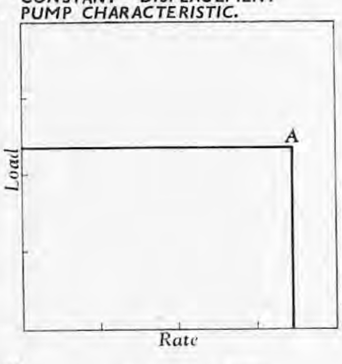


Fig. 6. CONSTANT-WORK PUMP CHARACTERISTIC.

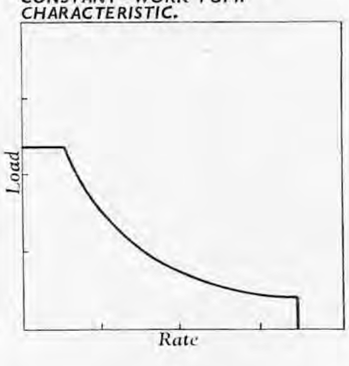
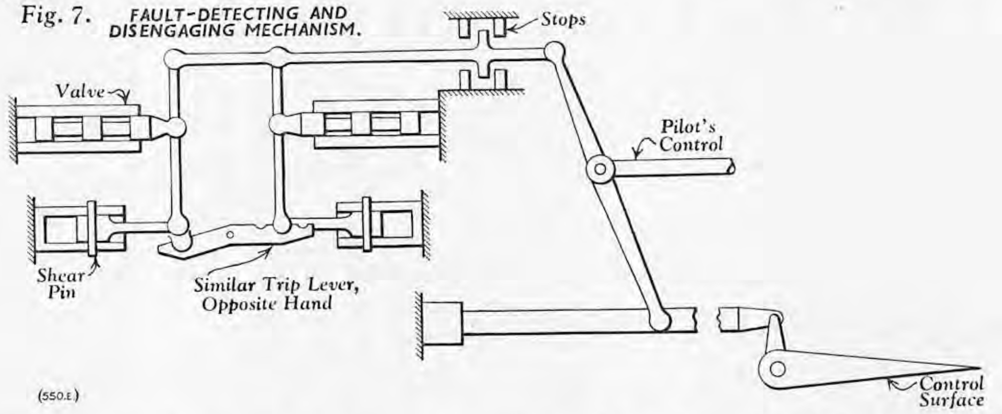


Fig. 7. FAULT-DETECTING AND DISENGAGING MECHANISM.



65 per cent. to 75 per cent. may be sufficient to ensure flutter-free controls, particularly when the screw jack is operated by a hydraulic motor which, owing to the small fluid volumes involved, will in itself have a high stiffness. When considering the combination of jack and hydraulic motor, it may be found possible to use a high-efficiency ball-bearing screw. The latter may also be driven by electric or pneumatic motors, but in these cases, the stiffness requirement will probably demand some form of clutch or automatic lock. Judder can arise on a simple screw-jack actuator, due to the difference between static and running friction; it generally occurs when the jack is working with a following load. Another disadvantage is that the weight of a screw-jack actuator can only be reduced at the expense of wear and increasing backlash.

The skew-roller jack, shown in Fig. 3, consists of an inner member and an outer sleeve, with rollers between them constrained in a cage so that the roller axes are at a slight angle (the pitch angle) to the axis of inner and outer members. The ram is restrained against rotation. The sleeve is free to rotate but is restrained axially. The difference between the outside diameter of the inner member and inside diameter of the sleeve is slightly less than twice the roller diameter, thus causing a slight elastic deformation of the outer sleeve. This mechanism, at present in the early stages of development at Messrs. Handley Page, Limited, Cricklewood, London, N.W.2, requires high-grade machining with very fine tolerances, but it offers practically no wear, no backlash, no judder, no adverse temperature effects, a high efficiency between 84 and 90 per cent., and it requires no lubrication.

The actuator may be located at the control surface or remotely. The principal advantage of the former arrangement lies in the short mechanical interconnection which can fairly easily be made free from backlash and stiff enough to eliminate flutter. When employing an all-electric actuator, high-altitude motor brush wear can be avoided by placing the motors remotely from the control surfaces in the pressure cabin. The remote electro-hydraulic actuator has an additional merit of enabling two or three electric-motor hydraulic-pump units to provide duplication for all three control surfaces, thus reducing weight and complication. There is also the possibility of servicing the units in flight. The main disadvantage is the difficulty of installing long mechanical drives with backlash and potentially low stiffness. The possibility of flutter arising from lack of stiffness can, however, be overcome by using shaft transmission with irreversible screw jacks at the control surfaces. The high weight of the long mechanical drives may be more than offset by the reduction in weight of the actuators.

When using hydraulic actuators, the hydraulic pumps may be directly driven from the engines or remotely by small electric motors. With engine-driven pumps, hydraulic power-transmission is required between the engines and the actuators. During approach and landing, when the rate of operation of the control surfaces is required to be at its highest value, the engine speed, and therefore the pump output, is at its lowest.

The remote electrically-driven pump enables the power-control actuator to be designed as a compact self-contained unit with no external pipes. Such a unit can be fully tested before assembly in the aircraft and be made easily removable for servicing under controlled conditions. It makes possible also the direct control of variable-stroke pumps, thus dispensing with control valves. This advantage is partly nullified if the loads required to displace the pumps are of such magnitude that servo action is required. Ideally, the pump should be balanced so that direct operation by the pilot's signalling system is possible. On a self-contained electro-hydraulic unit, the electric-motor weight may be as much as 25 per cent. of the total. It follows, therefore, that more careful attention must be given to the choice of hydraulic pump than when using engine-driven pumps. The characteristic requirement for a power-control system is for high loads at low rates (high-speed condition) and low loads at high rates (approach and landing condition). A typical curve of end load plotted against rate is given in Fig. 4. A constant-displacement pump provides a characteristic, when plotting end load against rate, as shown in Fig. 5, and will require an electric motor of power corresponding to point A. The pump which gives the lightest electric-motor weight is one with a constant-work characteristic, as shown in Fig. 6. This is achieved either by using a variable-stroke pump with the stroke controlled by pressure, or by a two-stage unit with gear and piston pumps (British Patent Application No. 14837/49), the latter automatically decreasing delivery with increasing pressure.

The use of a hydraulic pump, valve gear and hydraulic motor between the electric motor and screw jack appears to be a roundabout way of doing the job. A constant-speed electric motor with on-off control switching can be used to drive the screw jack directly, with mechanical or electrical signalling, but it has a marked tendency to instability, a " stepped " output, a high starting torque and potentially bad reliability of the high-power switchgear and relays. Constant-speed continuously-running motors might be used with magnetic clutches. The follow-up gear switches which energise the clutches have relatively low powers to handle and either alternating- or direct-current driving motors could be used. A third possibility is a variable-speed motor with Ward Leonard control. This scheme is primarily suited to an electrical signalling system and, therefore, in the present state of development it may be unreliable and heavy. It has the prospect of becoming ultimately one of the best systems for very large aircraft. The variable-speed motor could also be used with thyratron control, but the use of electronic components is considered unacceptable until they are more reliable.

When an alternative system of manually-operated flying controls is not provided as a standby, it is usual to duplicate electric motors, hydraulic pumps and motors, etc. Valves and hydraulic jacks are duplicated in order to make the two hydraulic systems independent. If it is assumed that neither valves nor jacks will ever seize, then a relatively simple unit is possible in which the faulty half can be motored freely by the sound half. If the jack is assumed to be liable to seize, a mechanical disconnector must be arranged on the ouput side. Duplication of the simple screw jack is probably unnecessary and the faulty half-unit can be de-clutched or, in the case of a hydraulic drive, the fluid supply cut off and the hydraulic motor allowed to be motored freely by the sound half.

Mechanical, electrical or hydraulic devices for detecting and disengaging a faulty half-unit work generally on the error-operated principle. Lack of correct response causes the pilot's load to be increased in the signalling-system input to the faulty unit. This increase in load operates a mechanical break link (British Patent Application Numbers 14838/49 and 14840/49), or spring-loaded electrical contacts (British Patent Numbers 22808 and 19699), or a hydraulic device which, in turn, switches off an electric motor, de-clutches a drive, opens the ports of a hydraulic circuit or changes over a mechanical output. A typical mechanism, employing a shear pin as the mechanical break-link, is shown in Fig. 7. Since mechanisms of this type are " triggered off " by the actuator-input load exceeding a pre-determined amount, any snatching of the controls, particularly if accompanied by excessive inertia on the actuator side of the detector, may inadvertently cut out both sides of a duplicated unit. For this reason it is desirable to inter-connect the detectors so that they cannot operate both together.

A second actuator, normally idle or " off load," can be arranged to take over when the primary actuator fails, either automatically or as a result of some action by the pilot. Alternatively, two actuators may normally share the load, with provision for automatic detection and disengaging of either, in the event of its failure. The only disadvantage of the latter alternative is that in the event of failure, the remaining actuator operates the controls at half load or half rate. The other alternative is invariably heavier, and some delay is inevitable, which could lead to catastrophe with a runaway control. It is suggested that $\frac{1}{20}$ second is probably the maximum time that can be allowed for change-over on a modern high-speed aircraft.

(To be continued.)

REMOVAL OF SULPHUR FROM TOWN GAS.

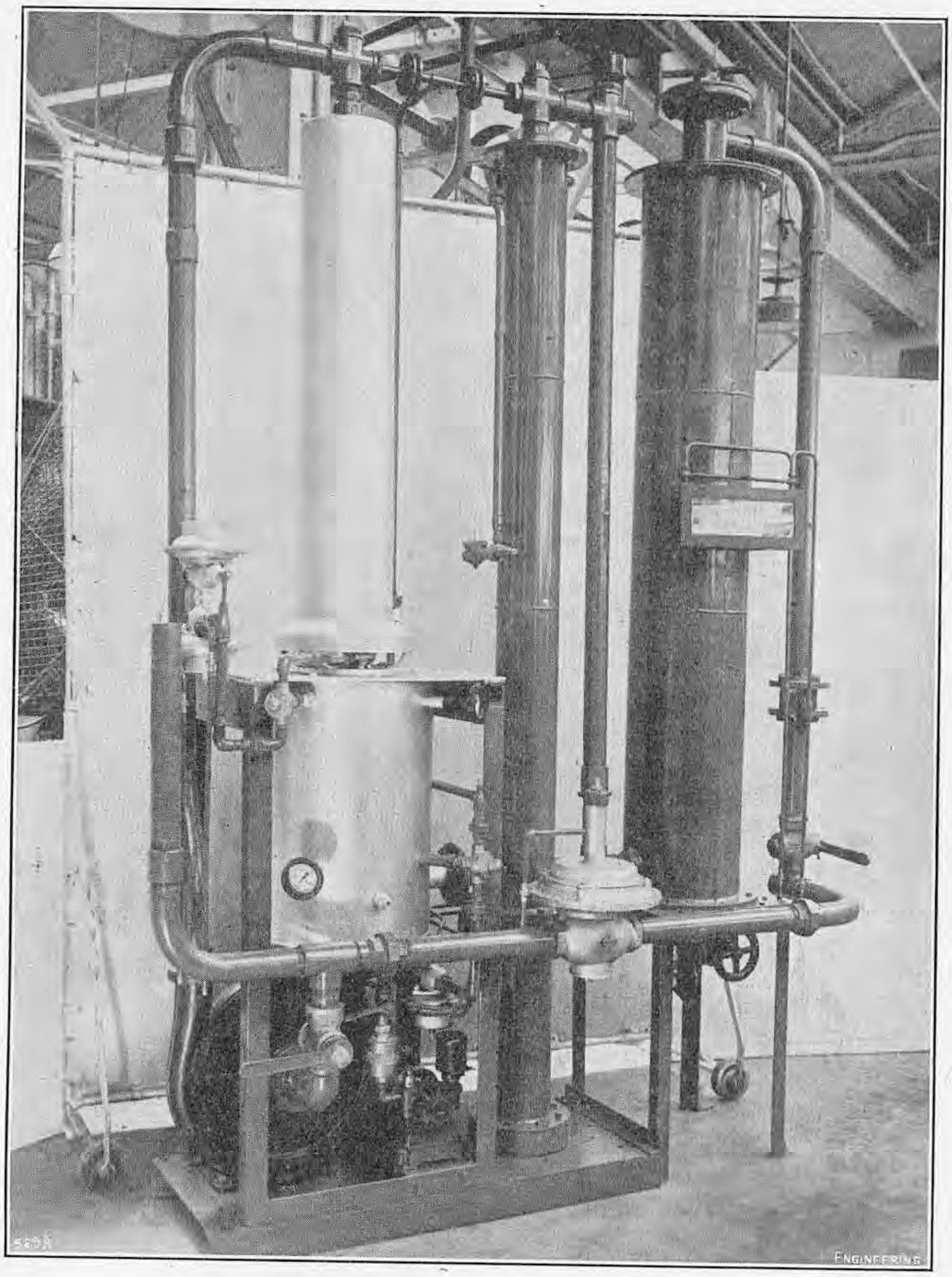


Fig. 1. Plant for Treating 1,000 Cub. Ft. per Hour.

TRUNK RADIO SYSTEMS.

In the chairman's address which he delivered to the Radio Section of the Institution of Electrical Engineers on Wednesday, October 17, Dr. D. C. Espley dealt with the directive radio links of a permanent character, such as had become important since the war. These links, he said, were appropriate to the trunk system of a national network or for interconnection on an international basis. Most of the traffic which they might be expected to carry could, however, be dealt with by cable networks and he would therefore attempt to show in what ways their special qualities could be used, as alternatives or additions, to deal with the traffic planned during the next 20 years. Nevertheless, it was unwise to consider radio trunks as detached networks, as overall systems of a national or international character in which radio links were merged with cable and line networks on a permanent or switched basis were necessary.

The use of radio-multiplex was analogous to the technique of composite cables in which a number of balanced pairs and coaxial tubes could be contained within one duct and sheath without the need for common repeater or terminal equipments. In cases of band width shortage, for example, a television signal might be transmitted over a radio-multiplex link in which the code pulses were distributed between two or more channels each of restricted band width. In view of the band width obtainable with modern aerial systems, there would be an increasing use of common-aerial and filter arrangements for simultaneous transmission and reception.

As regards the problem of frequency, an increase in operating frequency was not a panacea. There was little justification for regulating the lower part of the spectrum. It might be feasible to increase the usage of a given band by the allocation of the same frequency to many stations, by the use of highly directional beams and as a result of the severe wave attenuation beyond the horizon. It would be unwise to say that an effective choice of frequency could be found from consideration of international allocations and propagation conditions alone. The availability of special valves, particularly in the ultra-high frequency range, was likely to be a dominant factor for some time.

The position with regard to aerials was a little curious, since although an immense amount of theoretical and experimental work had been carried out, every project in this field seemed to require a significant amount of development work. However, in the very-high frequency range, the choice usually remained between broadside array and Yagi aerials, while in the ultra-high frequency range most aerial systems used paraboloid reflecting surfaces; variants of this type were likely to remain, in spite of other recent developments. Much of the work was concerned with the engineering details of particular aerials, screens and mountings. Although many factors were involved in the operations of trunk radio repeaters, one of the worst problems was that of power supply to remote stations.

In conclusion, Dr. Espley expressed the opinion that if the potentialities of pulse-code modulation and very large band widths were fully taken into account the radio link could be designed to compare favourably with a cable network.

CATALYTIC REMOVAL OF SULPHUR FROM TOWN GAS.

The report* on which this article is based is a sequel to I.G.C.C. Report No. 41/4/59, D 072, entitled "The Production of Low Sulphur Content Atmospheres for Heat Treatment Processes." Since the publication of the earlier report, further experience has been gained, in the light of which the plant there described has been redesigned, without alteration of principle. As before, the plant makes use of the nickel catalyst developed in the Fulham laboratories of the Gas Light and Coke Company. These laboratories have contributed substantially to the design of the plant and the preparation of this report.

The three important compounds of sulphur present in purified town gas are carbon disulphide, CS_2, 2 to 15 grains S per 100 cub. ft.; carbon oxysulphide, COS, 3 to 10 grains; and thiophen, C_4H_4S, 1 to 8 grains, making a total of 8 to 30 grains S per 100 cub. ft. (One grain S per 100 standard cub. ft., referred to as 1 grain, is equivalent to 17·2 parts per million by volume of thiophen or carbon oxysulphide, or 8·6 parts per million by volume of carbon disulphide.)

The carbon disulphide and carbon oxysulphide in town gas may be destroyed chemically in a catalytic process by which they are converted to the compounds sulphur dioxide and hydrogen sulphide. Unconverted carbon disulphide and carbon oxysulphide is usually about 1 grain, and the overall reduction in the sulphur content is, for example, from 20 to 25 grains, to 3 to 4 grains per 100 cub. ft. Low-sulphur gas from a small catalytic plant is of great benefit to certain industrial consumers. The chief applications are in glass working, in the preparation of metallurgical-furnace atmospheres, or for the direct firing of materials which are normally protected from sulphur in a muffle or closed saggar.

Thiophen cannot be removed from gas by any practical chemical method. The physical methods of removing thiophen involve the simultaneous separation of the benzole. Benzole recovery is practised to a limited extent in most gasworks, using oil-washing or active-carbon plant. These processes can be specially adapted to remove nearly all of the carbon disulphide as well as the thiophen; they cannot remove the carbon oxysulphide.

The catalytic process of the North Thames Gas Board operates in the following manner. The gas, together with a small proportion of added air, is heated to a temperature above 180 deg. C.; preferably 280 deg. to 320 deg. C. In a gasworks plant, the preheating is effected by heat exchange from the treated gas, but a small plant requires external heating, usually in a gas-fired pre-heater with thermostatic control. The pre-heated gas then passes through the catalyst bed at about 1,000 standard cubic feet per cubic foot of the bed. The active material is nickel subsulphide, Ni_3S_2, on small cylindrical pieces of porous fired china clay. The carbon disulphide and carbon oxysulphide in the gas are converted to sulphur dioxide. Most of the oxygen in the gas (for example, 0·5 per cent. by volume originally present and 0·5 per cent. added as air) reacts with some of the hydrogen to form water vapour. This catalytic combustion of hydrogen produces enough heat to give the required temperature of 380 deg. C. near the outlet of the catalyst bed, which temperature is controlled by thermostatic adjustment of the air added at the plant inlet. Some of the sulphur dioxide formed near the inlet to the catalyst bed is reduced to hydrogen sulphide at the hot oxygen-free end.

The treated gas, containing hydrogen sulphide, sulphur dioxide and additional water vapour, then flows upwards through a washer-cooler. The counter-current wash of soda-ash solution or hard water removes the sulphur dioxide; the temperature and dew-point of the gas are reduced almost to the temperature of the wash liquid. Finally, the gas is freed from hydrogen sulphide in a purifier containing iron oxide, preferably a compact tower charged with specially active spherical oxide nodules. Gas flow in the tower is upward and at the rate of about 200 cub. ft. per hour per cubic foot of oxide nodules. Spent oxide is removed periodically in small quantities from the base of the tower and fresh nodules are added to the top. To prevent the deposition of water on the nodules, it is desirable that the washer-cooler should reduce the dewpoint of the gas below the temperature around the purifier; otherwise, a small heater is needed to keep the gas entering the oxide above the dewpoint.

The oxide operates best when there is sufficient oxygen available to reconvert the iron sulphide to iron oxide. Some air may therefore be added at the purifier inlet. This catalytic process is protected by British Patents Nos. 489,398 and 529,711, and the special iron-oxide purification by No. 567,231. A royalty on the catalytic process is based on the nominal capacity of

* Report No. 51/1/81, D 072, entitled "The Catalytic Removal of Sulphur from Town Gas," of the Industrial Gas Development Committee of the Gas Council. Abridged.

the plant; it is a single charge included in the initial cost of the plant.

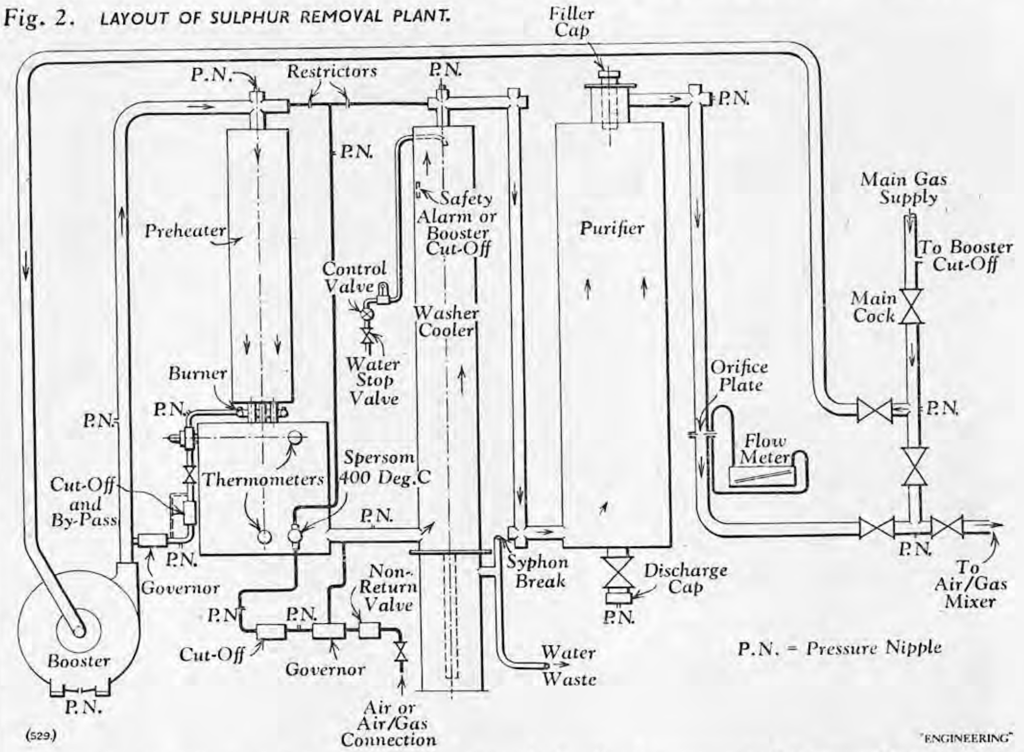
When reducing atmospheres are prepared by burning town gas with a deficiency of air, the sulphur present is converted chiefly to hydrogen sulphide and sulphur dioxide, but some carbon oxysulphide remains unconverted. For some applications (for example, the bright annealing of copper) rigorous purification of the atmosphere gas is needed to remove sulphur compounds; but if the town gas is rich in sulphur, the purified atmosphere gas will still contain enough carbon oxysulphide to spoil the surface of the metal in the furnace. In most areas, the town gas supply does contain sufficient sulphur to cause this trouble for several months in the year. The difficulty is fully overcome when a catalytic plant is installed to treat the gas before it passes to the furnace-atmosphere unit. The methods used to cool and purify catalytically treated town gas from sulphur dioxide and hydrogen sulphide are also quite generally applicable to reducing-atmosphere gases. The use of the special oxide nodules is particularly valuable as a substitute for bulkier purifier boxes containing bog iron ore. For heat treatment in oxidising atmospheres, a catalytic unit will, in many cases, lower the sulphur content of the gas sufficiently to permit direct firing where a muffle or closed saggars are now necessary.

Sulphur-removal plant using the nickel subsulphide catalyst is made under licence by several manufacturers. In addition, two sizes of plant for industrial consumers have now been standardised by the North Thames Gas Board. The smaller unit, with a nominal capacity of 1,000 cub. ft. per hour, contains 1 cub. ft. of catalyst; the larger unit is of twice this capacity. Both will supply any demand for low-sulphur gas up to 125 per cent. of the nominal capacity; the heating up time in each case is 2 to 3 hours. The height of the plant is 8 ft. 8 in. The ground space required is about 1 ft. 9 in. by 5 ft. 6 in. for the 1,000 cub. ft. unit, and 2 ft. 3 in. by 6 ft. 8 in. for the 2,000 cub. ft. size. Fig. 1, on page 667, shows the 1,000-cub. ft. per hour plant.

A diagrammatic lay-out is given in Fig. 2. A centrifugal fan is employed as a booster to overcome the pressure loss through the plant; this is initially about 3 in. w.g. at nominal capacity and $5\frac{1}{2}$ in. w.g. at 25 per cent. overload. With the booster it is possible to recycle treated gas when there is little or no demand for low-sulphur gas; a throughput of about 50 per cent. of nominal capacity is needed when heating the plant from cold or to keep it at full temperature, but this may all be recycle gas. The average gas consumption for preheating is $2\frac{1}{2}$ to 3 per cent. of the gas treated. The combustion of hydrogen on the catalyst consumes just over 1 per cent. of the heating value of the gas.

REMOVAL OF SULPHUR FROM TOWN GAS.

Fig. 2. LAYOUT OF SULPHUR REMOVAL PLANT.



240-MW STEAM POWER STATION AT WINDSOR, ONTARIO.

The J. Clark Keith generating station at Windsor, Ontario, which was opened on Friday, November 16, is one of two steam plants that are to be commissioned this year by the Hydro Electric Power Commission of Ontario, to supplement the power obtained from the water resources of the province. A scheme for installing thermal plant in an area which is rich in water power has been under consideration for 20 years, but has been postponed owing to the delay in the development of the St. Lawrence waterway. The rapid industrial development which occurred during the war in Toronto and the south-west of the province has, however, led to shortages, and although all the water power, which could be economically utilised, has been put into service, constructional work on some of the stations is still in progress. It was for this and other reasons that the Commission decided to utilise steam power in the areas of heavy demand, one of which is at Windsor on the Clair River, opposite Detroit.

The plans for this station envisaged the installation of four 60-MW sets with the associated steam-raising and condensing plant. Orders for two of the sets were placed with the English Electric Company, Limited, Queen's House, Kingsway, London, W.C.2, early in 1948 and the first of these is now running. Later, a contract for the third set was placed with the same firm and a fourth set has now been ordered. Each set is designed to operate with steam at a pressure of 850 lb. per square inch and a temperature of 900 deg. F. and to give an output of 60 MW at 13·8 kV at a power factor of 0·85 and a frequency of 60 cycles when running at 3,600 r.p.m. It exhausts to a vacuum of $28\frac{1}{2}$ in. of mercury.

The turbine consists of a high-pressure cylinder of the impulse type and a double-flow reaction-type low-pressure cylinder. Its general arrangement will be clear from Fig. 1, opposite, which shows the bottom half of the turbine with the shafts in position and from Fig. 2, which illustrates the low-pressure shaft.

Steam is supplied through two centre pressure stop-valves to two cast-steel steam chests which are arranged symmetrically, each chest being provided with a combined main stop and emergency trip valve. A separate cast-steel chest is welded to each main steam chest and carries the main throttle valve and overload valve. The chests operate in parallel, each main throttle valve being connected to the turbine by two pipes and each overload valve by one pipe. The arrangement is such that the pipe thrusts generally cancel out, thus relieving the turbine of any undue loads from this source.

The high-pressure rotor has been machined from a solid forging and the diaphragms in the high-pressure cylinders are of built-up construction. The double-flow low-pressure rotor is a solid forging, except for a separate disc which is shrunk and keyed on at each end and carries the last rows of blades. The couplings throughout are of the multi-tooth flexible type with generous axial float and, as the high-pressure turbine is provided with its own thrust block, differential expansion is confined to the individual cylinders. The high-pressure thrust block can be moved by a small amount in an axial direction while the turbine is in operation, so that the effects of differential expansion during the starting or unloading periods are minimised. To attain the same object when starting, the flanges of the high-pressure cylinder are provided with controllable steam heating.

The blading is of stainless iron or chromium-plated 5 per cent. manganese nickel steel, depending on the stress conditions. It is found that manganese nickel steel is particularly suitable for withstanding the heating necessary when attaching lacing wires by silver soldering without air hardening and for avoiding the consequent risk of the formation of hair-line cracks. All the moving blading is machined out of solid-bar material and has integral roots. The blade fixings are of various types, depending on the service stresses. The fixings of the long blades of the last row at each end of the low-pressure turbine are of the "side entry" type, in which each root is held in a separate groove in the disc head, the grooves being cut across the head in an approximately axial direction. The effect of this is that the bending stresses are virtually eliminated, both in the blade root and in the disc head. The total resultant stress at this vital point is therefore much reduced.

The glands throughout the machine are of the steam-packed labyrinth type; and the gland system is so arranged that when the machine is on load the leakage steam from the various high-pressure glands is conducted to the lower-pressure stages of the turbine, where it performs useful work. The vacuum glands of the low-pressure turbine are packed by steam taken from the high-pressure cylinder at a moderate temperature. The system is also so arranged that, when starting and stopping, the glands are fed by steam at a temperature suited to their temperature at the time.

A hydraulic system of governing and load regulation is employed, the function of which is to convert the normal characteristic of the speed governor into a hydraulic oil pressure which is transmitted to secondary relays and, through them, controls the opening of the steam valves and consequently the load on the machine. A small high-speed centrifugal governor is driven at 1,200 r.p.m. through gearing from the main shaft and operates a sleeve which is mechanically connected to an oil-governing valve. Any movement of this sleeve transmits a corresponding movement to the governing valve which, through the action of a bellows sleeve, increases or decreases the area of an oil leak-off port. The quantity of oil flowing to drain is thus varied, and consequently the oil pressure in a primary relay cylinder is increased or decreased in relation to the characteristic of a spring opposing the oil load. This change in pressure is transmitted to secondary relays which, in turn, operate the steam valves through oil distribution valves and relay pistons. To vary the speed or the load on the machine provision is made for hand operation or remote operation of the oil distribution valve. If loss of governing oil pressure occurs, the steam valves automatically close.

The emergency governor gear is actuated by a mechanical overspeed governor of the unbalanced-ring type, by an electrical overspeed governor, by a hand trip at the turbine or by an electrical trip operated from the control room. In all cases, both the emergency valves and the governing valves are closed so as completely to shut off the steam supply to the turbine. Once the trip has operated, the mechanism remains in the tripped position until it is reset by hand.

The lubrication system comprises an oil tank and a main oil pump which is housed in the high-pressure pedestal and driven from the main turbine shaft through helical gearing. In addition, a steam-driven full-duty auxiliary oil pump and an alternating-current motor-driven lubricating-oil pump are provided. As it is intended to uncouple the generator and to run it as a synchronous condenser under certain conditions of load on the system, two further lubricating-oil pumps, one with alternating-current and one with direct-current drive, are provided. Oil is drawn from the tank and delivered through a non-return valve to the distribution box. This is fitted with a relief valve, set at about 60 lb. per square inch, through which surplus oil is returned to the tank. Pressure oil is supplied to the governor relay gear from the distribution box. Oil for lubricating purposes passes through a pressure-reducing valve to the coolers and thence to the bearings at a pressure of about 15 lb. per square inch. Oil from the bearings passes through sight boxes to the common return pipe which conveys it back to the oil tank through strainers. Alarm signals are transmitted to the main control board if the temperature of the return oil from any bearing should rise to an excessive value.

Electrically-driven barring gear is provided, to reduce to a minimum any risk of the turbine rotors distorting due to uneven heating or cooling while the set is shut down. The gear turns the rotors at about 20 r.p.m. It is put into operation by hand, but is thrown out automatically when the turbine speed under steam exceeds that of the gear. High-pressure oil jacking is

240-MW STEAM POWER STATION AT WINDSOR, ONTARIO.

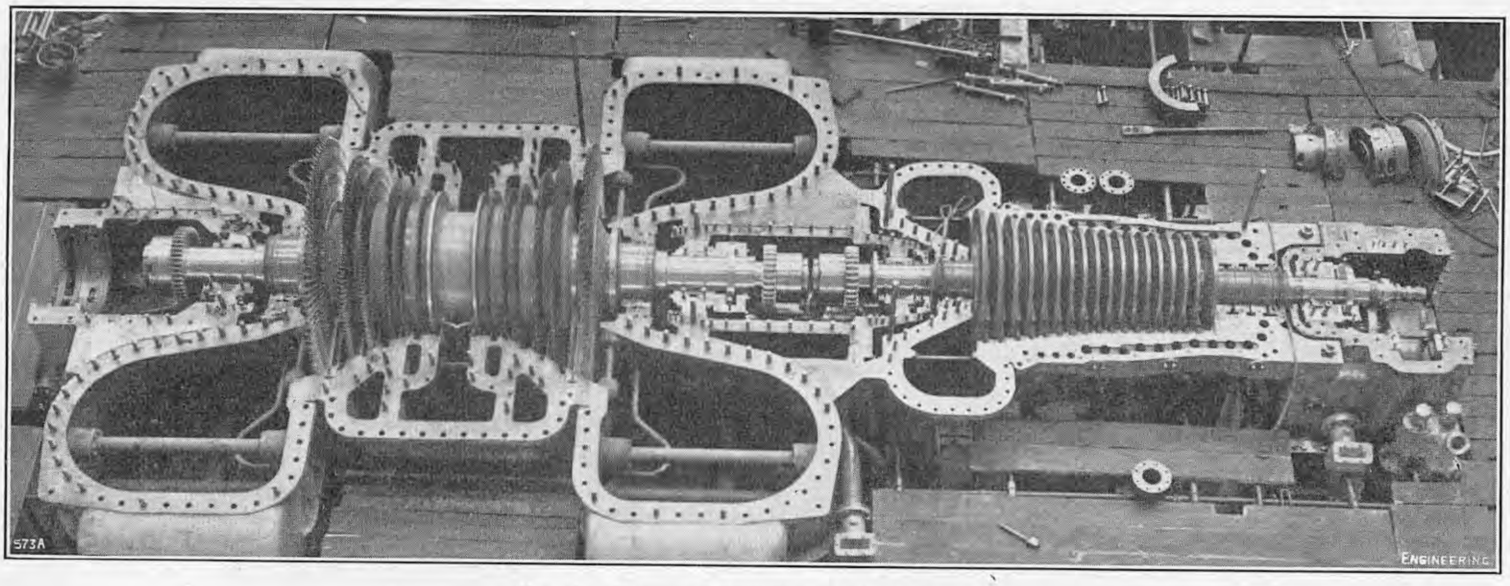


Fig. 1. Bottom Half of 60-MW Turbine.

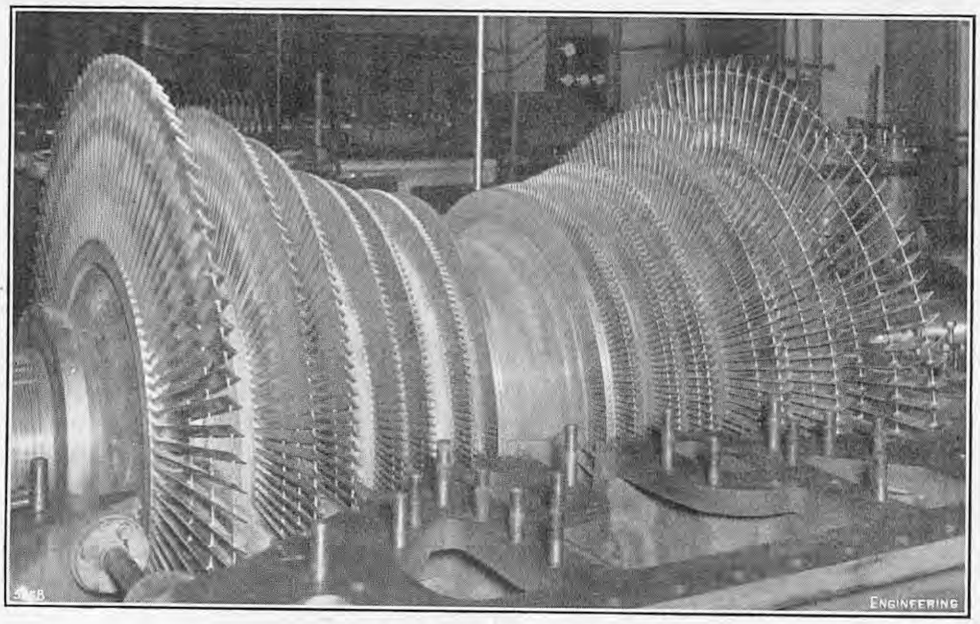


Fig. 2. Low-Pressure Rotor.

provided at the low-pressure turbine and alternator bearings to ensure that each of these journals is supported by a continuous oil film before barring commences and until the journal speed is sufficient to maintain a film when oil is supplied by the auxiliary pump. Damage to the bearings is thus avoided and the starting effort required from the barring motor is greatly reduced.

In order to obtain close control when starting up and shutting down, the set is equipped with supervisory instruments to give information regarding the condition and behaviour of various components, particularly in the high-pressure turbine. These instruments include an electrical speed indicator, which indicates and records the speed from about 100 r.p.m. upwards; a shaft eccentricity indicator and recorder; and a shaft position or axial differential expansion indicator and recorder. The last two instruments operate on the principle of introducing the distance to be measured as a variation in an air-gap controlling the reactance of an inductive circuit. Further, a high-pressure pedestal expansion indicator is fitted to record the pedestal expansion by measuring the relative motion between the steam-end pedestal and the pedestal base. Finally, vibration indicators, in the form of pick-up heads, are mounted on the bearing pedestals, just below the centre line of the turbine shaft, to measure the amplitude of the transverse vibration.

Vacuum load-limiting gear is provided to unload the set gradually by action on the governor gear. It commences to operate when the vacuum has fallen to about 23 in. and continues until, at about 17 in. of vacuum, all load has been removed. Arrangements are also provided for supplying the turbine with dry saturated steam to wash away any deposits formed in the turbine. Blade washing is carried out at no load and at a considerably reduced speed.

The stator frame of the hydrogen-cooled alternator is a fabricated structure, which is ribbed and stayed internally to ensure rigidity. The bearings are supported on separate cast-steel brackets which are bolted to the end plates of the frame. Precautions are taken to prevent the formation of an explosive mixture of air and hydrogen during the operation of the machine, but to provide for unforeseen conditions, the stator frame is designed to withstand the presure set up by an explosion. The stator core is built up from segmental stampings carried in a skeleton frame inside the main stator frame by flexible leaf springs. Any 100-cycle vibration produced by magnetic attraction between the poles of the rotor and the stator core is thus largely prevented from reaching the main structure and the foundations, while at the same time the core is rigidly restrained against the load and short circuit torques. The alternator is entirely self-contained, in that the two gas coolers are mounted axiall in the upper part of the outer frame and the gas is circulated by axial-flow fans. There are two fans, with blades of aerofoil section, one being mounted at each end of the rotor. This construction eliminates all external ducting and thus greatly simplifies the maintenance of a gas-tight enclosure.

The rotor is of conventional design and is coupled to the turbine through a multi-tooth flexible coupling. It is machined from a single forging of carbon steel, with additions of manganese, nickel and vanadium. Ventilation channels are provided beneath the slots and down the centres of the teeth. As the result of cutting the slots to contain the field winding, the inertia of the rotor is different across the two major axes, so that the static deflection at the centre of a long rotor such as this is appreciably greater when the pole axis is horizontal than when it is vertical. This effect gives rise to a vibration of the rotor at twice the running frequency, to eliminate which, as far as possible, transverse grooves are machined in the pole centres. The field winding is formed of semi-hard silver-bearing copper in order to prevent coil distortion through differential thermal expansion. The turns are taped throughout their length with glass-backed mica tape, which completely eliminates the risk of short-circuits developing between turns owing to leakage across the edges of strip separators. The leads from the winding are brought out of the gas-tight housing as semi-circular conductors which run through the central inspection hole of the forging to the slip-rings. The bearings, which are of the usual spherically-seated type, are carried in cast-steel brackets bolted to the outer frame. Excitation is provided by a dynamo running at 1,000 r.p.m. and driven through gearing from the main alternator shaft.

Leakage of hydrogen along the shaft is prevented by oil-sealed glands of the floating-ring type. Two bronze rings are mounted side by side in an annular groove in a cast-steel support which is carried rigidly from the inner surface of the bearing bracket. They are permitted to move with the shaft in a plane perpendicular to the axis of the rotor, but are prevented from rotating with it. The clearance between the rings and the shaft is kept down to the minimum consistent with satisfactory running. Similarly, the clearance between the rings and the side of the groove in which they are contained is kept small to reduce the oil flow as much as possible and to maintain a satisfactory seal at this point. The groove behind the rings is supplied with oil at a pressure of about 10 lb. per square inch above that of the gas in the frame, and feed holes in the rings allow the oil to pass into a small annulus formed between the rings by machining the rings themselves. The film of oil thus maintained between the rings and the shaft forms the gas seal and at the same time lubricates and cools the rings. The seals are supplied with oil which is normally vacuum treated to remove entrained air and water in order to prevent adulteration of the hydrogen occurring from the oil which flows to the gas side of the seals. The seal-oil treating unit is located at basement floor level within the foundation block and contains the various items of auxiliary equipment associated with the oil supply to the seals.

Demonstration of Miniature Circuit-Breaker.—Dorman & Smith, Ltd., Manchester, 5, have arranged to give demonstrations of their miniature circuit-breaker at St. Ermin's Hotel, Westminster, London, S.W.1, at 3 p.m., on Monday, November 26, and at 11 a.m. and 3 p.m. on Tuesday, November 27, when the technical aspects and applications of the circuit-breaker will be dealt with. Accommodation is limited and persons desirous of witnessing the demonstrations should apply to the firm's London office, at 10, Emerald-street, W.C.1.

Proposed Oil Refinery in India.—The Burmah Oil Company and the Shell Group, the partners of Burmah-Shell India, are considering the erection of an oil refinery at Bombay. They are sending representatives to Delhi, at the request of the Government of India.

KILN BUILDING OF PRE-CAST CONCRETE UNITS.

The building shown under construction in Fig. 1, herewith, has been designed by Messrs. W. S. Atkins and Partners, 158, Victoria-street, London, S.W.1, and built by Messrs. C. Cornes and Son, Hanley, to extend the Whieldon works of Messrs. Doulton and Company, Limited, Stoke-on-Trent. Above the first floor, which houses two kilns, as shown in Fig. 2, pre-cast concrete framing with a span of 85 ft. is used.

The Whieldon Works specialise in sanitary earthenware and vitreous china. Previously, all the firing was carried out in a number of coal-fired intermittent kilns known, because of their shape, as "bottle kilns," but these are being replaced by two Dressler continuous gas-fired tunnel kilns of modern design. The new kilns are each about 320 ft. long, and the building has been designed to provide accommodation for them and for all the processing after the first, or "biscuit" firing. The two tunnel kilns, with associated processes, are on the first floor. The ground floor provides facilities for testing, assembly, storage, packing, and dispatch of the goods. As a result of these arrangements, it has been possible to reorganise the earlier stages of manufacture carried out in the existing buildings, i.e., from the processing of the raw materials to the completion of the unfired or "green" ware. The two kilns have different functions: one produces unglazed or biscuit ware, the other glazed or "glost" ware. To maintain an unbroken flow in production the kilns are ranged side by side and head to tail down the centre of the building. Green ware is delivered to the north end of the new building at first-floor level. It is then passed through the biscuit kiln to emerge into a spacious working area where it is inspected, brushed, glaze applied and dried, ready for the next firing. During this second, or "glost" firing, which the other kiln performs, the ware is returned to the northern end, where it is finally inspected and is then transferred by lift to the ground floor.

Owing to the fact that the site consisted largely of made-up land and the load-bearing capacity was therefore poor, the whole building is founded on a system of *in-situ* piles—a good load-bearing stratum being found at from 20 ft. to 30 ft. to minimise any danger of differential settlement. Up to and including the first-floor slab, all the construction, with the exception of a small annex to the east, is *in-situ* concrete framed. It is on this construction that the load of the kilns is carried. Columns at 15-ft. centres divide the building lengthwise into 32 equal bays; main beams run longitudinally and span the 15 ft. from column to column, and secondaries at 7 ft. 6 in. centres span transversely between the main beams. The suspended slab of the first floor is 5 in. thick and is cast integral with the beams. At the ground level the pile caps are connected by a series of cill beams, but in general the ground-floor slab is not suspended. Where concentrated loads have to be carried, it is suspended, and the cill beams and slab are then cast integral. Elsewhere, paper joints separate the one from the other.

From the first-floor slab upwards, the construction changes from the *in-situ* system to a proprietary pre-cast system of framing, of which the span is 85 ft. Spans in framing of this kind have been steadily increasing for some time, and although that at Whieldon has been exceeded in France by one from the same designers, this of 85 ft. is thought to be the largest yet erected in Britain. The framing consists of transversely-spanning portals spaced at 15-ft. centres, which carry pre-cast purlins 4 ft. 6 in. apart and special gutter units along the eaves. Each main cross-spanning portal is made of four separately-cast members with a patented system (Lambda) of scarfed jointing at the connections, which maintains the required degree of structural continuity. The leg members are L-shaped; they weigh about $2\frac{1}{4}$ tons each and are stiff to minimise moments of bending in the rafters. Rafter elements weigh about $1\frac{1}{2}$ tons apiece, and despite their span are only 18 in. by 7 in. in cross-section. Laterally, the stiffness and structural rigidity come from the purlin and gutter units—with the method of jointing used at their connections, shown in Fig. 3. To form these joints, U-shaped bars projecting from each end of both types of unit are looped round fixing bolts that protrude upwards from the backs of the rafter principals; the nut on these bolts is tightened down over a large washer which grips and holds the U-bars in place; and the joint is completed by filling with a grout and flushing up the 2-in. wide gap formed between the ends of the units. All the pre-casting for the main frames was carried out at the site, but the smaller units—purlins, gutters, roof slabs, etc.—were all factory-made. Main frame sections were actually cast on the first-floor slab, and, to save handling, as near as practicable to the places in which they were ultimately to be used. Because wheel loads from a mobile crane would have been too great for the slab to withstand, the lifting was performed with four guyed timber poles, blocks and hand-operated winches.

PRE-CAST CONCRETE KILN BUILDING.

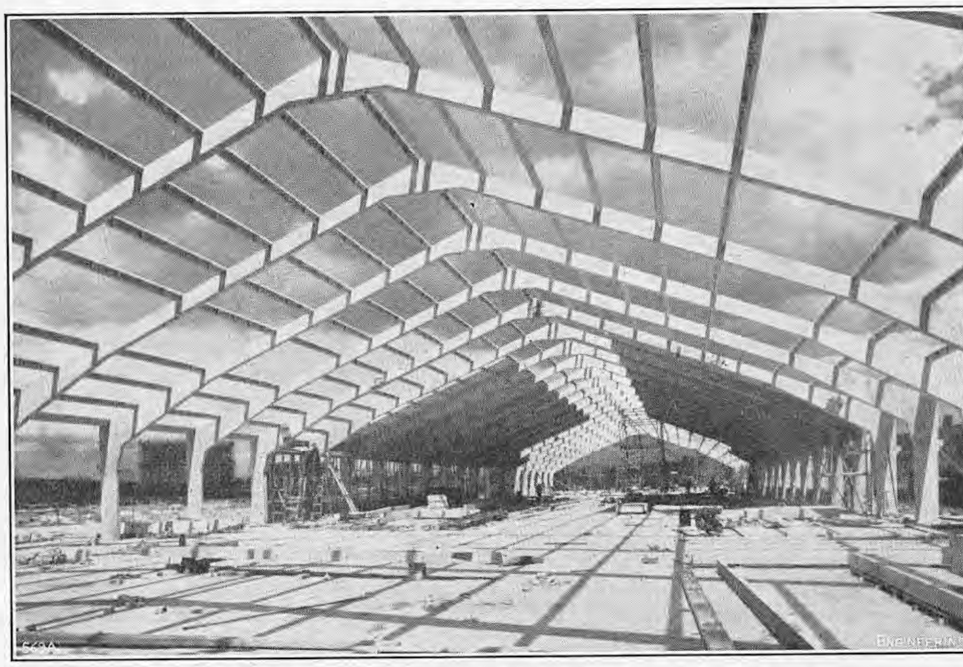


Fig. 1. Pre-cast Structure at First-Floor Level.

Fig. 3.

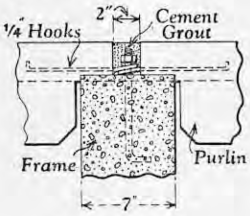
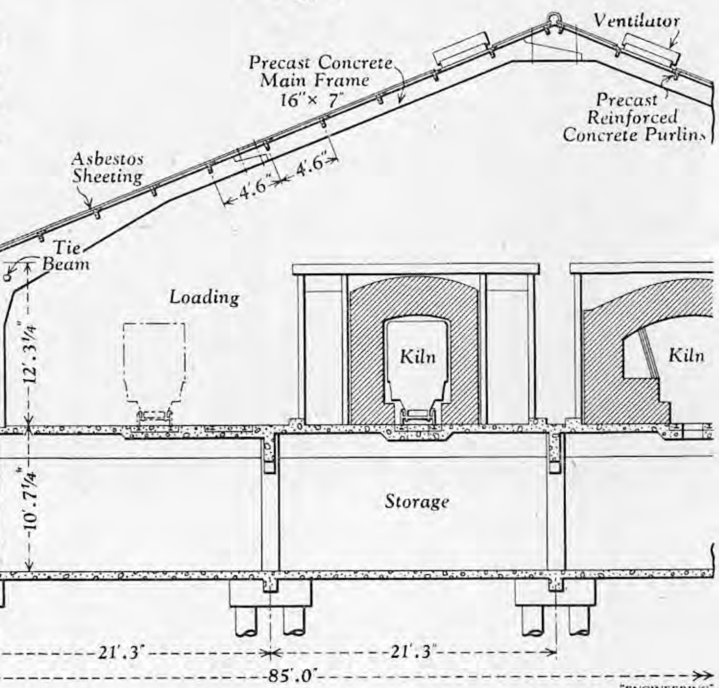


Fig. 2.



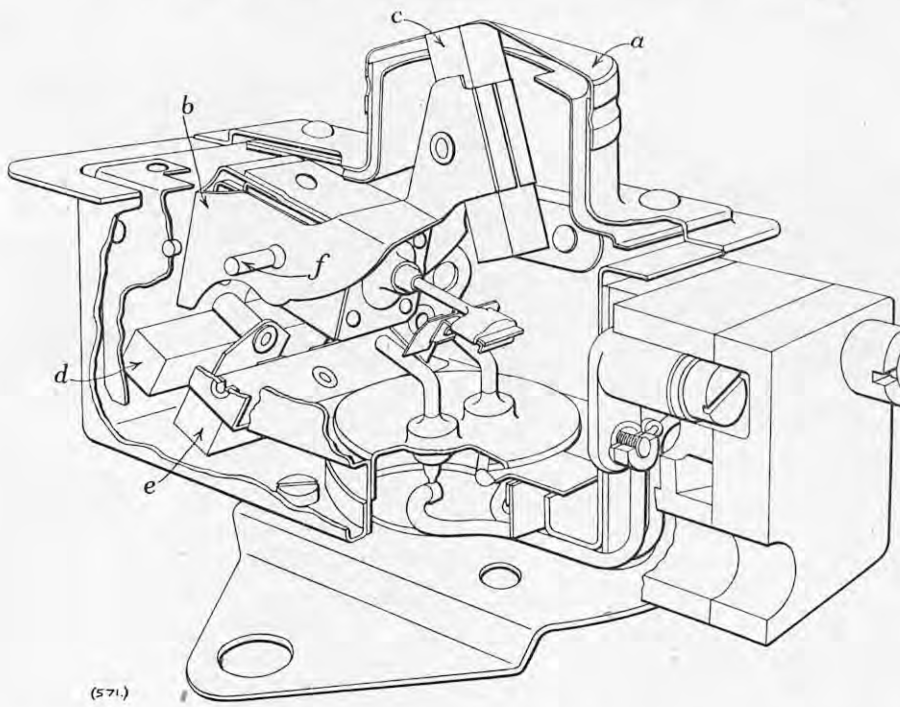
After being lifted into position, the leg members were plumbed and lined up along the scarfings and kept in line by temporary scaffold frames. These units were dowelled at the foot with the *in-situ* concrete of the lower storey, and, during the placing, were wedged accurately into position in holes pre-formed in the first-floor slab. They were lined on the external faces with those of the columns below by temporary clamps. The lifting and placing of the rafter members followed, and it was not until these had been bolted up that the weight on the poles was eased and the dowels grouted up. Erection of purlins and gutter units followed on immediately after the erection of the portals.

The external wall in-filling to all the reinforced-concrete framing is in 11-in. cavity brickwork. The windows are metal casements which, on the first floor, extend from column to column and uninterruptedly from end to end of the building. For the main roof the covering is asbestos-cement corrugated sheeting. Above the kilns this is of the normal type, laid with normal laps, but to the working area at the south end of the building, where thermal insulation is of importance, the sheeting is of the combined type. In the kiln area there is little need for central top lighting, since that given by the windows is adequate. At the north end, however, where glost ware is inspected and good lighting is essential, 6-ft. wide strips of patent glazing are incorporated in the roof. Patent roof glazing was also fitted into each of the two gables. To reduce glare through the gable facing south, the rough-cast wire glass used was sand-blasted on the inside. Lead-covered steel bars have been used for the patent glazing throughout. The reason for this is that, during the biscuit firing, fluospar in the clay gives rise to fluorine gas which might attack bars of any other material.

Joint Committee on Materials and their Testing.—A symposium on "Recent Developments in the Notch-Bar Testing of Materials and their Relation to Welded Construction" is being arranged by the Joint Committee on Materials and their Testing of Technical Institutions and Societies in Great Britain (to give this Committee its full title) and the Institute of Welding. The presentation of, and discussion on, the symposium will take place at the Institution of Civil Engineers, Great George-street, London, S.W.1, on Wednesday, December 5, commencing at 10 a.m., and resuming after an interval for lunch, at 2.30 p.m. Papers will be contributed by Mr. W. Barr, A.R.T.C., F.I.M., Mr. G. M. Boyd, A.M.I.Struct.E., M.I.N.A., Professor W. Soete, Mrs. C. F. Tipper, Sc.D., and Dr. J. H. Van Der Veen. All papers will be preprinted and will be presented by Dr. N. P. Allen as *rapporteur*. The chairman will be Mr. H. J. Thompson, M.I.Mech.E., President, Institute of Welding. Admission is by ticket only, obtainable from Mr. G. Parsloe or Mr. G. H. Ford, 2, Buckingham Palace-gardens, London, S.W.1, from whom advance copies of the papers are also obtainable.

MAGNETIC TEMPERATURE DETECTOR.

GRAVINER MANUFACTURING COMPANY, LIMITED, COLNBROOK.



MAGNETICALLY-OPERATED TEMPERATURE-DETECTION SWITCH.

The practical application of the change of the magnetic properties of ferro-magnetic alloys with temperature was proposed originally by the Royal Aircraft Establishment. A prototype magnetic temperature detector, made by the Graviner Manufacturing Company, Limited, Poyle Mill Works, Colnbrook, Buckinghamshire, to the requirements of the Royal Aircraft Establishment, was demonstrated in the 1949 exhibition of the Society of British Aircraft Constructors' and was described on page 161 of our 169th volume (1950). The instrument consisted of a spring-loaded moving temperature-sensing armature of a suitable ferro-magnetic material, normally held in contact with a permanent magnet by mutual attraction. When the temperature rose above the Curie point of the armature material, and the armature lost its magnetism, the spring forced the armature to shift and, in so doing, to complete an electric circuit and operate a flame-warning lamp. Since then, the Graviner Company have developed a considerably improved instrument; the spring has been eliminated and a fixed temperature-sensing element is employed, instead of a moving armature. A number of magnetic temperature detectors, connected in flame-warning circuits, are at present undergoing extensive flight trials on 21 different types of aircraft in this country, the United States, Sweden and Australia, and in the laboratories of Air France and the K.L.M. Royal Dutch Air Lines.

The accompanying illustration shows the Graviner magnetic temperature detector. Silver-soldered to the cover-plate of the instrument is the temperature-sensing element—a projecting conical cap *a*, in a nickel-iron alloy, which shows a sharp change of magnetic permeability at the temperature at which the switch is required to operate; at present, the detector is available in two marks for operation at 170 deg. C. and 290 deg. C., respectively. Inside a seam-welded stainless-steel sealed casing is the magnet assembly, which consists of a balanced beam *b* at one end of which is a shrouded permanent-bar magnet *c* which, under normal temperatures, is attracted to the cap. The other end of the beam carries another magnet *d*, adjacent to a fixed magnet *e* of similar polarity, so that there is a repelling force between them. At normal temperatures, the repulsion between the two lower magnets is overcome by the stronger attraction between the upper magnet and the cap. When the temperature rises to the critical value, however, and the cap ceases to attract the upper magnet, the repulsion between the two lower magnets causes the beam to swing about its pivot *f*, closing two contacts in the detector circuit. As soon as the temperature falls below the Curie point, and the magnetic properties of the cap are restored, the beam swings back to its normal position and the detector circuit is opened. To ensure that no moisture or fumes can penetrate into the mechanism, the electrical leads are introduced into the casing through bonded metal-to-glass seals.

In comparison with the differential-expansion type of temperature detector, which is in current use in aircraft fire-detector circuits, the magnetic detector, which weighs $2\frac{3}{4}$ oz., is 45 per cent. lighter. Most of the components can be manufactured by press work, and the Graviner Company expect that, when in full production, the cost of the magnetic detector will be appreciably lower than that of the current type. Routine checks of the operation of the magnetic detector are carried out simply by a special magnetic tester; there is no necessity for applying a flame. The accuracy of the temperature-sensing element cannot deteriorate in service, since it depends upon the properties of the material; the small magnets used in the detector are carefully calibrated and matched before assembly. Although the magnetic temperature detector has been developed in the first place for a specialised aircraft application, its robust simplicity and accuracy render it suitable for many other fields in which a temperature detector is required to close a warning circuit or to actuate a relay. Since there are alloys existing with Curie points ranging from room temperature, or even lower, to 700 deg. C., the instrument can easily be adapted for a wide range of possible uses.

British-Equipped Grain Elevator at Buenos Aires.—The latest of five large grain elevators which are being built at the principal Argentine grain-shipping ports, under the national elevator scheme of the Argentine Government, was inaugurated at Buenos Aires on November 2. The entire mechanical and electrical machinery and equipment of all five plants have been supplied, erected and put to work by Simon Handling Engineers, Ltd., Cheadle Heath, Stockport, the contract for the Buenos Aires elevator amounting to over 2*l*. million. This elevator has a total grain storage capacity of over 150,000 tons, and its equipment includes comprehensive grain-cleaning and drying machinery and dust-collecting plant. There are altogether some 250 electric motors giving a total of 7,500 h.p., and about six miles of conveyors. Grain arrives at the elevator by rail, road and coastal barge; rail and road vehicles can be discharged at a rate of 2,000 tons per hour, and two travelling pneumatic plants, each of 70 tons per hour capacity, are installed on the quay-side for discharging barges. Grain can be loaded into ocean-going ships at the rate of 3,600 tons per hour; the shipping gallery, approximately half a mile long, allows five ships to be berthed and loaded simultaneously. The contract, which was placed in September, 1948, was completed on time, and in the course of the speeches made at the inaugural ceremony, Simon Handling Engineers, Ltd., were complimented on the efficiency with which the work had been carried out.

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.

Sound and Television Broadcast Reception.—The Council for Codes of Practice for Buildings, Construction and Engineering Services, Lambeth Bridge House, London, S.E.1, have now issued in final form Code No. 327.201, covering broadcast reception, sound and television by radio. It has been drawn up by a committee convened on behalf of the Council by the Institution of Electrical Engineers and the present Code is a revision of a draft previously issued for comment. The Code forms part of the series dealing with telecommunication services in buildings and sets out recommendations for the good reception of sound broadcasts on the long- medium- and short-wave bands, and of television broadcasts. Recommendations are made for the provision of aerial systems and for the earthing of radio equipment. Particular attention is given to measures for reducing the effect of electrical interference. Sections on inspection and testing and on maintenance are included. [Price 6*s*., postage included.]

Atmospheric-Pollution Deposit Gauges.—With the object of aiding the work of combating the problem of atmospheric pollution, the Institution has issued a new specification, B.S. No. 1747, covering the construction, installation and use of deposit gauges for the collection and measurement of atmospheric impurities which are deposited by their own weight or with the assistance of rain. As a secondary function the gauge provides a measure of the monthly rainfall. The apparatus and methods of analysis described are in accordance with recommendations based on the considerable experience of local authorities and of the Department of Scientific and Industrial Research. [Price 2*s*. 6*d*., postage included.]

Jointing Materials for Water, Town Gas, and Low-Pressure Steam Installations.—In response to a request from the Ministry of Works, a new specification, B.S. No. 1737, covering the preparation of jointing materials and compounds suitable for gas, water and low-pressure steam services in factories, offices and residential buildings, has now been issued. It covers the general and specific requirements for materials and compounds, and methods for testing the various materials are covered in a number of appendices. A jointing material is defined as a manufactured solid material provided either in sheets, from which the required shapes can be cut, or in pre-formed shapes. A jointing compound is a manufactured substance which, when prepared for use, shall be of a paste-like or paint-like consistency. The materials and compounds are for use with screwed, flat-faced flanged and flat-seated joints for cold water (up to 300 lb. per square inch), hot water (up to 50 lb. per square inch and 100 deg. C.), town gas (up to 50 lb. per square inch), and saturated steam (up to 30 lb. per square inch). [Price 5*s*., postage included.]

Portable Fire Extinguishers.—The Council for Codes of Practice for Buildings, Construction and Engineering Services have issued another Code, namely No. 402.401, relating to portable fire extinguishers. It has been drawn up by a committee convened on behalf of the Council by the Institution of Mechanical Engineers, and the present Code is a revision of a draft issued for comment. In the Code are made recommendations on the design, installation, testing, inspection and maintenance of portable fire-fighting appliances for general use in buildings. The appliances dealt with are portable extinguishers of the soda-acid, gas-pressure and foam types, fire buckets and portable pumps, such as can be carried by one person. [Price 2*s*., postage included.]

Bronze Welding by Gas.—A new specification, B.S. No. 1724, covering bronze welding by the oxy-acetylene, oxy-hydrogen or oxy-propane processes is a specification supplementary to B.S. No. 1723, relating to brazing, and it has been prepared as part of a programme of welding specifications authorised by the Welding Industry Standards Committee of the Institution. Under the heading "general requirement" are included a description of the parent metals to which the process can be applied, data regarding filler metals, and a system of testing procedure. The application of the process to specific parent metals, namely copper, mild steel, galvanised mild steel, cast iron, malleable iron and a combination of any two of these metals, is dealt with in individual sections, particular attention being given to the details of the joints. Included as an appendix are reproduced photographs illustrating neutral oxydising and carburising oxy-acetylene welding flames. [Price 3*s*. 6*d*., postage included.]

SCHOLARSHIPS IN NAVAL ARCHITECTURE AND MARINE ENGINEERING.

Particulars of three scholarships in naval architecture and one in marine engineering, to be offered for competition in 1952 and tenable for three or four years according to the length of the course at the university selected, have now been announced by the Institution of Naval Architects. The three scholarships in naval architecture are, respectively, the Institution of Naval Architects, the Trewent and the Denny scholarships. The first is valued at 175*l*. per annum and candidates must be below the age of 23. It is open to British apprentices or pupils in the Royal Dockyards or in private shipyards, and entries close on January 15, 1952. The Trewent and the Denny scholarships are worth 175*l*. per annum each and candidates must be under 19 years of age. The Trewent scholarship is open to British subjects who are, or have been, apprentices or pupils in private shipyards. The Denny scholarship in naval architecture is tenable for four years at the University of Glasgow, with apprenticeship for five years. It is open to British subjects who have not yet begun their apprenticeship, or have served not more than one year of it with Messrs. William Denny and Brothers, Limited, Dumbarton. Entries for both the Trewent and the Denny scholarships close on May 31, 1952. The one scholarship in marine engineering, the Denny, is valued at 175*l*. per annum and the age limit is 19. The conditions for this scholarship are identical with those for the Denny Scholarship in naval architecture. Further particulars may be obtained from the secretary of the Institution, 10, Upper Belgrave-street, London, S.W.1.

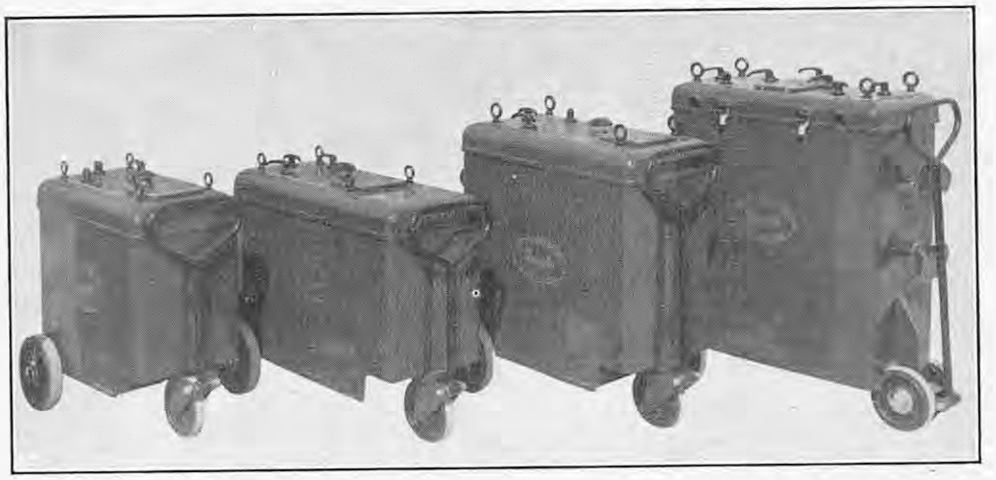
ANNUALS AND REFERENCE BOOKS.

Aircraft Engines of the World, 1951.—The ninth edition of this compact yet comprehensive hand-book, compiled in the United States by Mr. Paul H. Wilkinson, is arranged on similar lines to previous editions. It is divided into two main sections, the first of which deals with jet engines and gas turbines, and includes a list of aircraft thus propelled. The second section covers piston engines, including American compounded engines. Specifications of aviation fuels and lubricants are also given. Each section opens with a review of design trends in engines and accessories, and progress during the year in the various countries. Then follow individual data sheets for current engines, classified under the manufacturing country; it may be mentioned that specifications of six Russian turbo-jets and eight Russian piston engines are included. The data are arranged in a standard form, in English and metric units, so that different engines may be quickly compared. Some caution is advisable, however, in accepting the data presented for engines which have recently been "classified" under security regulations; for example, the Orenda engine, manufactured by Messrs. A. V. Roe (Canada), Limited, constructional details of which were officially released only in June, has a ten-stage compressor, whereas in this book, which must have been written considerably earlier, the compressor is stated to have nine stages, probably a confusion with the experimental Avro Chinook engine. It should be understood, however, that this inaccuracy is not typical of the book as a whole; it is, in fact, a valued work of reference. It is published, price 50*s*. net, by Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2.

Sell's National Directory and British Exporters' Register. Aviation Supplement, 1951.—Sell's Aviation Supplement is divided into three main sections, preceded by a review of the progress of the British aviation industry during the year. The explanatory notes to each section are given in English, French and Spanish. The first section contains, in alphabetical order, the names and addresses of the leading aircraft, equipment and accessories manufacturers, air-line operators, distributors, insurance firms, etc. Then follows a section classified under headings covering practically all aspects of aircraft construction and operation. The classified directory is preceded by an index, in English, to the classified trade headings, and also by French-English and Spanish-English alphabetical lists of items mentioned in the hand-book which are valuable in themselves to anybody handling French or Spanish technical sales literature relating to the aviation industry. Finally, there is a section giving brief particulars of British aircraft in production and under construction; as we suggested last year, this section would be improved if the compilers were to indicate clearly which aircraft are available now and which have not yet flown. The book can be recommended as a buyers' guide; a trade-names index might, perhaps, add to its value. It is published at the price of 10*s*. by Business Dictionaries, Limited, 133-137, Fetter-lane, London, E.C.4.

ARC-WELDING TRANSFORMERS.

QUASI-ARC COMPANY, LIMITED, BILSTON.



SINGLE-OPERATOR ARC-WELDING TRANSFORMERS.

The single-operator arc-welding transformers manufactured by the Quasi-Arc Company, Limited, Bilston, Staffordshire, have up to now been housed in a rectangular steel tank with the sides turned outwards at the top to form a 2-in. flange. The top plate was bolted to this flange. The firm have now re-designed this equipment to give greater compactness and robustness, as well as improved current selection controls. The appearance of the plant has also been altered to give a "cleaner" exterior.

The accompanying illustration shows the new range of plant. The two units on the left-hand side both have a current range up to 300 amperes, but the second is provided with a built-in capacitor. The third unit has a current range up to 450 amperes, while the fourth is a double-operator plant with a current range of 20 to 300 amperes on each transformer. It is fitted with a switch which enables both transformers to be connected in parallel and thus double the output to be obtained.

Two multi-position roller-action selector switches are incorporated in each unit and enable the welding current to be adjusted in small increments at an open-circuit voltage of either 80 or 100 volts. These switches have been housed in the tank without increasing its size by economising in the space occupied by other details. The board at one end of the tank, on which the handles for operating these switches are mounted, has been anodised to reduce the risk of short-circuiting the electrode or electrode holder to the top cover.

TRADE PUBLICATIONS.

Aluminium-Sheathed Cables.—British Insulated Callender's Cables, Ltd., Norfolk-street, London, W.C.2, have sent us a well-illustrated brochure in which full details of the types of aluminium-sheathed cables manufactured by them are given.

Pressed-Steel Joint Boxes.—Particulars of the "uncrushable" pressed-steel joint boxes, which they manufacture for use in mines, are given in a pamphlet received from British Insulated Callender's Cables, Ltd., Norfolk-street, London, W.C.2.

Industrial Vacuum Cleaners.—Types of vacuum cleaners suitable for a wide range of industries are dealt with in an attractive publication (No. 5006) entitled "Industrial Vacuum Cleaning," issued by the Sturtevant Engineering Co., Ltd., Southern House, Cannon-street, London, E.C.4.

Industrial Instrumentation.—Sunvic Controls, Ltd., 10, Essex-street, Strand, London, W.C.2, have sent us a temporary catalogue which describes the range of industrial instruments and controllers which they are now manufacturing under licence from the Moore Products Co., Philadelphia, U.S.A. The list covers thermometers, pressure regulators, flow meters, liquid-level gauges, automatic controllers, valve positioners and relays.

Electronic Equipment.—Dawe Instruments, Ltd., 130, Uxbridge-road, Hanwell, London, W.7, have prepared a 6-page illustrated brochure giving details of a wide range of electronic measuring equipment manufactured by their Instrument Division. This brochure covers resistors, capacitors, inductors, oscillators, electrical meters, thickness gauges, stroboscopes, balancing machines, sound and vibration meters, moisture meters, photographic accessories, etc.

BOOKS RECEIVED.

Vöest Jahrbuch, 1950-51. Vereinigte Österreichische Eisen- und Stahlwerke Aktiengesellschaft, Linz a.d. Donau, Austria.

Building Technicians' Pocket Diary, 1952. Association of Building Technicians, 5, Ashley-place, London, S.W.1. [Price 5*s*. 3*d*., post free.]

Foundations of Wireless. By M. G. Scroggie. Fifth revised edition. Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 12*s*. 6*d*. net.]

Servicing Guide to British Motor Vehicles. Cars, Commercial Vehicles and Tractors. By J. N. McHattie. Trader Publishing Company, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 63*s*. net.]

Department of Scientific and Industrial Research. Report of the Fuel Research Board, with the Report of the Director of Fuel Research for the Period 1st April, 1946, *to 31st March*, 1949. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3*s*. net.]

Road Research. Note No. 10. *A Rapid Method of Analysis for Bituminous Road Materials.* By Dr. A. R. Lee, C. M. Gough, and E. H. Green. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s*. net.]

King's Manual of Gas Manufacture. Section 5. By T. A. Tomlinson. Walter King, Limited, 11, Bolt Court, Fleet-street, London, E.C.4. [Price 7*s*. 6*d*. net, postage 3*d*.]

Fuel Economy Pays. A Guide to the Saving of Industrial Fuels. Federation of British Industries, 21, Tothill-street, London, S.W.1. [Price 2*s*.]

Refrigeration Insulation. By G. Yate Pitts. Published for the Institute of Refrigeration by "Modern Refrigeration," Empire House, St. Martin's-le-Grand, London, E.C.1. [Price 7*s*. 6*d*., post free.]

Electromagnetic Waves. By Sir John Townsend. Hutchinson's Scientific and Technical Publications, Stratford-place, London, W.1. [Price 6*s*.]

Vibration and Shock Isolation. By Charles E. Crede. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York, 16, U.S.A. [Price 6.50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 52*s*. net.]

The Nature of Polyphase Induction Machines. By Philip L. Alger. 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.]

Soil Testing for Engineers. By T. William Lambe. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 5 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 40*s*. net.]

Abridged Wiring Regulations. Based on Twelfth Edition, 1950. The Institution of Electrical Engineers, Savoy-place, London, W.C.2. [Price 5*s*. in paper covers, or 7*s*. 6*d*. cloth-bound, post free.]

The Electrician Red Book. Electricity Undertakings of the World. 1951-1952. Edited by Stanley G. Rattee. Benn Brothers, Limited, Bouverie House, 154, Fleet-street, London, E.C.4. [Price 30*s*., post free.]

Facts, Files and Action in Business and Public Affairs. By Dr. J. Edwin Holmstrom. Part One. *Sources and Backgrounds of Facts.* Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 36*s*. net.]

Schnellstähle und ihre Wärmebehandlung. By Dr.-Ing. Willi Haufe. Carl Hanser-Verlag, Leonhard-Eck-Strasse 7, Munich 27, Germany. [Price 29 D.M.]