THE SHELL OIL REFINERY, SHELL HAVEN.

THE reasons underlying the establishment in this country of large new oil refineries in place of the pre-war practice of developing refineries overseas and marketing the products here are too well known to need explanation. The advantages are manifest and the troubles experienced in Persia add emphasis to the arguments in favour of this policy, which has, of course, involved considerable expenditure. It has been estimated that by the time the programme of expansion has been completed, approximately 125,000,000*l*. of fresh capital will have been invested in new plant, etc., which will raise the country's output of refined petroleum from 3,500,000 tons in 1948 to 20,000,000 tons in 1953, sufficient, it is thought, to meet the home demand almost entirely. Most of the major oil companies have been concerned with this development and although the process of expansion will not be completed until the end of 1953, several firms have finished their individual programmes. The "Shell" Refining and Marketing Company, Limited, for example, have now constructed and put into operation new refineries at Shell Haven and Stanlow, which, together with operations at Heysham on a converted war-time plant, give a combined output exceeding 8,500,000 tons per annum, thereby establishing the company as the largest refinery operators in the United Kingdom.

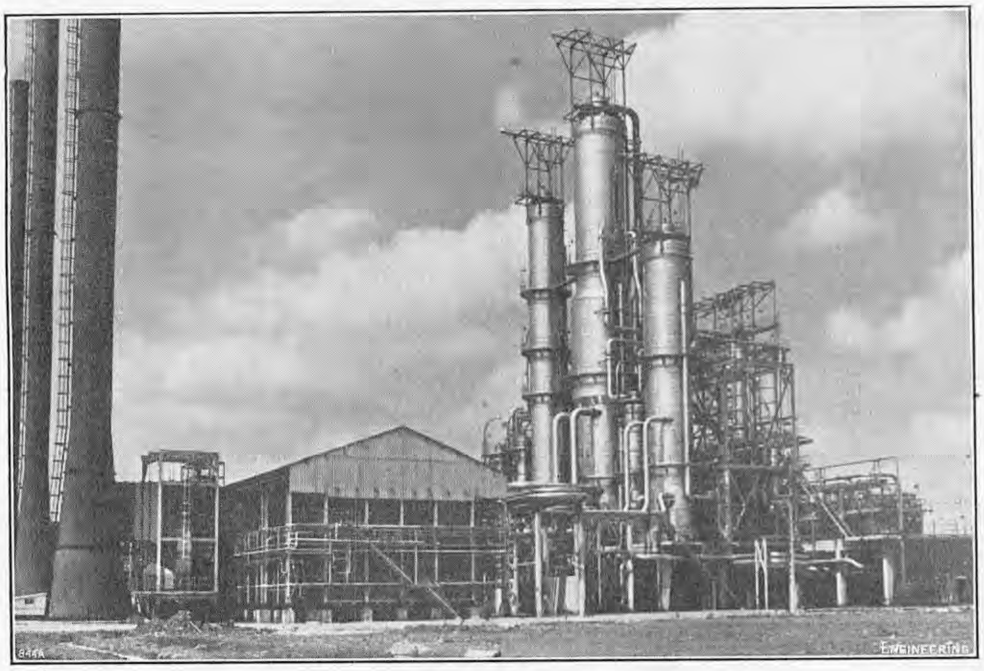


FIG. 1. PIPE-STILL FURNACES AND DISTILLATION UNITS.

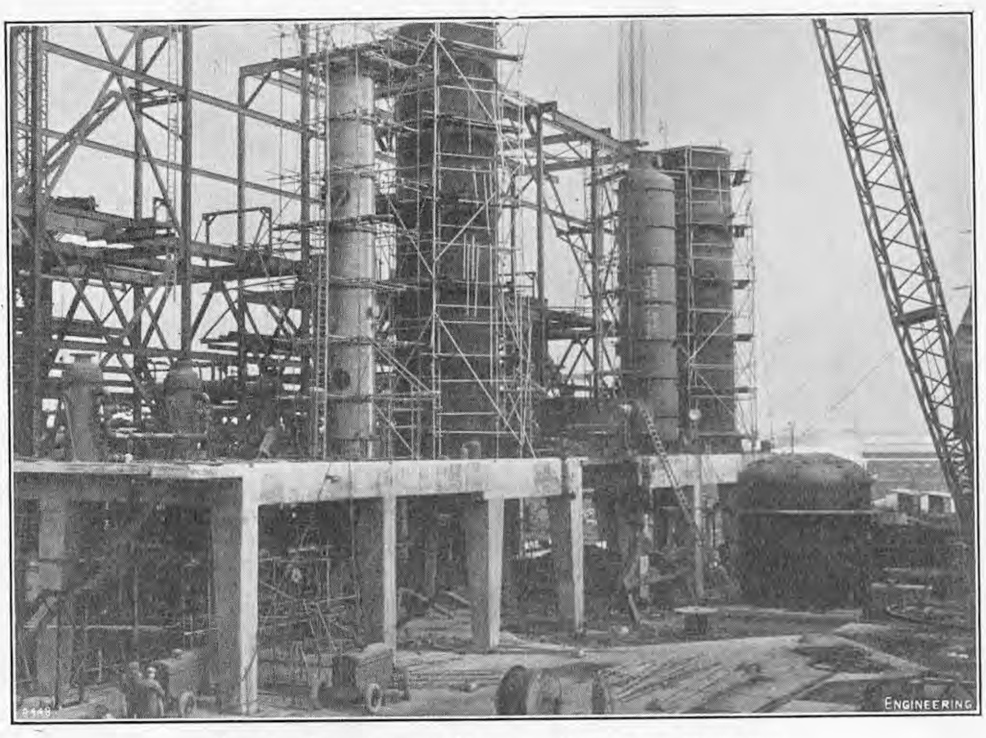


FIG. 2. DISTILLATION UNITS IN COURSE OF ERECTION.

This alone represents a remarkable achievement, as at the end of the Second World War, the refining facilities of the Company in this country consisted only of specialised plants at Shell Haven and Stanlow with capacities of 800,000 tons and 925,000 tons per annum, respectively, and a small asphalt plant at Ardrossan with a yearly capacity of 225,000 tons. The additions to the plants at Shell Haven and Stanlow, however, have brought the combined capacities of these two refineries to more than 7,000,000 tons per annum. The word "addition," so far as Shell Haven and Stanlow are concerned, is, perhaps, a misnomer as what is tantamount to a complete new refinery more or less separated from the original plant has been erected there. Known as the Shell Haven M.E.C. refinery, and located on the north bank of the Thames some 10 miles from Southend-on-Sea, it has been designed to process an intake of 6,000 tons of crude oil a day, and comprises a distillation unit, a doctor-treating plant, a re-forming unit and facilities for blending tetra-ethyl lead with gasoline to give the required octane rating. The doctor-treating plant is capable of handling 1,800 tons of straight-run and re-formed gasolines from the distilling unit and the re-forming unit, respectively. The latter has an intake capacity of 1,200 tons of naphtha or light gas oil a day.

DISTILLATION UNIT.

The products obtained from the distillation unit comprise propane gas, which is burnt as fuel in the refinery area, light gasoline and heavy gasoline, of which the latter can be either blended into finished gasoline or included in re-forming naphtha, paraffin, two grades of light gas oil and bunker fuel. Including the side strippers there are eight columns, all of which are situated on an elevated platform arranged over the pumps. Some of the main columns can be seen in the photograph of the distillation unit reproduced in Fig. 1, on this page, in Fig. 3, on page 734, and in Figs. 6 and 7, on Plate XXXIX. An impression of the construction of the platform can be gained from Fig. 2, herewith, which shows the plant in course of erection. The operation of the distillation plant will, perhaps, be best understood by reference to the abridged flow diagram reproduced in Fig. 4, on page 734. After passing through the pipe-still furnace lettered F 1 in the diagram, the crude oil enters the first fractionating column C 1. This has a diameter of 13 ft., a height of 95 ft. 6 in. and is provided with 31 trays fitted with the normal type of bubble caps. It operates at a pressure of 2·3 atmospheres and is designed to separate the lighter products, that is, propane gas and all gasoline, from the crude oil. The lighter products are, of course, removed from the top of the column as a mixture of gas and vapours, the vapours being subsequently condensed. Part of the heavy liquid residue, generally referred to as topped crude, is reboiled in a separate section of the pipe-still furnace to maintain the correct evaporation temperature within the column and the remainder is withdrawn from the base of the column and pumped through the pipe-still furnace F 2 to the vacuum tower C 2. This operates at a pressure of 0·2 atmosphere, the object being to lower the boiling point and thereby reduce the risk of cracking taking place. It has a height of 149 ft., a diameter varying from 20 ft. to 16 ft. 6 in., and is fitted with 34 trays. Its function is to split up the topped crude into its lighter fractions, which are removed overhead; a heavy gas oil, which is removed by the side stripper C 6; and a residue, namely, bunker fuel which is withdrawn from the base of the column and pumped to storage. As in the case of the first fractionating column, part of the residue is reboiled and fed back into the vacuum tower to maintain the operating temperature.

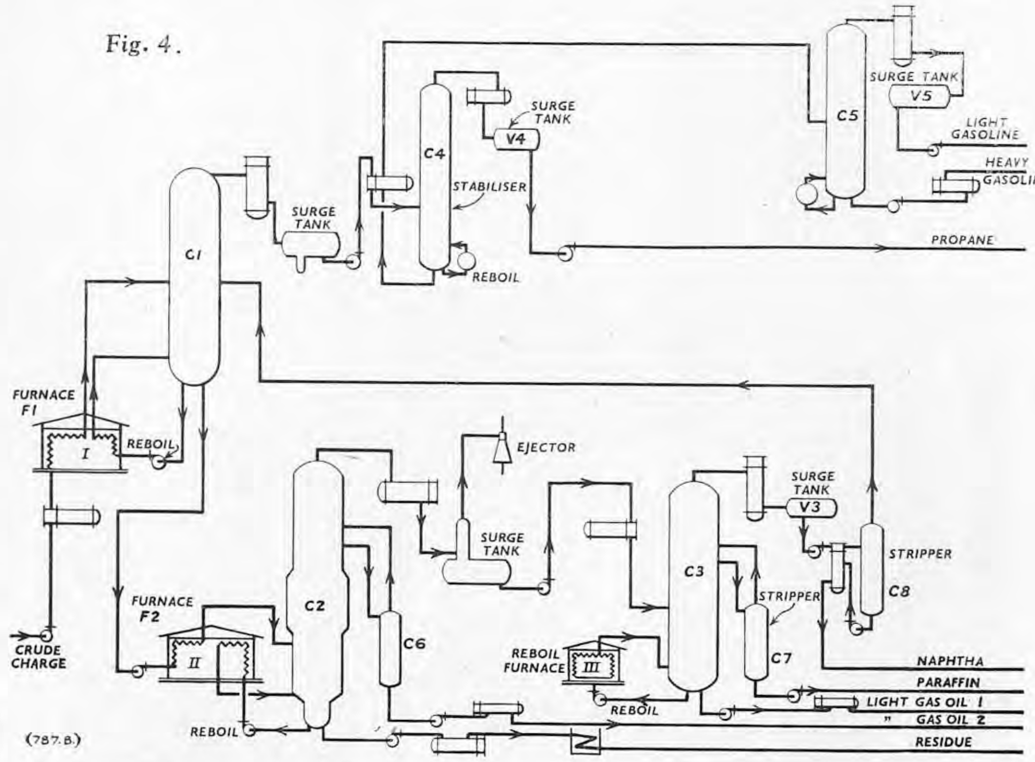
After being condensed, the top products from the vacuum tower are led into a surge tank, the top of which is connected to a steam ejector for maintaining the correct pressure inside the tower. The liquid is then heated and passed into the atmospheric tower C 3 which divides it into naphtha, paraffin and light gas oil, the naphtha being taken off overhead, the paraffin removed by the sidestripper C 7 and the residual light gas oil pumped to storage tanks. After being cooled, the naphtha is passed through the stripping column C 8 which removes any residual lighter fractions and returns them to the crude fractionating column for re-distillation, the naphtha subsequently being pumped to storage tanks for further treatment in the re-forming plant.

The overhead products from the crude fractionating column, namely, the lighter gasolines and propane gas, which, as previously mentioned, are a mixture of gas and condensed vapour with a preponderance of liquid, are transferred to the stabilising column C 4. This has a diameter of 7 ft. and a height of 93 ft., is fitted with 36 trays, and is designed to separate the gas from the gasoline. Some reboiling is employed as in the other columns and the bottoms are transferred to the gasoline tower C5 while the gas, as previously indicated, is used within the refinery area for heating the pipe stills, etc. The gasoline tower, which has a diameter of 8 ft. 6 in. and a height of 82 ft. 8 in., is fitted with 30 trays and is designed to divide the gasoline into

THE SHELL HAVEN OIL REFINERY.

Fig. 3. Vacuum Columns.

Fig. 4.



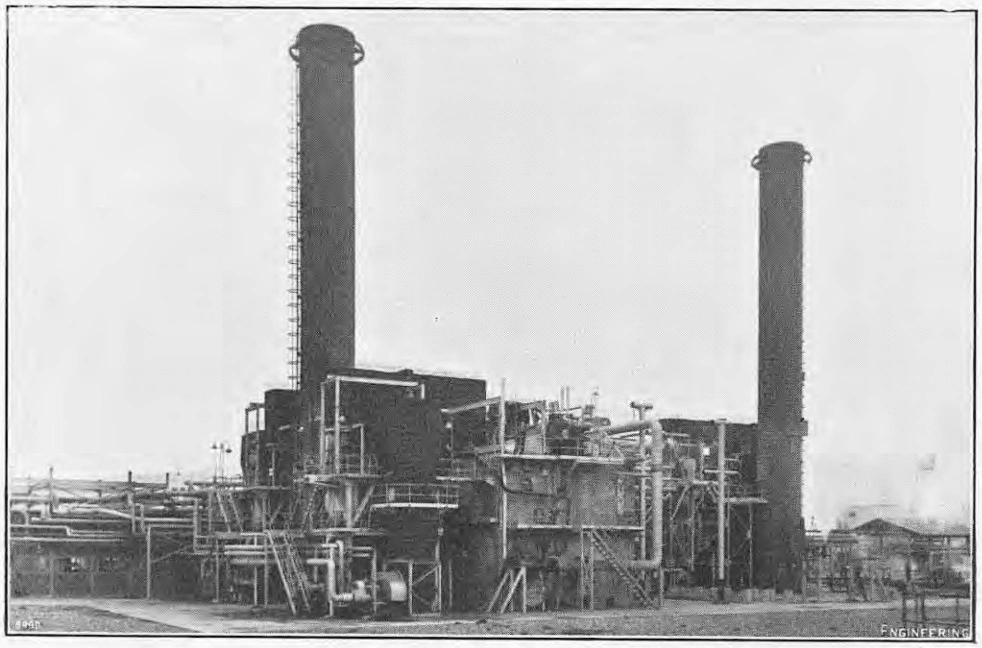


Fig. 5. Boiler Plant for Generating Process Steam.

light and heavy grades, the lighter grade, of course being removed from the top of the column.

The Re-Forming Plant.

As previously mentioned, the naphtha is treated further in the re-forming plant. Re-forming consists of subjecting the naphtha feed-stock to a controlled but intense heating, whereby the material is decomposed into the simpler parts which are composed mainly of gasoline with some light gases; a small amount of the simple products recombine to make a heavy material which is included in fuel oil. The re-forming plant at Shell Haven is illustrated in Fig. 8, on Plate XXXIX, and in this case the conditions are such that about 80 per cent. of the charge of naphtha is converted into gasoline of a high octane number. The plant comprises a high-pressure pump designed to operate at approximately 1,500 lb. per square inch, which feeds the stock into the re-forming furnace, where it is raised and held at the operating temperature for a controlled period after which it is quenched by the injection of cold oil to stop the reaction. After re-forming, the products are separated into their constituent parts by fractionating columns in the usual manner. The gasoline from the distilling unit and from the re-forming unit are treated for the removal of mercaptans, that is, the obnoxious constituents. This is carried out in the doctor-treating plant illustrated in Fig. 9, on Plate XXXIX, in which the mercaptans are oxidised to innocuous products without an unpleasant odour. The gasolines after leaving the doctor-treating plant are blended and tetra-ethyl lead is added to obtain finished gasolines of the required octane number.

The foregoing description of the distillation plant and its allied units give only a general outline. No reference has been made, for example, to the many different heat exchangers installed throughout the refinery to recover waste heat from one process for use in a subsequent or preceding process, thereby reducing fuel requirements to a minimum. An idea of the large number of heat exchangers required can be gained from the photograph reproduced in Fig. 10, on Plate XXXIX, which was taken when the refinery was still in course of erection and shows some of the heat exchangers used in connection with the distilling units. Neither has any reference been made to the numerous pumps used throughout the refinery, most of which are driven electrically, steam-operated pumps having been almost entirely eliminated. Various types of pumps are used according to the duties involved; Sigmund Pumps, Limited, for example, supplied a number of their single-stage and two-stage process pumps, horizontally split units, vertical-spindle pumps and multi-stage high-pressure units.

Erection of the process units and general mechanical services was supervised by the Lummus Company, Limited, 80, Regent-street, London, W.1, and Messrs. Foster Wheeler, Limited, Ixworth-place, London, S.W.3, the Lummus Company being responsible for the heaters used in connection with the distillation unit, the feed-preparation unit, the re-former and the doctor-treatment plant, and Messrs. Foster Wheeler for the 6,000-ton distillation unit. The Lummus Company also designed the heaters, feed-preparation unit, doctor-treatment plant and the re-former, the last-named, however, being designed in collaboration with the Universal Oil Products Company, Bush House, Aldwych, London, W.C.2. The distillation unit was designed by the Shell Petroleum Company, Limited, in conjunction with N.V. Comprimo, Amsterdam. The equipment such as the fractionating columns, etc., was manufactured by sub-contractors, notably Messrs. Babcock and Wilcox, Limited, Farringdon-street, London, E.C.4, and Messrs. G. A. Harvey and Company (London), Limited, Greenwich Metal Works, London, S.E.7. The latter firm, for example, supplied the Lummus Company with the flash-fractionating column, the debutaniser tower, the gasoline-fractionating column and the flash tower, and Messrs. Foster Wheeler with three of the main columns used in connection with the distillation unit.

Some of this equipment is exceptionally heavy; the flash-fractionating column, for example, has a diameter of 10 ft., a length of 84 ft., and a weight of 108 tons, and the debutaniser tower a diameter of 6 ft. 6 in., a length of 94 ft. and a weight of 50 tons. These two columns operate at comparatively high pressure and were therefore constructed to withstand hydraulic test pressures of 465 lb. per square inch and 590 lb. per square inch, respectively. Welded construction was employed throughout and both columns were stress relieved after fabrication, all welds being examined by X-rays. Of the three distillation columns, two are 95 ft. long and the other 83 ft. long. Here again, the specification called for high working pressures and one of the columns was subjected to a hydraulic-test pressure of 510 lb. per square inch. As in the cases of the fractionating column and debutaniser tower, this column was stress relieved after fabrication, but the welds were not examined by X-rays.

General Lay-Out and Planning.

The general lay-out of the refinery, which is situated on very soft Essex marsh land, involved many foundation problems and several thousand piles had to be driven; considerable use was also made of raft constructions. There was also a great variety of civil-engineering construction work which had to be planned. Many miles of roads, railways, pipe tracks, drainage systems and cooling-water

THE SHELL HAVEN REFINERY OF THE "SHELL" REFINING AND MARKETING COMPANY.

(*For Description, see Page 733.*)

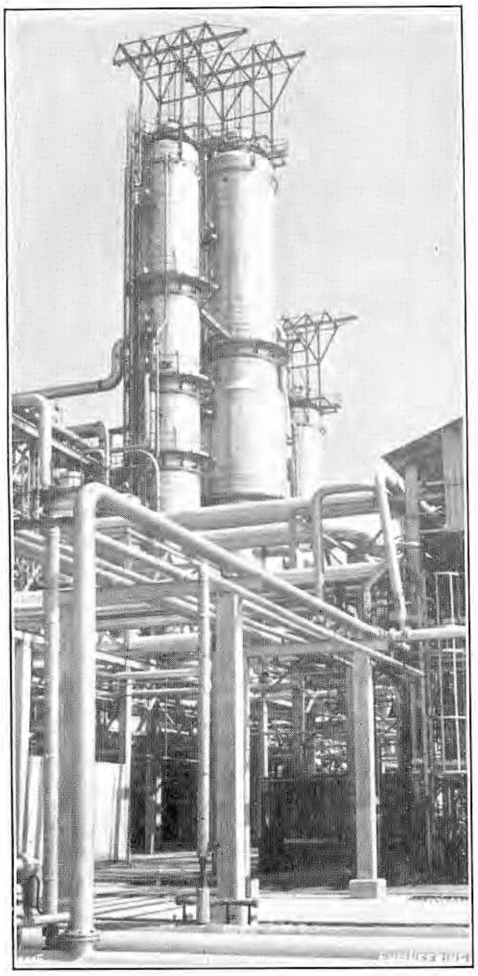


Fig. 6. Columns C3, C2 and C1.

Fig. 7. Columns C4 and C5.

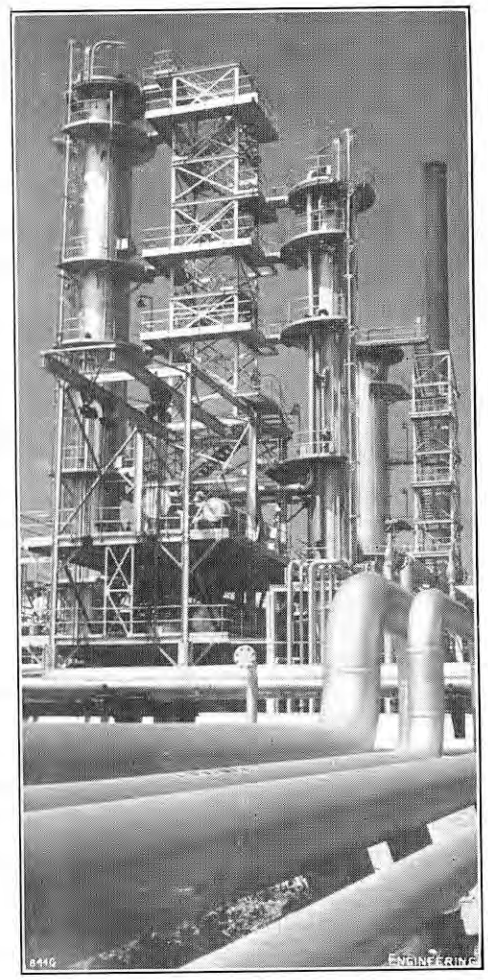


Fig. 8. Re-forming Plant.

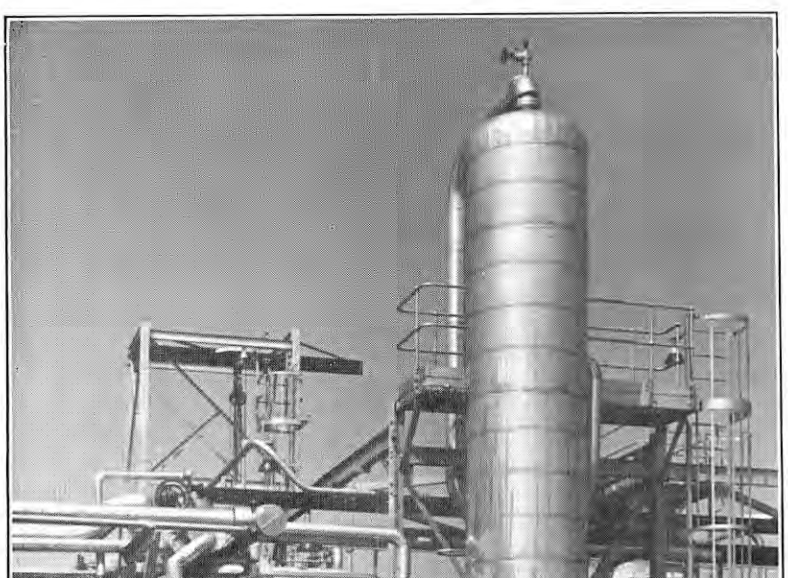


Fig. 9. Doctor-Treatment Plant.

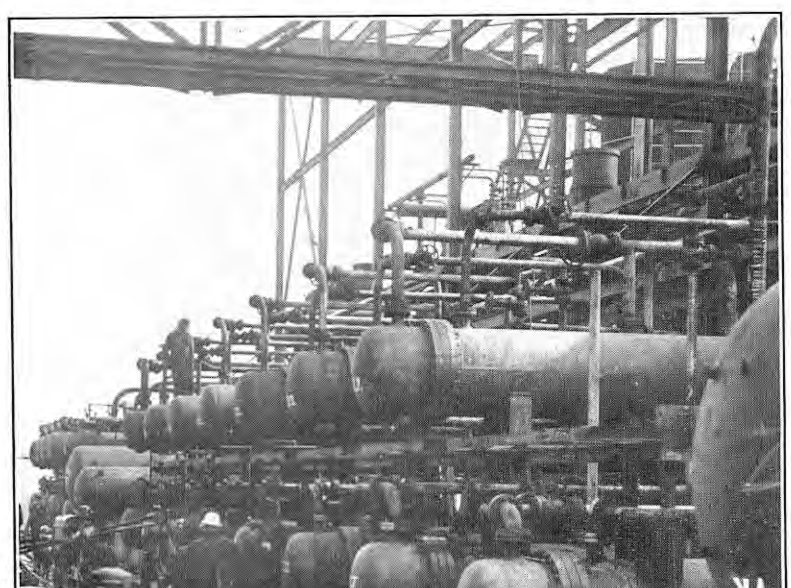


Fig. 10. Heat Exchangers in Course of Erection.

(To face page 734.)

THE SHELL HAVEN REFINERY OF THE "SHELL" REFINING AND MARKETING COMPANY.

(For Description, see Page 733.)

Fig. 11. Main Pump House.

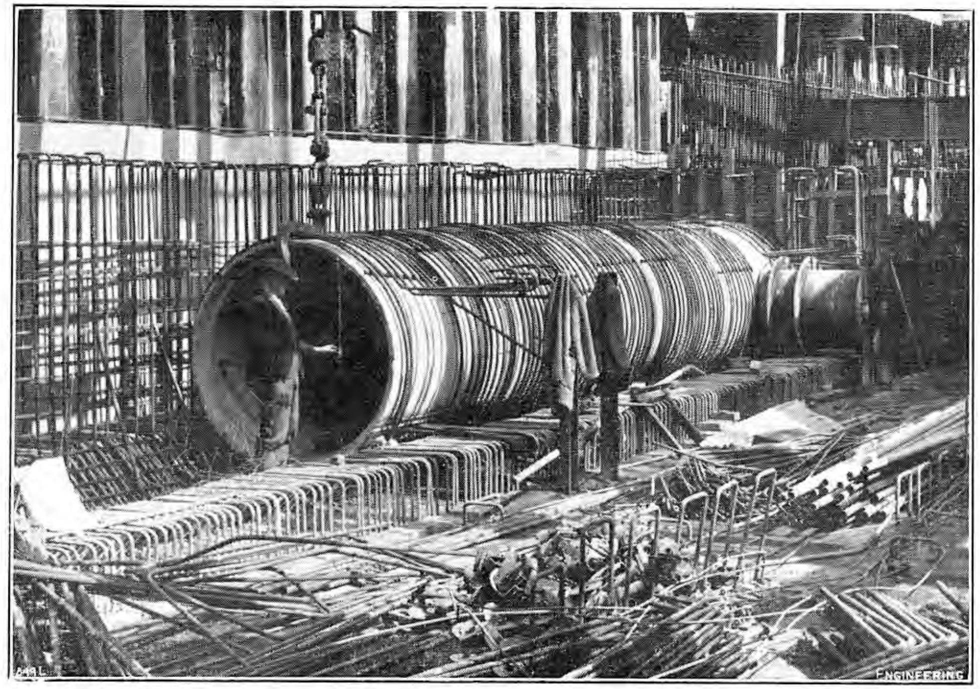


Fig. 12. Construction of Cooling-Water Intake Culvert.

Fig. 13. Interior of Pump House.

Fig. 14. Excavation of Cooling-Water Tunnel.

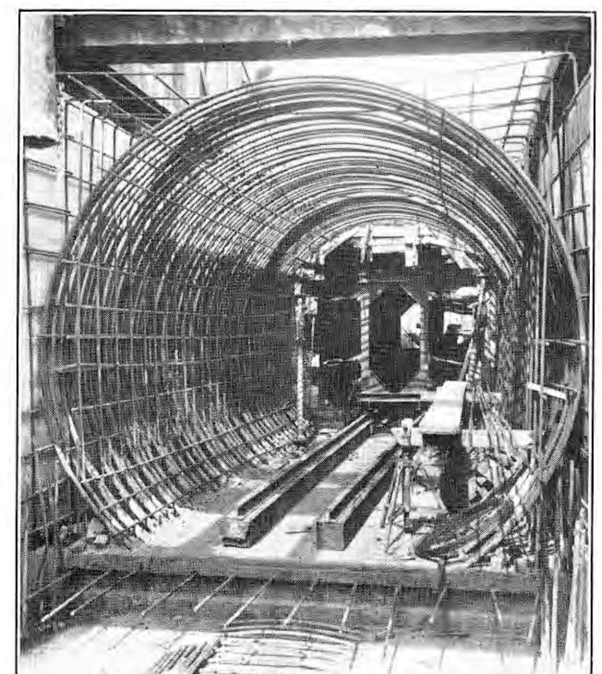


Fig. 15. Construction of Cooling-Water Delivery Culvert.

THE SHELL HAVEN REFINERY OF THE "SHELL" REFINING AND MARKETING COMPANY.

(For Description, see Page 733.)

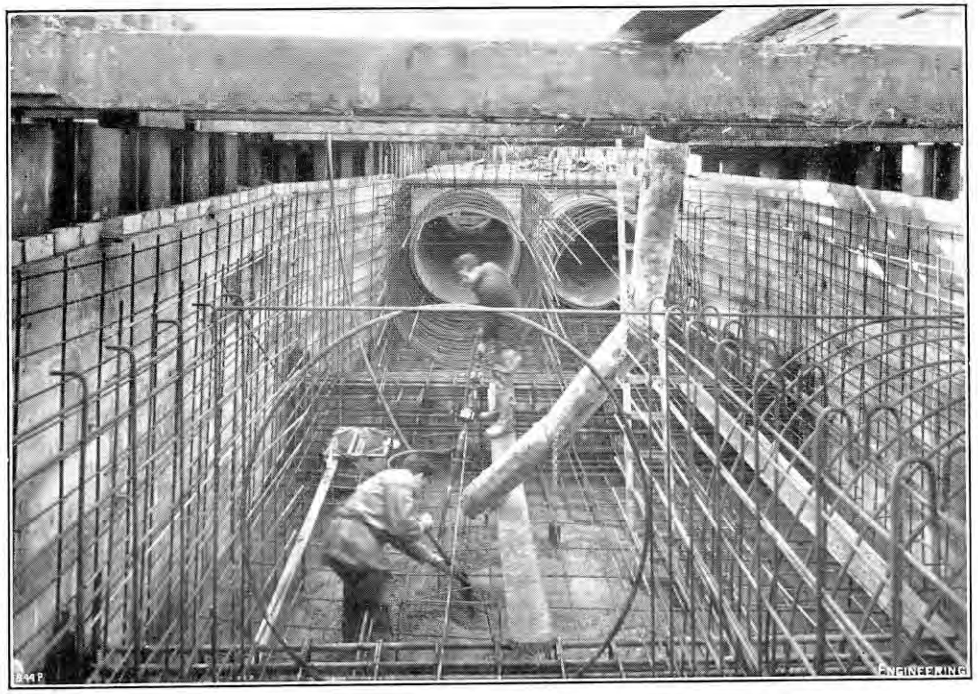


Fig. 16. Branch Culvert Valve Chamber under Construction.

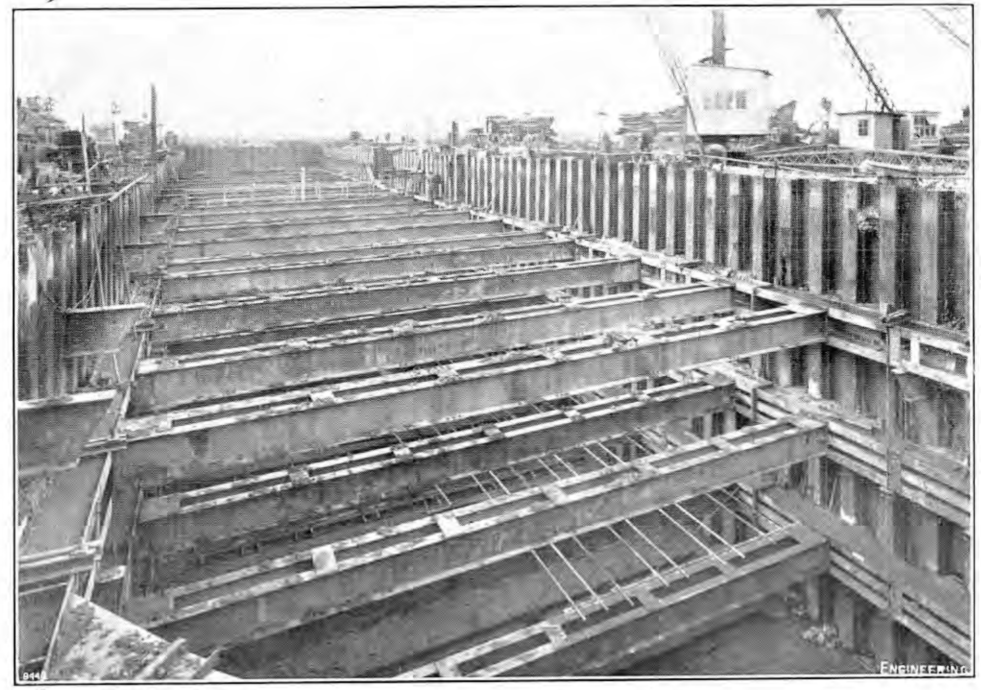


Fig. 17. Excavation for Pump House.

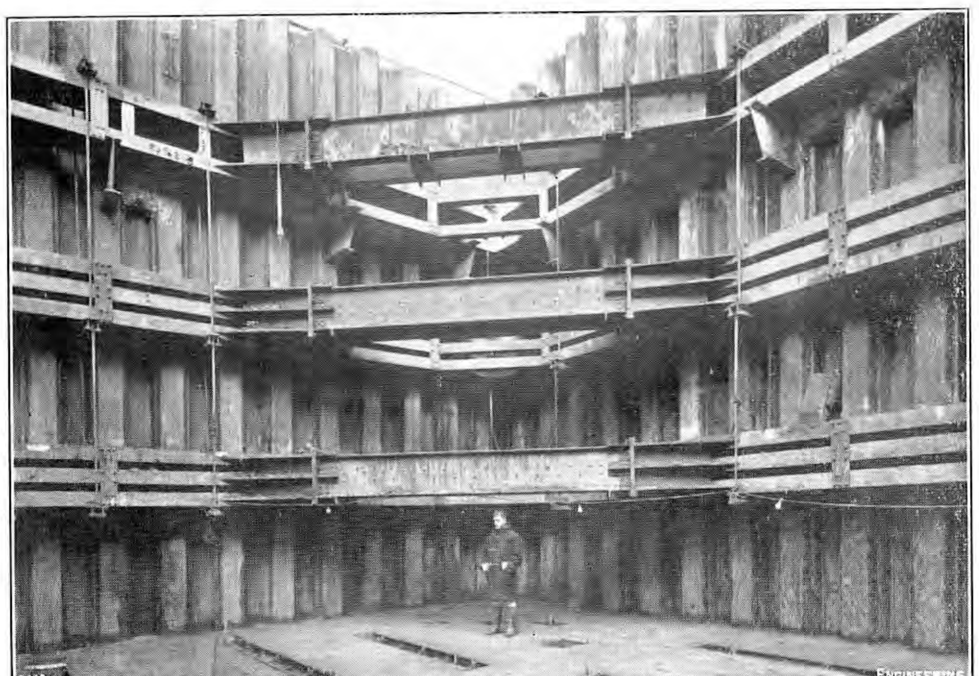


Fig. 18. Temporary Cofferdam for Pump House.

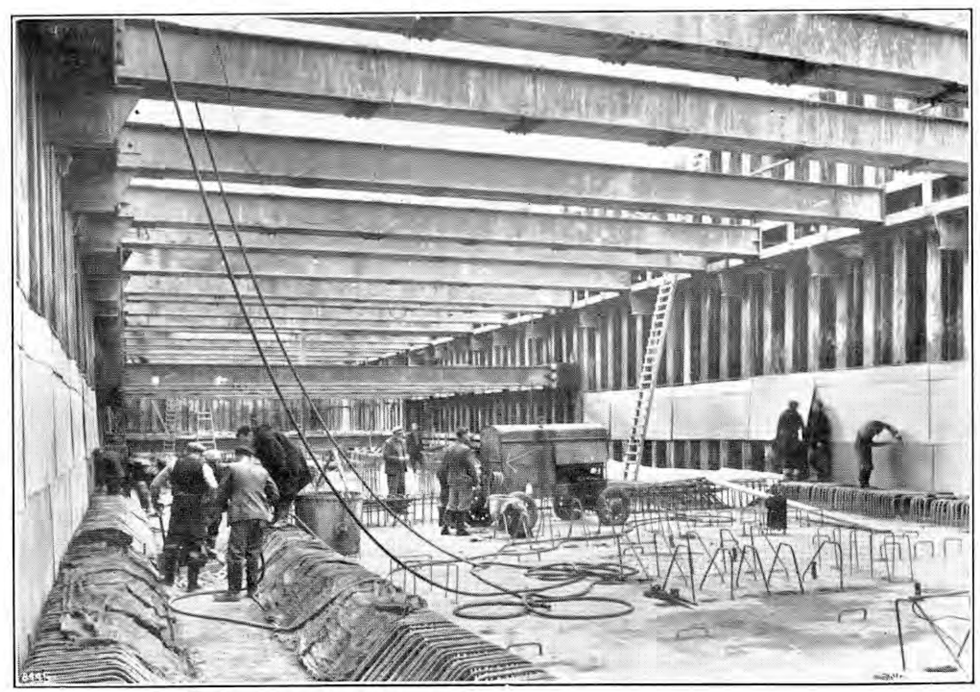


Fig. 19. Pump House in Course of Construction.

THE SHELL HAVEN REFINERY OF THE "SHELL" REFINING AND MARKETING COMPANY.

(*For Description, see Page* 733.)

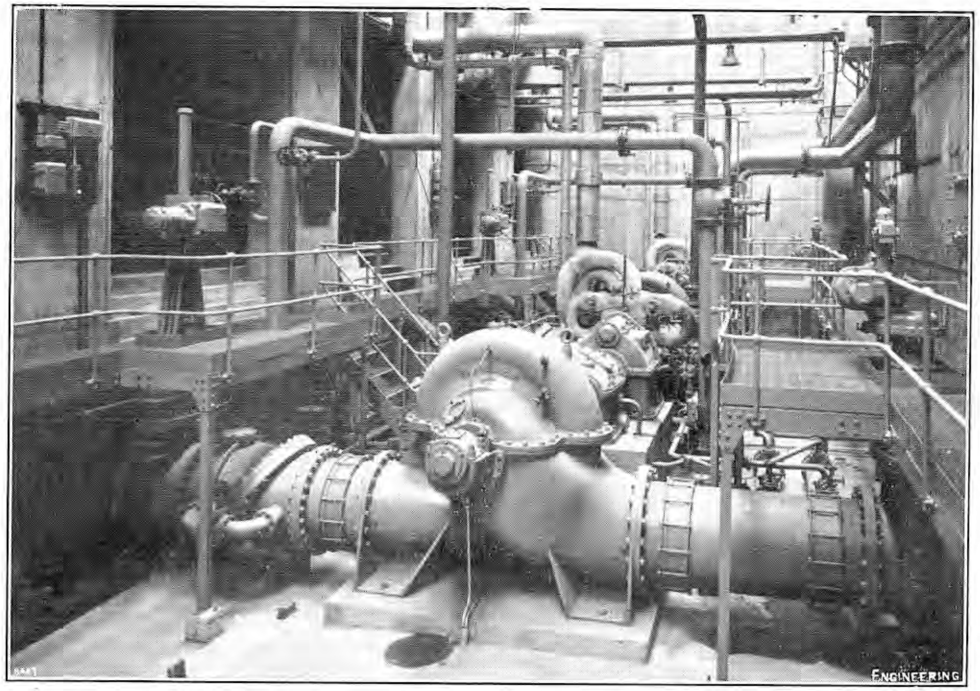


Fig. 20. Main Cooling-Water Circulating Pump.

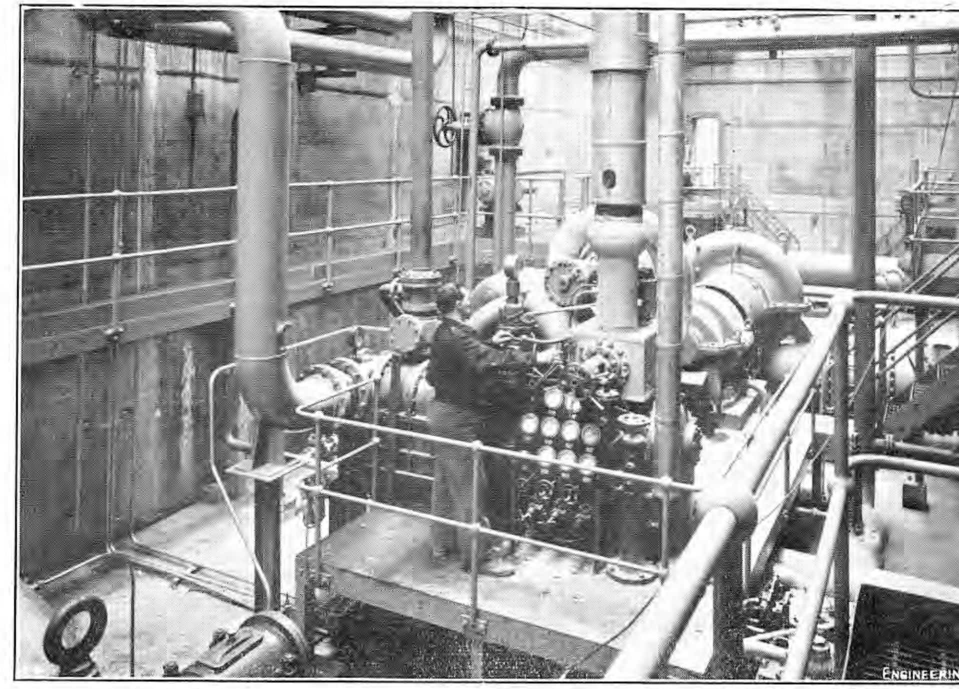


Fig. 21. Control Panel of Turbine Driving Main Pump.

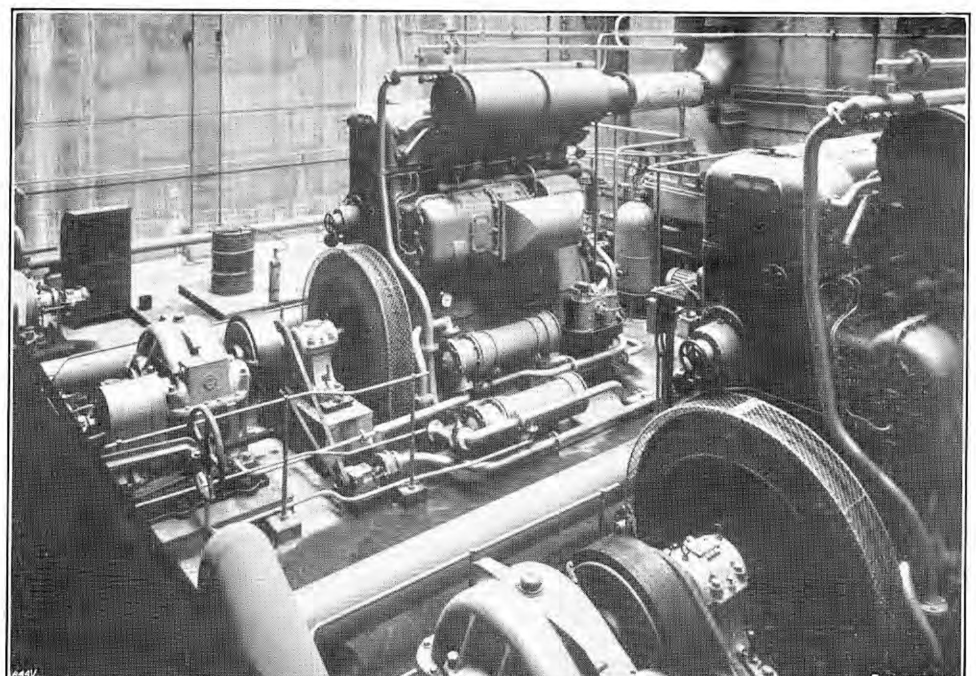


Fig. 22. Diesel Engines for Driving Main Fire Pumps.

Fig. 23. New Jetty under Construction.

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THE SHELL HAVEN OIL REFINERY.

Fig. 24. DETAIL OF PUMPHOUSE AND LANDSHAFT.

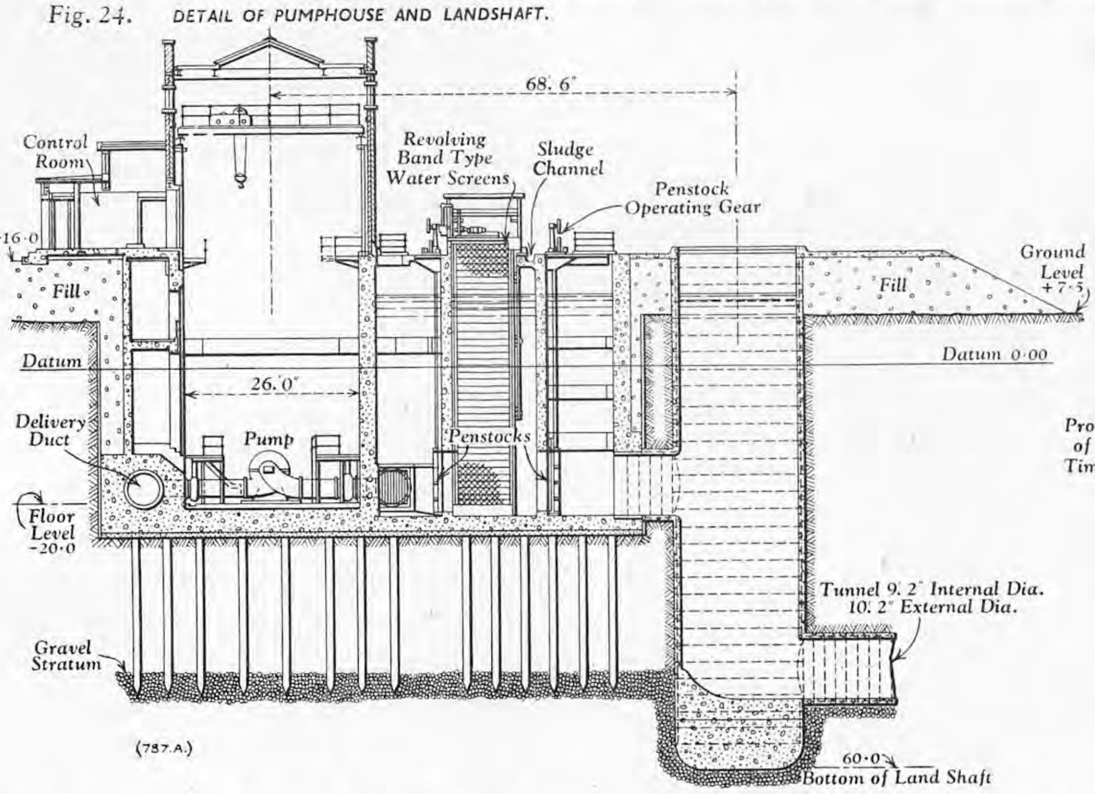
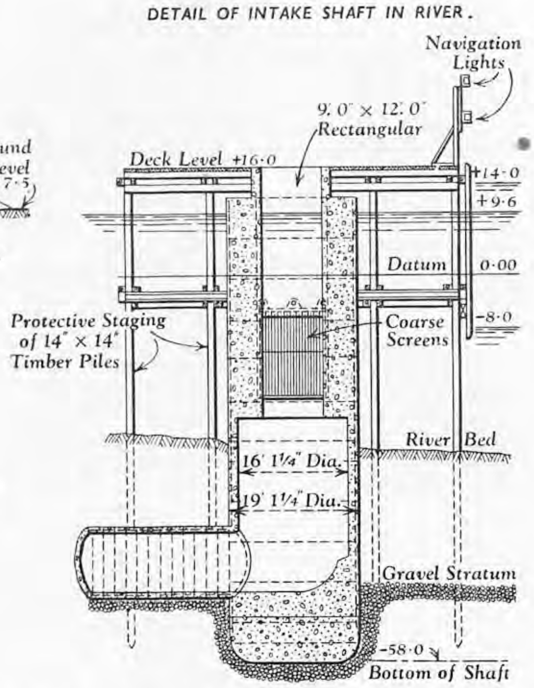


Fig. 25. DETAIL OF INTAKE SHAFT IN RIVER.



supply and return ducts had to be built, the total cost amounting to several million pounds sterling. The whole of the civil engineering and building work was carried out under the supervision and to the designs of the Shell Refining and Marketing Company's consulting engineers, Messrs. Maunsell, Posford and Pavry acting jointly with Sir Alexander Gibb and Partners. The general contractors for the refinery were John Mowlem and Company, Limited.

Steam required for the various refining processes and for operating general site ancillary equipment is provided by three Babcock and Wilcox boilers designed to operate at 250 lb. per square inch and 700 deg. F., each being capable of generating 132,000 lb. of steam per hour. An unusual feature is the siting of the boilers in the open, there being no boiler house in the accepted sense of the term. This arrangement will be clear from Fig. 5, opposite, which shows the boilers and associated fans, uptakes, etc. The boiler plant has been laid out so that a duplicate set of boilers can be installed if required at a later date and incorporates facilities for supplying compressed air to the various parts of the refinery. Electrical power is taken entirely from the National grid, no generators being installed in the refinery area. It is taken from both the Tilbury and Rayleigh 33,000-volt systems, thus affording a twin source of supply to ensure against possible failures. Power is distributed to the different sub-stations installed in the refinery area at 6,600 volts. Domestic water is taken from the South Essex Water Board main system, which was extended to a point approximately two miles from the site. From there, the water is conveyed in a 16-in. diameter welded pipeline to storage tanks situated within the refinery area, suitable water-treatment plants having been installed to ensure adequate supplies of conditioned water for the boilers and other services.

COOLING-WATER SYSTEM.

The cooling water required in connection with the refining processes is obtained from an intake shaft sunk in the River Thames and is pumped to offtakes situated in the process area through underground concrete ducts. After circulating through the various process plants, it is returned through a similar duct to an interceptor designed to extract entrained impurities and ensure the return of uncontaminated water to the river. The main pump house, which is illustrated in Fig. 11, on Plate XL, is 250 ft. long by 50 ft. wide, with the floor level on which the pumps are mounted 20 ft. below Newlyn datum and 27 ft. below ground level. The portion below ground level is divided by bulkheads into three separate compartments, the downstream compartment containing Diesel-driven and electrically-driven fire pumps and the centre compartment the main circulating pumps which are driven by steam turbines. The upstream compartment is at present unoccupied, having been provided to accommodate additional pumps should the refinery be extended at some future date with consequent increased demands for cooling water. One of the dividing bulkheads, which are of reinforced-concrete construction, can be seen in Fig. 13, on Plate XL, which shows a general view of the interior of the pump house.

The intake system includes a vertical shaft in the River Thames and a land shaft on the river bank, which are connected by a tunnel 9 ft. 2 in. in diameter and 935 ft. long. Normal methods were used in excavating the tunnel, the men working behind a shield moved forward by jacks. As a safety precaution, the compressed air used to prevent the ingress of water was supplied by both electrically-driven and Diesel-driven compressors. The tunnel is circular in cross-section and is lined with cast-iron segments with a further lining of concrete. Some of the cast-iron segments can be seen in Fig. 14, on Plate XL, which shows the tunnel in course of excavation. The intake shaft is similar in construction to the tunnel, consisting of cast-iron segments bolted together and subsequently lined with concrete. A sectional drawing of the intake shaft is given in Fig. 25, on this page, from which it will be seen that the unit is in two parts, an upper portion rectangular in cross-section and containing coarse screens, which opens out into a lower circular section 16 ft. 1¼ in. in diameter. Both the tunnel and the intake shaft rest on gravel so that there was no need for piling; several 14-in. square timber piles were driven into the gravel, however, to form a protective staging round the completed shaft.

The circular riser shaft at the inland end of the tunnel is of the same construction as the tunnel and intake shaft, the base of the shaft resting on the same gravel bed. It is connected by an offtake at approximately mid height to a screen chamber located in front of the pump house, the shaft being of a sufficient height to prevent overflow in the event of exceptionally high tides. This lay-out will be clear from Fig. 24, above, which shows a cross-sectional elevation through the riser shaft, screen chamber and pump house. The screen chamber is joined by a further offtake to a concrete culvert situated along the back of the pump house, the level of the culvert being below that of the lowest recorded tide to ensure permanent priming of the pumps. At the delivery side, two further culverts, one from the chamber housing the existing pumps and the other from the "spare" chamber, unite to form an irregular octagonal culvert measuring 8 ft. across the flats which conveys the water to the refinery area. Various branch culverts lead away from the main culvert; these are circular in cross-section with diameters of from 4 ft. to 5 ft., depending on their duty and are joined to the refinery units by steel feeder pipes. A unique method was adopted for the construction of the branch culverts, the "cores" of which are formed by spun-concrete pipes. These were wound externally with steel reinforcement to resist the bursting stresses and the reinforcement was subsequently embedded in a course of concrete. A good impression of this form of construction can be gained from Fig. 16, on Plate XLI, which shows a branch culvert valve chamber under construction. A similar method was employed for forming the intake culvert at the back of the pump house, Fig. 12, on Plate XL, showing part of this culvert with the internal pipe and external reinforcement in position. This method could not be employed, however, for the construction of the main culvert. In this case, a travelling former located on rails inside the steel reinforcement was used, as shown in Fig. 15, on Plate XL. For part of their route, the intake and outlet culverts are located one above the other; part of the reinforcement for the lower culvert can be seen at the bottom of Fig. 15. The main culverts and some of the branch culverts are supported by piles, precast concrete piles being used for this purpose. The system has been designed to operate at a delivery pressure of 140 ft. head and is believed to be the largest system constructed in reinforced concrete to withstand such a high pressure. The maximum flow is 330 cub. ft. per second, equivalent to 33,000 tons per hour.

Construction of the pump house involved the excavation of a cofferdam 250 ft. long by 50 ft. wide by 32 ft. deep. Larssen No. 5 steel sheet-piles, 65 ft. long, were used to form the walls of the cofferdam; these were driven approximately 9 ft. into the gravel strata underlying 50 to 55 ft. of silty clay. As the dam was excavated, walings and struts were placed in position as shown in Figs. 17 and 18, on Plate XLI, to take the heavy side thrusts. Submersible pumps situated in 6-in.

wells were used to lower the water table to prevent the risk of clay being lifted by upward water pressure; if permitted, the water level at high tide would have been at ground level and the upward pressure, therefore, very considerable. Before the lower part of the pump house was erected, 16-in. by 16-in. reinforced-concrete precast piles were driven into the base of the cofferdam so that they penetrated the gravel strata, as shown in Fig. 24. They were driven in with a double-acting hammer suspended from the jib of a derrick and held by short girders attached to the pile head. The Larssen sheet piling was left in position while the reinforced-concrete structure forming the lower part of the pump house was erected, building paper being placed between the face of the piles and the concrete so that the piles could be withdrawn when the concrete had set. Fig. 19, on Plate XLI, shows the cofferdam with the concrete floor laid and preparations in hand for building the retaining walls.

PUMPING MACHINERY.

As previously mentioned, the lower part of the pump house is divided into three separate compartments, the downstream and central compartments containing the fire pumps and main circulating pumps, respectively, and the upstream compartment being held in reserve for future extension of the refinery. At present, two main circulating pumps, each driven by a separate steam turbine, are installed in the central compartment but sufficient floor space is available for installation of a third set. The pumps were supplied by Gwynnes Pumps, Limited, Hammersmith, London. They are of the horizontal centrifugal type with split casings and double-entry impellers, the suction branch having a diameter of 33 in. and the delivery branch a diameter of 30 in. The casings and impellers are made from gunmetal and the spindles, which are fitted with stainless-steel sleeves, are supported by split whitemetal-lined bearings lubricated by rings in the usual manner. Each pump is capable of delivering 26,500 gallons per minute against a head of 120 ft. when operated at 590 r.p.m., the efficiency being approximately 84 per cent.

The single-cylinder turbines were constructed by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17. They are of the Metrovick all-impulse pass-out type and each is rated at 1,250 brake horse-power; steam is supplied at 250 lb. per square inch and 600 deg. F. Each turbine comprises a velocity-compounded stage and three high-pressure impulse stages before the pass-out belt, followed by another velocity-compounded stage and three low-pressure stages. When no process steam is required, each turbine uses 12,800 lb. of steam per hour to drive the circulating pump but when the pump is working at full load and 21,700 lb. of steam at a pressure of 55 lb. per square inch is passed out per hour, a total steam quantity of 28,000 lb. per hour is required. Admission of steam is controlled by a centrifugal governor but control of the pass-out steam pressure is effected by a sliding disc valve which, through the medium of oil relays, varies the number of nozzles open to the low-pressure section of the turbine.

The condenser, which is integral with the bottom half of the low-pressure casing, has a cooling surface of 800 sq. ft. and is designed to produce a vacuum of 28·6 in. of mercury when supplied with 1,700 gallons of cooling water per minute at a temperature of 60 deg. F. The drive from each turbine is transmitted to its associated pump through two sets of double-helical reduction gears arranged in series and designed to give an overall reduction from 7,500 r.p.m. at the turbine rotor to 590 r.p.m. at the pump shaft. Two reduction gearboxes forming a set can be seen in Fig. 20, on Plate XLII, which gives a general view of one pumping set with the other in the background. One of the turbines and its control panel is shown separately in Fig. 21 on the same Plate. Both turbines are arranged for automatic starting and if for any reason the delivery water pressure should fall below 30 lb. per square inch, the stand-by turbine is started up automatically. The decrease in the delivery water pressure causes a motor-operated valve to open and admit steam to the turbine glands, the exhauster and second stage of the air-ejector unit and the auxiliary air pump. When the vacuum reaches 18 in. to 20 in. of mercury a second motor-operated valve is opened to admit steam to the turbine nozzles. As the turbine approaches its normal running speed, the speed governor controls the steam supply to the machine through the medium of the relay oil system and the governor valves, the auxiliary oil pump shutting down automatically when the main oil pump builds up the required pressure. The drains are then closed by hand, steam is admitted to the first stage of the air ejector and the turbine then operates as a simple condensing unit capable of dealing with the full pump load. Pass out operation is effected by opening two hand-operated valves in the pass-out line.

Normally, the fire ring main is kept at a constant pressure by an electrically-driven centrifugal pump which automatically starts up when the mains pressure falls to a predetermined value and is stopped when the pressure is brought back to its normal value. This pump is large enough to cope with minor outbreaks but should the demand for water outstrip the pump output, the consequent severe drop of pressure in the main automatically starts up a Diesel-driven fire pump. There are two such pumps, one working and one stand-by both of which were supplied, together with the Diesel engines, by Messrs. W. H. Allen, Sons and Company, Limited, Bedford; one of these sets is illustrated in Fig. 22, on Plate XLII. Each engine is a four-cylinder two-stroke unit operating on the uniflow scavenge system and developing 464 brake horse-power at 358 r.p.m. They are arranged to drive the pumps through Francis-Shaw speed-increasing gearboxes which are coupled to the engines and pumps through Allen "Ambiflex" flexible couplings. Starting is accomplished by means of compressed air, the starter mechanism automatically coming into operation when the pressure in the fire main falls to the predetermined value; they may also be started and stopped by push-button controls situated at local and remote-control stations. The delivery pressure from the pump is regulated in each case within close limits by a hydraulic servo motor which operates directly on the fuel-pump control shaft; the maximum speed of the engine, however, is always under control of the main engine governor. Each pump is of the Allen "Conqueror" double-entry single-stage centrifugal type with 12-in. diameter suctions and 10-in. discharge branches, the output of which is 2,500 gallons per minute against a pressure of 180 lb. per square inch at the discharge branch.

OIL JETTY.

Berthing facilities for both the Thames Haven and Shell Haven refineries are provided by London and Thames Haven Oil Wharves, Limited, whose premises adjoin the two refinery areas. Construction of the new refinery necessitated an expansion of these facilities and consequently a new jetty has been built which, it is claimed, is now the largest on the Thames. The jetty is unique in that it is constructed largely from pre-stressed concrete beams and incorporates a new type of fender designed to absorb energy up to 270 ft.-tons. The jetty was constructed by Messrs. John Mowlem and Company, Limited, Mr. Thomas C. Rolland, and Messrs. L. G. Mouchel and Partners acting as the marine and civil-engineering consultants, respectively. It is L-shaped, the approach being 414 ft. long by 23 ft. wide, and the head 240 ft. long by 40 ft. wide. Both the approach and the head are supported by 4-ft. diameter concrete cylinders consisting of pre-cast sections, each 8 ft. long, spigoted together, the lower edge of the bottom section being fitted with a steel cutting edge for penetrating the bed of the river. These were sunk into the river bed to a depth of approximately 34 ft., and then filled with concrete which incorporated suitable reinforcement. There are five 77-ft. clear spans in the approach, each span resting on a single cylindrical support at each end, with the exception of the first span, which rests at the river end on two cylinders; these are shown in the course of construction in Fig. 23, on Plate XLII. The pre-stressed-concrete beams were made in three lengths on the shore, and after they had first been placed in position on temporary staging, the pre-stressing cables were threaded through each section and then pre-stressed to form a single continuous member.

The jetty head is supported by three dolphins, each of which comprises six cylindrical supports, approximately 70 ft. long, three at the out-river side and three at the inshore side. Each pair of supports is joined by a pre-stressed concrete beam 9 ft. wide by 8 ft. 6 in. deep by 40 ft. long, cast *in situ*, and these are spanned by five pre-cast pre-stressed I-section concrete beams, which, unlike the approach beams, were cast in one length. The decking throughout consists of pre-cast concrete slabs, those on the approach being 23 ft. long, 2 ft. wide, and 5 in. thick, and those on the head 9 ft. long, 2 ft. wide, and 4 in. thick. The fenders are of the horizontal pendulum type, the design being based on a patent taken out by Professor A. L. L. Baker. There are six in all, each consisting of a pre-stressed reinforced-concrete slab, 48 ft. long by 7 ft. 6 in. wide by 14 ft. deep, suspended below the deck of the jetty by four 1½-in. diameter chains arranged so that, by an inward and upward movement, energy of 270 ft.-tons can be absorbed. They protrude 6 ft. at the front and 2 ft. at the rear of the jetty.

LITERATURE.

The Displacement Method of Frame Analysis.

By G. P. MANNING, M.ENG., M.I.C.E. Concrete Publications, Limited, 14, Dartmouth-street, London, S.W.1. [Price 9s.]

METHODS of frame analysis may be broadly divided into two classes: those in which every appearance of simultaneous equations is avoided at all costs, and those in which it is assumed that the student or engineer is not going to be scared by the mere mention of equations to be solved. Here, apparently, are two very different schools of thought, but the distinction is not so much one of physical reality as of analytical and computational detail. Ever since Hardy Cross presented his simple and elegant, if somewhat tedious, routine for the solution of rigid frames, with its admirably direct physical interpretation, there has been a tendency to write down any method of the second class, in which equations are introduced and solved without apology or reservation. Mr. Manning rightly makes no attempt to camouflage his basic equations, which are necessarily identical with those occuring at some stage or other in any system in which the unknown quantities, either directly or by implication, are the rotations of the joints and not the unknown moments. He offers a readily understandable physical basis for the derivation of the equations, which, so far as it can be stated in a few words, is simply the computation of the effects of rotating the joints, or of introducing the motions of side-sway, taking each displacement separately.

In any method of frame analysis, the necessity for taking systematic account of positive and negative signs results in the formulation of an artificial convention, and here the rotations of the joints are taken as positive in the same direction. This is unexceptionable, but when a distorted frame is drawn with all the joints rotated positively, there is a possibility of confusion if the reader is not very effectively warned that this picture has nothing to do with the shape of the structure as it deforms under a practicable loading system.

When a method of analysis depends on the solution of a set of simultaneous equations, it is always possible to formulate a problem in which a solution is hard to derive by normal methods, just as it is easy to set up a structure for which the solution by moment distribution converges very slowly. Mr. Manning, however, does not go looking for trouble of this kind. He brings to his task the experience of a designer who knows that, in practice, the most satisfactory structure is one in which the action of a load is most potent in the immediate neighbourhood of its point of application, and therefore he is never concerned with an unmanageable set of equations. There are many worked-out examples and the treatment extends to members of non-uniform section.

CONTINUOUS TUBE-FORMING AND WELDING MACHINE.

BRONX ENGINEERING COMPANY, LIMITED, LYE, WORCESTERSHIRE.

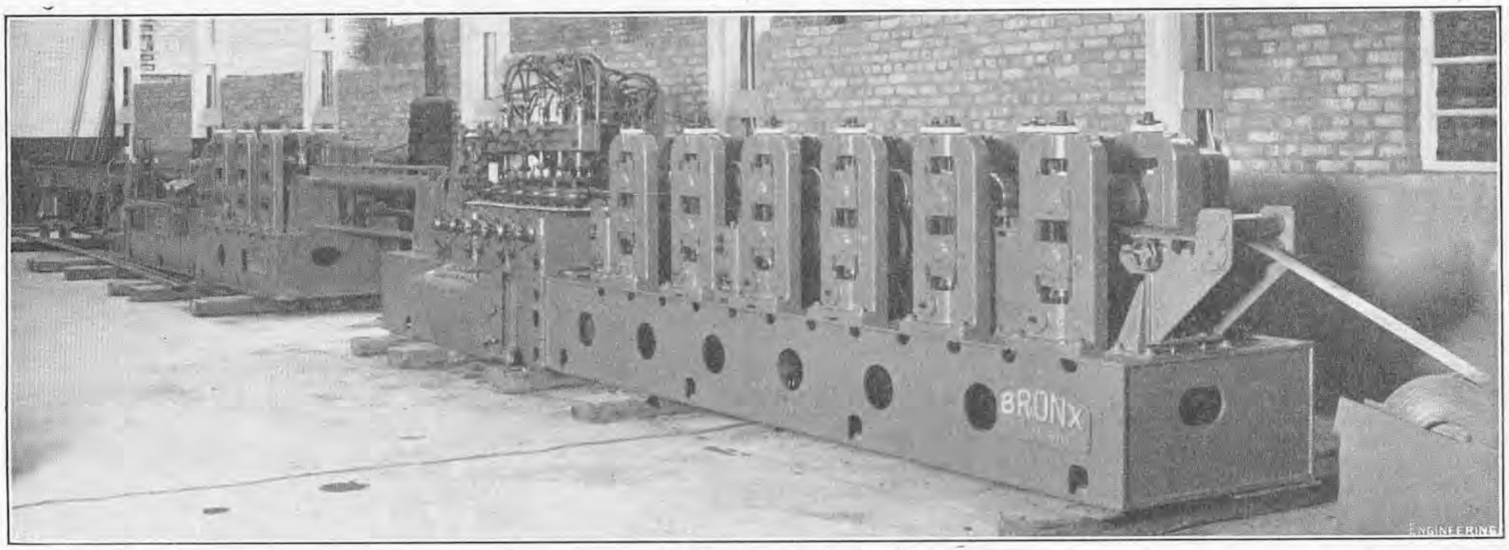


FIG. 1. COMPLETE MACHINE.

Thermal Properties of Buildings.

By N. S. BILLINGTON, M.Sc., M.I.H.V.E. Cleaver-Hume Press, Limited, 42a, South Audley-street, London, W.1. [Price 25s. net.]

THE author of this book is head of the National College for Heating, Ventilating, Refrigeration and Fan Engineering, London, and was formerly engaged for many years at the Building Research Station on the study of the thermal properties of building materials, building components and buildings as a whole. In addition to his own work, he has had access to that of former colleagues. Many of the investigations carried out at the Building Research Station, and in university and other laboratories at home and abroad, however, have been published in monographs and journals not always readily available to the student or the practitioner. It is therefore convenient to all who require authoritative information on the heating, ventilation and thermal insulation of buildings to find the latest available results of research and observation collected into a single volume such as this, with full bibliographic references given to the original sources of the information.

Some of the author's general statements might, for the layman, have been more lucidly expressed; the captions to illustrations and headings of tables are not always self-explanatory; and the few photographs included are poorly reproduced. For instance, Fig. 4.3, on page 100, fails to show the differences listed in the caption and thus merely duplicates Fig. 4.1, on page 94. These, however, are minor blemishes, and the book should prove useful, not only to the research worker and the specialist student, but to architects and engineers responsible for the design and equipment of buildings. Though familiar with the conditions of comfort in buildings constructed with well-established materials, designers now often have to meet special requirements, to save weight, or to avoid restrictions on the use of scarce materials, by using materials and forms of construction which compel them either to call in science to supplement limited experience, or to risk defects which may be difficult and expensive to remedy. Such designers will welcome the concise information on the flow of heat, on the causes and means of avoiding condensation, on pattern staining, on the storage of heat in the fabric of intermittently heated buildings, on the utilisation or exclusion of solar heat, and particularly the numerical data given in the tables contained in this compendious handbook. Those who have occasion to go deeply into the mathematics of the flow of heat and such matters, will find them treated in the appendices to the relevant chapters. The book concludes with alphabetical indexes to authors of works referred to in the text, to subjects and to the contents of tables.

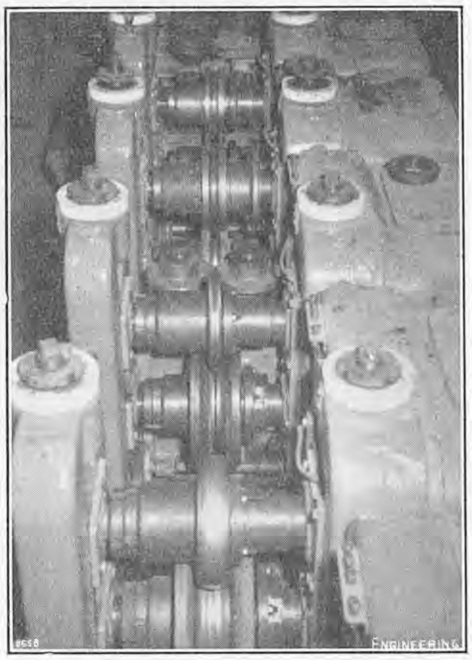


FIG. 2. PART OF TUBE-FORMING UNIT.

CONTINUOUS TUBE-FORMING AND WELDING MACHINE.

A MACHINE for the continuous production of welded steel tube, from $\frac{1}{2}$ in. to $2\frac{1}{2}$ in. in diameter and from 20 to 10 s.w.g. in thickness, has recently been built by the Bronx Engineering Company, Limited, Lye, Worcestershire, for a firm in South America. The designed range of speed is from 40 ft. to 120 ft. per minute.

The complete machine is illustrated in Fig. 1, on this page, and the five chief parts, from right to left of the illustration, are the forming unit, oxy-acetylene welding unit, sizing and straightening unit, flying cut-off, and (hardly visible in Fig. 1) the run-out and discharge table. Ancillary units are interposed between the major items; they comprise a tube guide prior to the welding unit, a weld trimmer after the welding unit, and a discharge roll at the entry end of the run-out and discharge table. The machine here referred to incorporates an oxy-gas welding unit, but an electric welding head can be supplied on otherwise similar machines.

The forming unit of the machine is shown in Fig. 2. It consists of six sets of horizontal forming rolls, preceded by a guide bracket and supporting rollers for the strip feed shown in Fig. 1. The forming-roll spindles are supported at the inner ends by twin tapered-roller bearings, the outer bearings being Hyatt-type rollers. The outer bearings are mounted in pedestals which are removable for roll-changing. On each side of the final horizontal forming roll, there is a set of vertical rolls, the outer of which give the final contour to the tube prior to welding. All rolls have top and bottom adjustment, the top roll being set with the aid of a micrometer scale on the top of each bearing housing for both the inboard bearings and the outboard bearings in their pedestals. As will be understood from Fig. 2, the strip is gradually formed into a tube by the rolls.

The strip, now in the form of a tube, passes into the welding unit, shown in Figs. 3 and 4, on page 748, through a tube guide consisting of a blade which fits between the abutting edges of the tube and so ensures that the joint is kept in line beneath the welding head. The tube then passes between six sets of laterally-adjustable rolls; each roll is cooled by water, which is delivered through branch pipes, under the machine, to the hollow roll spindles. The cooling water passes up through the spindle and is fed through two small branch pipes into a cup formed in the top of the roll, as shown in Fig. 4. Subsequently it overflows through an annulus in the centre of the roll and passes thence into a trough under the bed of the unit. In the case of a machine fitted for oxy-acetylene welding, the welding unit consists of five blowpipe bodies, each carrying a flat head with a multiple nozzle array. These five heads are arranged continuously in line. The first three carry 53 No. 4-B.A. thread nozzles set in two rows. In the fourth head there are 75 nozzles set in two rows which converge in the direction of the travelling tube. These four sets of nozzles are for heating only; the final set is the actual welding head, which consists of 41 nozzles in a single row. Vertical and lateral adjustment are provided for the nozzle heads individually by mounting them on a beam located over the longitudinal centre-line of the table. Vertical adjustment is effected by means of five control levers, each actuating an eccentric; lateral movement is given by a worm and nut mechanism with five small handwheels. The beam is supported by a saddle riding on a pillar behind the unit, and is set to the correct height by a stop which is adjusted by a handwheel at the front of the welding unit. The beam is counterbalanced and is lowered into the working position by an air cylinder located underneath the balance weights and controlled by a hand-operated air valve. Prompt elevation of the welding head from the work, complete with its nozzles, is accomplished by the balance weights when a foot-operated stop is released.

The blowpipe shanks and the nozzle heads for heating and welding are cooled by water which passes down casings around the blowpipes into the nozzle heads, whence it is allowed to overflow through small-diameter tubes into the cups of the rolls. Immediately under the portion of the tube being heated and welded, there is a slotted channel faced with asbestos. The slot is the entry for an exhaust duct running along the centre of the welding unit. Fumes are conducted through the duct to a branch pipe at each end and extracted by a centrifugal fan situated behind this section of the machine. In the oxy-gas machine the gas supplies to the welding and heating heads is controlled from a panel in front of the unit which carries oxygen and acetylene pressure gauges, the oxygen regulator and the valve control for the gases to each blowpipe. For trial purposes, the acetylene regulator was mounted on a separate board with the acetylene manifold, there being, at that time, two banks of ten cylinders, but it is understood that, when the machine is put into operation in South America, it will use generated acetylene which has been compressed to provide a minimum outlet pressure of 6 lb. per square inch. The welding equipment was designed and supplied by the British Oxygen Company, Limited. Test runs producing tubes 1¼ in. in diameter and 14-s.w.g. thick gave welds with complete penetration and good fusion. Pieces from sample welds were subjected to 90-deg. bend tests without signs of cracking.

The weld is trimmed by a tool which is mounted in a tool-post for adjustment, as can be seen in Fig. 3. The cutting face is ground slightly concave to accommodate tubes of different diameters, and support is given by a roller under the tube. The trimmer is mounted at the entry end of the sizing and straightening unit which comprises three sets of rolls. Following the sizing and straightening rolls, there is a flying cut-off, shown in Fig. 5, page 748, the return ram and tube clamp of which are pneumatically operated. The cut-off wheel is of the abrasive type, 16 in. in diameter, and runs at 3,600 r.p.m. It is traversed across the tube by means of a pick-up wheel running up an inclined ramp as the cut-off head travels down the length of the unit. This arrangement gives a rocking motion to the cut-off head. The speed of travel of the cut-off head is tied to that of the tube by the operation of pneumatic clamps on each side of the cut-off wheel. The length of tube cut can be varied by an adjustable limit switch on the discharge table, which can be set for lengths from 10 ft. to 20 ft. The discharge pinch roll runs at a higher speed than the main rolls, so that when the tube is severed, the cut portion is accelerated to increase the gap between it and the following section and propel it the full length of the discharge table, which is shown in Fig. 6, on page 748. From there it is released on to a cooling rack by pneumatically-operated triggers. All the rams, clamps and ejector mechanisms are operated by air at 75 lb. per square inch; the total air supply required for these purposes is 300 cub. ft. per minute.

The main rolls of the machine are driven by a 25-h.p. variable-speed direct-current motor running at 500 to 1,500 r.p.m., the drive being by V-belts to the machine and thence through chain couplings to the forming, sizing and straightening rolls. The exhaust fan is driven by a separate motor. The 15-h.p. motor driving the cut-off wheel runs at 3,600 r.p.m. The drive to the cut-off spindle is by a flat belt arranged so that there is no bending stress on the spindle, which runs in Hyatt-type bearings; the drive is first taken by a pulley running on the housing of the cut-off head and this is keyed to the main spindle. By this means, bending loads are taken on the housing and the spindle is only subjected to rotational stresses. The machine is 70 ft. long, 6 ft. 6 in. high, and 5 ft. wide, and the net weight is 26 tons 19 cwt.

DOCUMENTARY AND INDUSTRIAL FILMS.—We have received an annotated list of 16 mm. and 35 mm. films, on such subjects as petroleum, aviation and motoring, power and engineering, agriculture, etc., issued by the Petroleum Films Bureau, 29, New Bond-street, London, W.1. The films may be borrowed *gratis* by educational establishments, scientific and technical societies, Service units, and other organisations.

THE JENBACH VERTICAL OIL ENGINE.

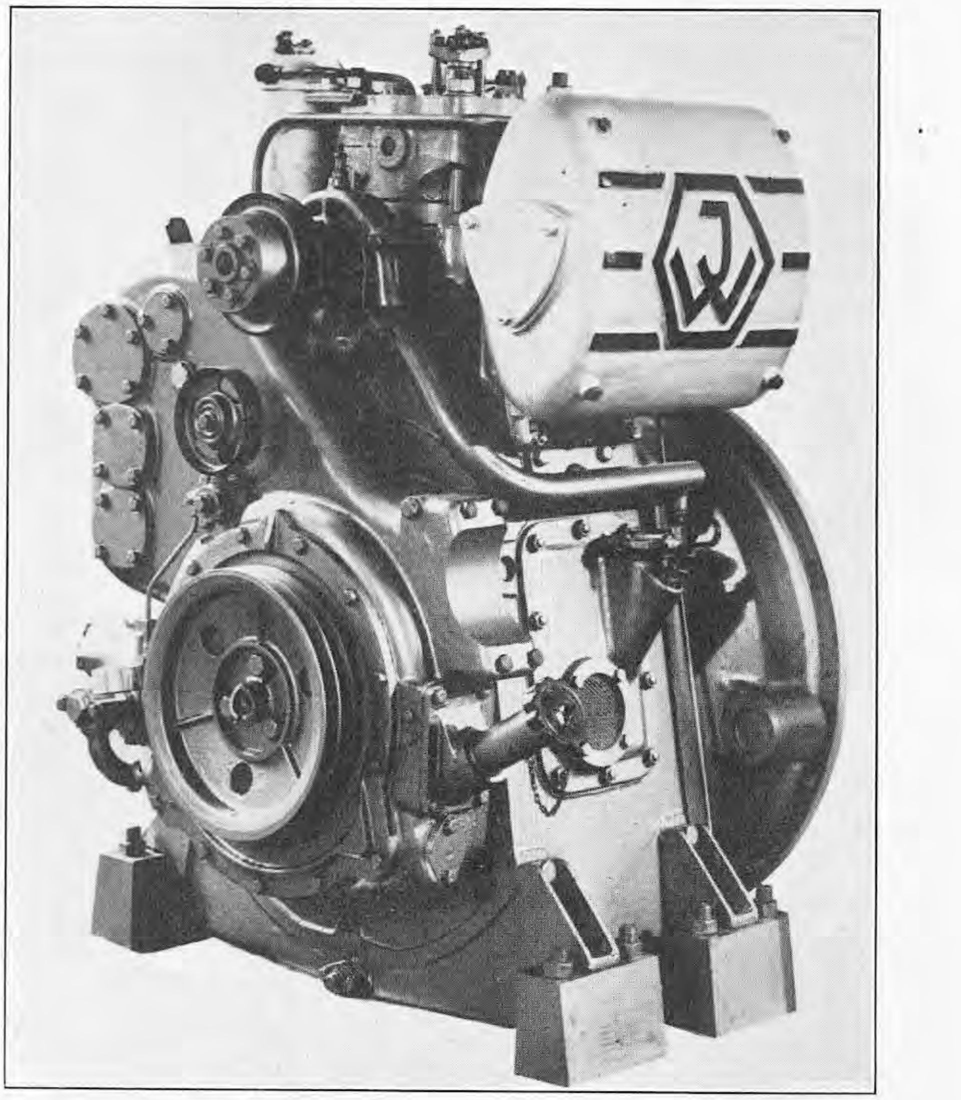


FIG. 1. ENGINE, SHOWING EXPANSION BOX.

ANALYSIS OF THE PERFORMANCE OF THE JENBACH TWO-STROKE VERTICAL OIL ENGINE.

By PROFESSOR S. J. DAVIES.

AN important branch of the study of the development of oil engines has been concerned with the interesting and protracted competition between the four-stroke and two-stroke cycles. The advantages of the two-stroke cycle, of a more even turning moment, fewer working parts, and a better utilisation of the materials of construction, have not so far led to that universal adoption expected by some of its protagonists, and the four-stroke cycle has continued to hold its own, especially in engines of small bore and stroke running at high speeds of revolution. There are signs, however, on the Continent, in the United States, and in this country, that this state of affairs is changing, and in the high-speed field in particular, the two-stroke cycle is receiving more active attention than ever before. An interesting example in illustration of this tendency is provided by the new vertical two-stroke oil engine, type JW 50, now being built by the Jenbacher Werke, Jenbach, Tirol, Austria, to the designs of the Ingenieurbüro Professor Dr. Hans List, consulting engineers, Graz. This is the first of a series of engines, of the same unit dimensions, which are intended to be built with one, two, three, four, six and eight cylinders; those with two and three cylinders will be in-line engines and those with four, six, and eight cylinders will be V-engines. The single-cylinder and two-cylinder engines are in production.

A single-cylinder engine of this type was recently the subject of comprehensive tests by the author in the laboratories of the Technische Hochschule, Graz. In the engine under investigation the cylinder bore is 150 mm. (5·91 in.) and the stroke is 170 mm. (6·69 in.), giving a swept volume of 3 litres. The speed range is from 750 to 1,500 r.p.m., and, over this range, the maximum output increases with speed from 25 to 50 brake horse-power, the rated output for continuous running being 10 per cent. lower. Fig. 1 shows the general appearance of the engine and Figs. 2 and 3 show longitudinal and transverse sections, respectively. As will be seen, loop scavenge is provided. The air from the Root's blower* is delivered into a receiver and thence to two sets of admission ports, arranged with one set on each side of the single set of exhaust ports; the exhaust gases pass to the expansion box, shown on the right in Fig. 3 and also visible in Fig. 1. The advantages of loop scavenge over that in which exhaust valves are fitted are greater simplicity, cheapness and reliability.

The combustion chamber is of the direct-injection type, in which the chamber proper is in the cylinder head, the top of the piston being slightly hollow. A high brake mean-effective pressure, a low fuel consumption, and easy starting are to be expected from this form of chamber. The compression ratio, from the top of the exhaust ports is, according to the author's measurements, 14 : 1. The injection pump was made by Friedmann and Maier, Hallein, Austria, and works on the jerk-pump principle; it was provided with a governor for speed regulation. The injection nozzle was supplied by C.A.V., Ltd., London. It is of type BDL 150 T 697, has eight holes of 0·25 mm. (0·01 in.) diameter, and was set

* The blower is of the Root's type for engines with up to three cylinders and of the turbo type for engines with four and more cylinders.

THE JENBACH VERTICAL OIL ENGINE.

Fig. 2.

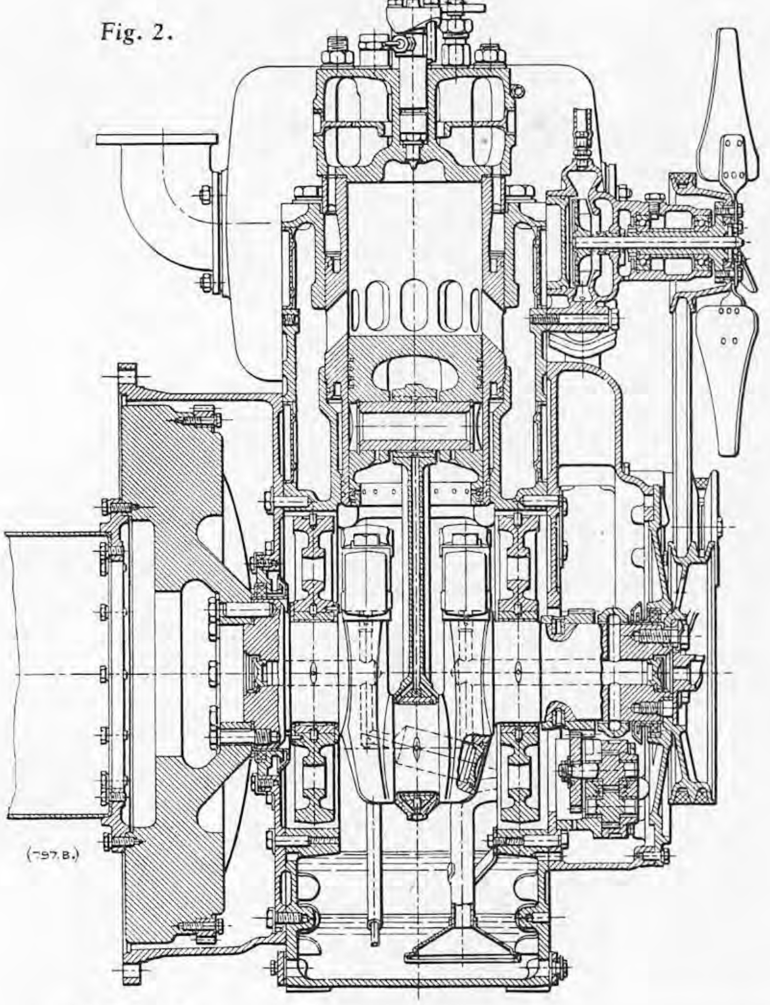


Fig. 3.

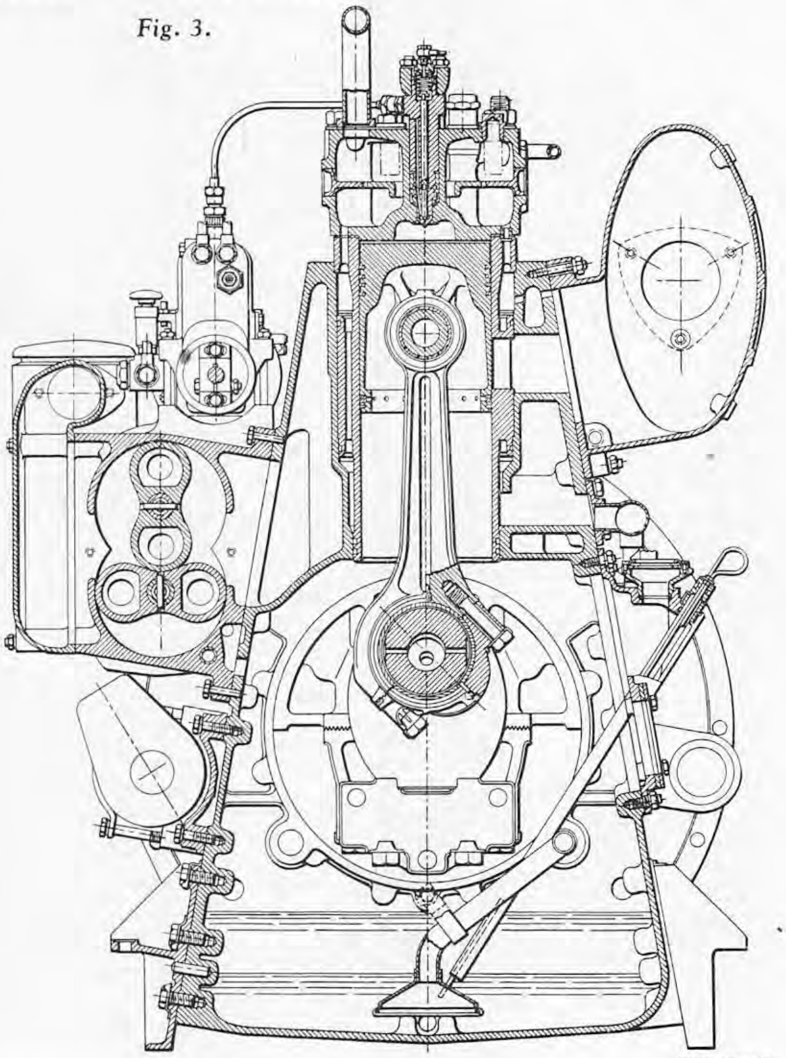
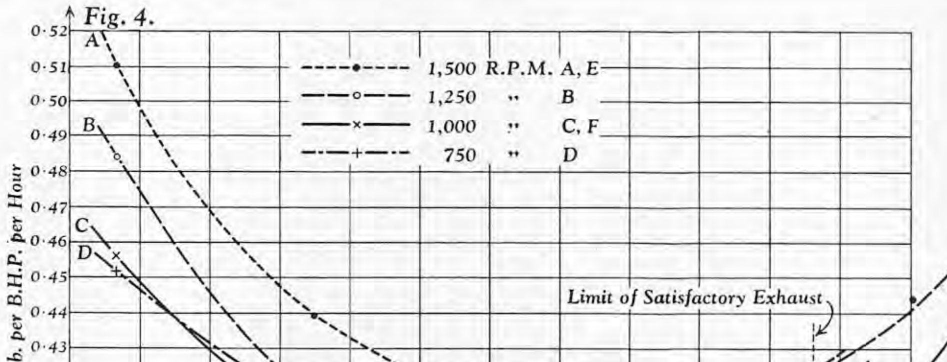


Fig. 4.



to deliver at a pressure of 240 kg. per square centimetre (3,400 lb. per square inch). Pump delivery under all conditions was set to begin 18 deg. before top dead centre, adjustment with change of speed being unnecessary. The author is informed that in the production model the delivery pressure is 200 kg. per square centimetre (2,840 lb. per square inch). To suit the application of the engine, governing can be arranged for a single speed, with fine adjustment as necessary, or to give a wide range of speeds.

The engine body is of cast iron and is arranged in one piece in "tunnel" form, this form combining simplicity with stiffness. For ease and cheapness of machining, it is designed on all sides with plain surfaces, without projections. The tensile forces from the combustion are carried from the cylinder head by four long tension bolts, so that the crankcase is relieved of tensile stresses. As may be seen in Figs. 2 and 3, the main crankshaft bearings are carried in cylindrical casings, which are built up and inserted, together with the crankshaft, into the engine body, in which they are secured by tension bolts; these bolts are carried up to the top of the engine body. This arrangement makes it possible, in the case of multi-cylinder engines, to provide plain bearings between the cylinders, while the crankshafts are made in one piece. Side openings in the crankcase render it possible, after removal of the cylinder head, to withdraw the connecting rod and piston. The cylinder head is simple in design, and includes the fuel-injection nozzle, the valve for the starting air, and a valve for charging the compressed-air bottles.

The cylinder liner, which is provided, of course, with the admission and exhaust ports, is of special iron, cast centrifugally, and is arranged for easy dismantling. Its construction may be seen in Figs. 2 and 3, from which it will be observed that ample cooling is provided. The piston is made of a super-eutectic aluminium-silicon alloy, which has a low coefficient of expansion and good strength at high temperatures. It is provided with four pressure rings and two scraper rings. The connecting rod is a drop-forging of chrome-molybdenum steel. A central hole through the rod provides lubrication for the gudgeon-pin bearing. The big-end bearing has a steel shell with lead-bronze lining. In order to secure a rigid connection of the bearing cap with the rod, they are formed with grooved faces. The crankshaft is also of drop-forged chrome-molybdenum steel and the bearing surfaces are flame-hardened; it is provided with balance weights and is carried in lead-bronze bearings.

The blower unit, which is made by the engine builders, is secured independently to the engine body, the blower being driven through gearwheels and through a flexible coupling. An amply-dimensioned filter of the oil-bath type is fitted at the intake to the blower, which turns at 2·455 times the speed of the crankshaft. The fuel-injection pump has its own drive and, with its governor and fuel-supply pump, is fixed to the top of the blower and driven through the usual four-clawed sliding coupling from a shaft in the gear casing. The gearcase, which carries the bearings for the drives to the blower, the fuel pump, and the gear pump for the lubricating oil, is also secured separately to the engine body. The cleaning of the lubricating oil is effected by a laminar-flow filter, before which a magnetic filter is placed.

The engine was designed to be used in a wide range of applications. The speed of revolution can be adjusted to meet the conditions of service; for the heaviest continuous duty, as for the propulsion of ships or for driving electrical generators, 750 to 1,000 r.p.m. is envisaged; for heavy duty, as a power unit in cranes, road rollers, bulldozers, locomotives and road tractors, 1,200 to 1,350 r.p.m. may be used; for lighter duty, as, for example, in power units for peak loads in power stations, 1,500 r.p.m. is permissible. The engine can be delivered for both right-hand and left-hand rotation, and the gearcase may be placed at either end of the engine, to meet installation conditions or to give right-hand or left-hand control. The flywheel can be chosen to suit the application as, for example, in the generation of electrical power, for which it must be specially heavy. If desirable, a special casing can be flanged directly to the crankcase in order to contain an electric generator or a reversing gear for a ship. The cooling system may similarly be adapted to the field of application; in its usual form, it comprises a closed system which includes an amply-dimensioned radiator and a water-circulating pump, arranged to provide the bearing for the radiator fan. The pump is driven by a rubber V-belt, the tension of which may be adjusted by a jockey pulley. Alternatively, when the engine is applied to the propulsion of a ship, a self-priming water and bilge pump is substituted for the water-circulating pump, and the drive is taken through gearwheels.

Starting may be carried out either electrically or by compressed air. In the former case, a starter motor of 4 h.p. is provided, and its pinion turns the engine through a gear ring secured to the periphery of the flywheel. The generator is driven by a V-belt from the end of the crankshaft and takes its bearing on the gear casing. Provision must, of course, be made for batteries. With air starting, a simple control gear for the compressed air is coupled to the drive of the fuel-injection pump. The cylinder head, as stated above, is provided with a starting-air valve. In order to fill the storage bottles, which have normally a capacity of 60 litres (2·1 cub. ft.), the charging-valve in the cylinder head is brought into service.

In the basic tests, the engine was run at a series of constant speeds, 1,500, 1,250, 1,000 and 750 r.p.m. and, at each speed, the loads were varied from light to full. At first, the injection pump was set so as to limit the b.m.e.p. to about 78·2 lb. per square inch; later, this limitation was removed and the load gradually increased to go beyond the "limit of satisfactory exhaust," this point being taken as that load at which the exhaust gases, when passed through a stop-cock in the exhaust pipe into the open laboratory, first become visible. The principal data from both these sets of conditions are given in Table I; series A, B, C, D, have limitations to the quantity injected, and in series E, at 1,500 r.p.m., and F, at 1,000 r.p.m., the extensions of series A and C, respectively, the limitations are removed.

TABLE I.

Test No.	R.p.m.	B.m.e.p., lb. per sq. in.	B.h.p.	Fuel, lb. per hour.	Fuel, lb. per b.h.p. per hour.
A 1	1,498	4·3	1·3	5·69	4·270
A 2	1,505	14·2	9·9	7·36	0·742
A 3	1,501	28·4	19·8	10·10	0·510
A 4	1,500	42·7	29·6	13·01	0·439
A 5	1,502	56·9	39·5	16·43	0·416
A 6	1,500	64·0	44·5	18·18	0·408
A 7	1,495	71·1	49·2	20·40	0·415
A 8	1,510	78·2	54·6	23·20	0·425
E 1	1,495	71·1	49·2	20·48	0·416
E 2	1,504	78·2	54·5	23·06	0·422
E 3	1,500	85·3	59·3	26·23	0·444
E 4	1,500	88·9	61·7	28·33	0·459
B 1	1,257	28·4	16·6	8·00	0·484
B 2	1,251	42·7	24·7	10·28	0·415
B 3	1,250	56·9	32·9	13·24	0·403
B 4	1,250	64·0	37·1	14·69	0·396
B 5	1,253	71·1	41·3	16·52	0·400
B 6	1,261	78·2	45·7	18·68	0·409
C 1	1,000	2·6	1·2	2·76	2·300
C 2	996	28·4	13·1	6·00	0·456
C 3	1,003	42·7	19·8	8·08	0·407
C 4	1,003	56·9	26·4	10·22	0·387
C 5	993	64·0	29·4	11·44	0·389
C 6	996	71·1	32·8	12·90	0·394
C 7	1,000	78·2	36·2	14·62	0·404
F 1	1,000	71·1	32·9	12·90	0·391
F 2	1,007	78·3	36·5	14·65	0·402
F 3	1,000	81·8	37·8	15·50	0·409
F 4	1,007	85·3	39·8	16·80	0·421
F 5	998	88·9	41·0	18·50	0·452
D 1	750	28·4	9·9	4·47	0·452
D 2	755	42·7	14·9	6·15	0·413
D 3	748	56·9	19·7	7·80	0·396
D 4	748	64·0	22·2	8·81	0·398
D 5	748	71·1	24·6	9·90	0·402
D 6	750	79·4	27·2	11·39	0·418

The observations necessary to obtain the data tabulated are brake torque, revolutions per minute, and fuel consumption. The power developed by the engine was absorbed by an electrical dynamometer of the torque-reaction type; this dynamometer was afterwards uncoupled from the engine and its dimensions checked, showing the values of torque recorded to be without measurable error. While a tachometer afforded a continuous check of the constancy of the speed of revolution, the counting of the revolutions and the fuel consumption were simultaneously observed. The time to consume a measured volume of fuel was observed by means of a stop-watch; the counter, which received through a contact on the dynamometer shaft an electrical impulse once every revolution, was switched on at the instant when the consumption of the measured volume of fuel commenced and switched off again at the instant the fuel was consumed. The quantity of fuel to fill the measured volume was weighed and from the times, as observed by the stop-watch during the tests, the fuel consumptions in pounds per hour and the revolutions per minute of the engine were calculated. In the tables the brake torques have been converted into the equivalent values of b.m.e.p.

During the series A, B, C, D, the barometer stood at 28·6 in. of mercury and the room temperature was never below 65 deg. F. The gas oil used during the test was investigated by Dr. Sablatnög, of the Department of Chemistry, the Technische Hochschule, Graz, who reported as follows: "The density was 0·8755 at 61 deg. F.; the lower calorific value was 18,090 B.Th.U. per lb., and the higher calorific value was 19,240 B.Th.U. per lb.; the carbon content was 86·63 per cent., and the hydrogen content was 12·43 per cent." The lubricating oil used was Socony Vacuum Mobiloil A, with a viscosity of 8 deg. Engler (245 sec. Redwood Standard) at 112 deg. F.

Fig. 4 shows curves of specific consumption, in lb. per brake-horse-power per hour, for these tests. The limitation in the main series was at a b.m.e.p. of 78·2 lb. per square inch (5·5 kg. per square centimetre), except in series D, when it was somewhat higher. Careful observations of the exhaust, with gradually increasing loads at each speed, showed that this value of the b.m.e.p. corresponded with the limit of satisfactory exhaust, as indicated in Fig. 4. Since maximum output is given at all speeds with a value of the b.m.e.p. of 71·1 lb. per square inch (5·0 kg. per square centimetre), there is the reasonable margin of 10 per cent. between this value and the limit of satisfactory exhaust. Bearing in mind that the engine in question has a single cylinder, and is of the simplest possible construction to work on the two-stroke cycle, the curves indicate results of great interest. At 750, 1,000 and 1,250 r.p.m., for example, the values of the specific consumptions from half-load to well beyond full-load lie always below 0·445; at normal full-load the values lie below 0·402. Even at 1,500 r.p.m., a speed at which the frictional losses begin to exert a greater influence, the value at normal full-load is only 0·413. The values of the b.m.e.p. are similarly very good, especially when the low barometer reading (Graz is at an altitude of over 1,000 feet) is taken into consideration.

The curves in Fig. 4 are those of the greatest practical importance. They are, naturally, the integration of all the factors of the performance of the engine and comprise the two main elements: the efficiency of the combustion and the mechanical efficiency. The former includes such factors as the design of the combustion chamber, the proper correlation of the injection and combustion processes, and the efficacy of the scavenging and charging processes; the latter includes the normal frictional losses and the work done in the blower. It is thus desirable, in order to obtain the most comprehensive information concerning the engine, to extend the analysis of the test results as far as practicable.

(*To be continued.*)

UNITED KINGDOM IMPORTS OF IRON ORE.—During the first four months of the present year, 2,944,931 tons of iron ore were imported into this country, compared with 2,279,998 tons during the corresponding period of 1951. The two main sources of the 1952 imports were Sweden (1,152,065 tons) and Algeria (597,534 tons).

MECHANISMS FOR INTERMITTENT MOTION.

By O. LICHTWITZ, M.I.Mech.E.

(*Continued from page 486.*)

EXTERNAL STAR-WHEEL MECHANISMS.

THE number of stations of a Geneva mechanism cannot be smaller than 3, nor can the partial movement of the driven shaft exceed one-third of a revolution except in the case of modified mechanisms (similar to that shown in Fig. 16). A frequent requirement, nevertheless, is to impart to a shaft complete revolutions with intermediate standstills. Geneva mechanisms offer little scope, since, for a given number of stations and a given distance between the shaft centres all the relevant dimensions and kinematic relations are fixed, including the distribution of motion and standstill. Another unfavourable feature of Geneva mechanisms is that the duration of each period of motion decreases when the partial movement of the driven gear is increased, which accounts for the unfavourable kinematic properties of mechanisms having a small number of stations.

Star-wheel mechanisms impose none of the restrictions mentioned above. Figs. 24 and 25, opposite, show mechanisms in which the partial movement of the driven shaft is a full revolution and a half revolution, respectively. Figs. 26 to 28, show mechanisms for producing partial movements of a quarter revolution. In the case of Fig. 26, the motion occurs during a quarter revolution of the driving gear, or the same as in the case of the Maltese Cross shown in Figs. 4 to 7, on page 452, *ante*. Figs. 27 and 28 make it obvious that the duration of motion can be varied. In the case of Fig. 27, it is increased to a full revolution of the driving gear, so that there is no standstill; in the case of Fig. 28, it is reduced to less than one-seventh of a revolution of the driving gear. The driving gear is in all cases equipped with at least two driving rollers. The first roller serves for accelerating, the last roller for retarding, and the intermediate rollers for imparting a uniform motion to the driven gear. There is also a period of uniform motion if the driving gear has only two rollers, as in Fig. 28.

Referring to Fig. 24, the motion commences when roller 1 enters slot 1. When that roller is in the central position, the driven gear reaches its maximum velocity and retains it, owing to the action of rollers and teeth 2 to 7. The same velocity is still maintained when roller 8 enters slot 8 and until it reaches the central position. As slot 8 is the mirror image of slot 1, the driven gear is decelerated while roller 8 is receding from slot 8, and comes to a standstill when the roller leaves the slot. The standstill is secured in the usual manner by a locking drum, connected to the driving gear, and engaging with recesses in the driven gear. Pin gearing designed to produce uniform motion is seldom used nowadays and, as will be demonstrated, such gears can be replaced by ordinary involute gears. Nevertheless, pin gearing has been selected by way of illustration because it makes the functioning easier to understand.

Figs. 29 and 30 show a star wheel mechanism in which the means for acceleration and retardation are combined with parts of involute gears. That arrangement should not be confused with an inferior form of intermittent gear sometimes employed, which consists of involute gears with some teeth removed. Such gears are actually mutilated, and in order to ensure that the driving gear engages with the still stationary driven gear, and disengages after the driven gear has completed its motion, the height of the first and last teeth, or of the first and last two teeth of such gears is reduced. At the same time, the first tooth should actually be stronger than the others because, for such gears, the motion of the driven gear commences abruptly. To withstand the shock at the commencement of motion, projections having doubtful shapes are to be found in many cases fixed to both gears. They are intended as auxiliary gears, but they neither improve the kinematic conditions, nor remove the noise. Such crude forms of intermittent gears will not be considered in the case of spur gears, for which a more

MECHANISMS FOR INTERMITTENT MOTION.

Fig. 24.

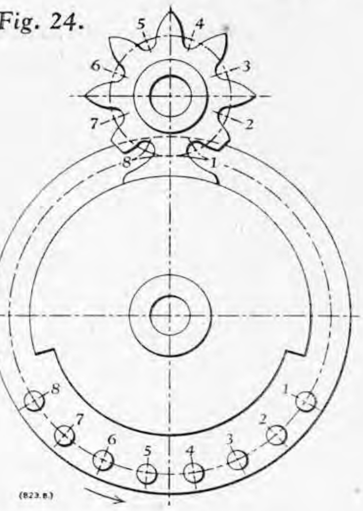


Fig. 26.

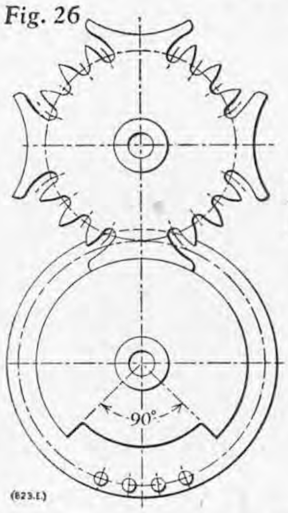


Fig. 27.

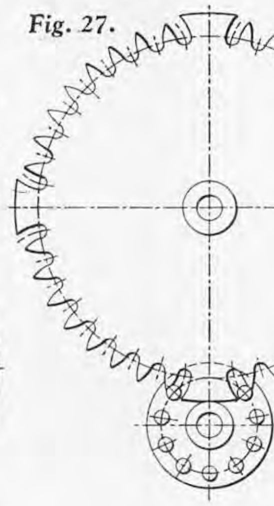


Fig. 28.

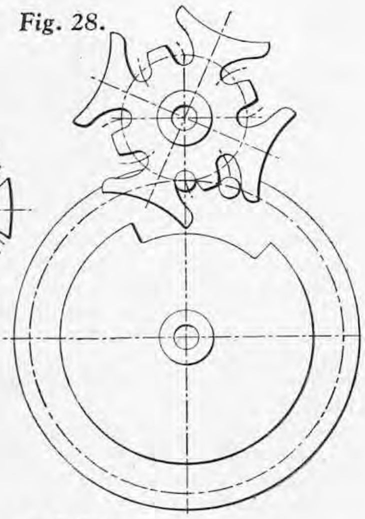


Fig. 25.

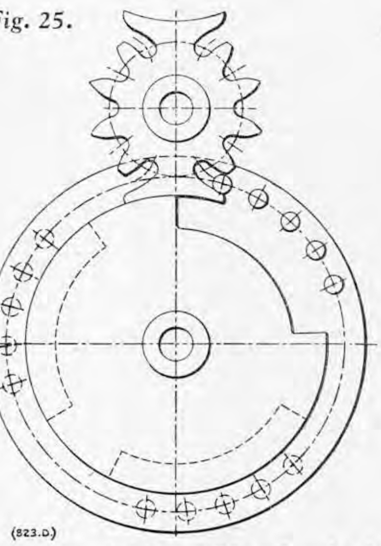


Fig. 29.

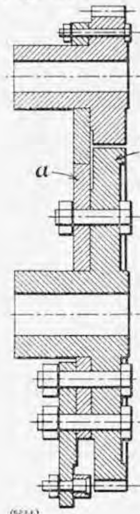
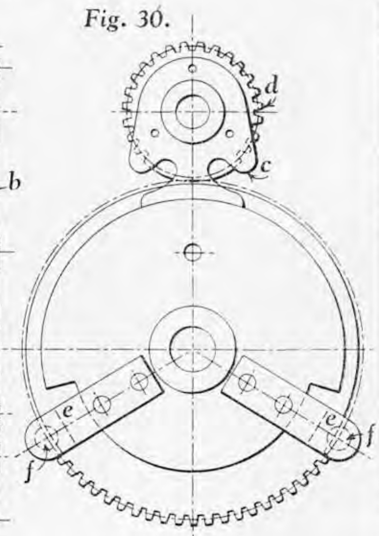


Fig. 30.



perfect solution exists, but will be referred to later in connection with intermittently working bevel-gears.

If the elements for uniform motion are separated from those for non-uniform motion, as in Figs. 29 and 30, it is possible to impart more than one revolution to the driven shaft during a partial movement of the driving shaft. Since the driving gear becomes rather bulky in such cases, however, and as a multiplication of the movement of the driven shaft can be achieved otherwise by simple means, such cases will not be considered.

Geometry.—Fig. 31, on page 743, shows a star-wheel mechanism in the position where the driven gear commences to move. A subsequent position, which will be referred to later, is shown in Fig. 32. The shape of the accelerating slot is determined by the requirement that the roller must recede from the slot subsequently when both gears are rotating with uniform velocity. The centre line of the slot must, therefore, be part of an epicycloid which is traced by a point on the circumference of the pitch circle of the driving gear when rolling without sliding on the exterior of the pitch circle of the driven gear. To start and finish the motion without shock, the epicycloid and the former pitch circle must have a common tangent at the point D.

A circle of the size of the pitch circle of the driving gear may be imagined touching the pitch circle of the driven gear at the point C, and rolling afterwards along that circle until it gets into the position for which the point of contact is at E, and the generating point of the epicycloid at D. The centre of the rolling circle is then at A′. As the triangles A B D and A′B D are congruent, the angles D A′B and D A B are equal, namely, the angle α_0 through which the driving roller has to rotate from the initial to the central position. If the line A E is produced to the further intersection F with the pitch circle of the driven gear, the resulting isosceles triangle E B F is similar to the triangle E A′D, so that the angle E B F is also α_0. Another triangle similar to the previous one is the isosceles triangle B A F, two sides of which are equal to the sum of the radii of the two gears $(r_2 + r_1)$, the third side being the radius r_2 of the driven gear. It follows that

$$\sin\frac{\alpha_0}{2} = \frac{r_2}{2\,(r_2 + r_1)}, \quad \text{or with } \mu = \frac{r_2}{r_1},$$

$$\sin\frac{\alpha_0}{2} = \frac{\mu}{2\,(1 + \mu)} \quad . \quad . \quad . \quad . \quad (20)$$

$$\alpha_0 = 2\sin^{-1}\frac{\mu}{2\,(1 + \mu)}. \quad . \quad . \quad . \quad (21)$$

The line B G which bisects the angle E B F is perpendicular to the line A E F H, and the line B H is perpendicular to A B. The angle G B H is therefore α_0, and the angle F B H is $\frac{\alpha_0}{2}$. As the angle E B H, therefore, is equal to $\frac{3\,\alpha_0}{2}$, the angle C′ B E is $\left(\frac{\pi}{2} - \frac{3\,\alpha_0}{2}\right)$, and the angle ϕ_0 which determines the outer end of the slot is half of it, or

$$\phi_0 = \frac{\pi}{4} - \frac{3\,\alpha_0}{4} = \frac{\pi}{4} - \frac{3}{2}\sin^{-1}\frac{\mu}{2\,(1 + \mu)}. \quad (22)$$

The arcs C E and D E are equal, and the latter is $r_1\alpha_0$. The angle C B E, therefore, is $\frac{r_1\alpha_0}{r_2} = \frac{\alpha_0}{\mu}$, and it follows from Fig. 31 that the angle β_0, which determines the inner end of the slot, is

$$\beta_0 = \frac{\pi}{2} - \frac{\alpha_0}{\mu} - \frac{3\,\alpha_0}{2} = \frac{\pi}{2} - \frac{\alpha_0}{2}\left(\frac{2 + 3\,\mu}{\mu}\right)$$

$$= \frac{\pi}{2} - \left(\frac{2 + 3\,\mu}{\mu}\right)\sin^{-1}\frac{\mu}{2\,(1 + \mu)}. \quad (23)$$

If the distance between the centres of the driving and driven gears is a $(= r_2 + r_1)$, the radii of the two gears are

$$r_1 = \frac{a}{1 + \mu} \quad . \quad . \quad . \quad . \quad (24)$$

$$r_2 = \frac{a\,\mu}{1 + \mu}. \quad . \quad . \quad . \quad (25)$$

The distance s = D C′ is

$$s = 2\,r_1\sin\frac{\alpha_0}{2} = \frac{r_1\,r_2}{r_1 + r_2} = \frac{a\,\mu}{(1 + \mu)^2}. \quad (26)$$

The point D can be constructed by means of the calculated value of s, or entirely graphically, in the following way. A circle is described with centre A, and radius A B. Its point of intersection F with the pitch circle of the driven gear is joined to A. The line intersects the pitch circle of the driving gear at the required point D, as can easily be proved.

The distance ρ_0 = B D can be obtained from the triangle C′ B D, in which the angle B C′ D $= \frac{\pi}{2} + \frac{\alpha_0}{2}$, and the angle C′ B D $= \phi_0 = \frac{\pi}{4} - \frac{3\,\alpha_0}{4}$. Thus, the third angle C′ D B $= \frac{\pi}{4} + \frac{\alpha_0}{4}$. By the sine rule,

$$\rho_0 : r_2 = \sin\left(\frac{\pi}{2} + \frac{\alpha_0}{2}\right) : \sin\left(\frac{\pi}{4} + \frac{\alpha_0}{4}\right) = 2\cos\left(\frac{\pi}{4} + \frac{\alpha_0}{4}\right),$$

whence

$$\rho_0 = 2\,r_2\cos\left(\frac{\pi}{4} + \frac{\alpha_0}{4}\right),$$

or

$$\rho_0 = 2\,a\,\frac{\mu}{1 + \mu}\cos\left(\frac{\pi}{4} + \frac{\alpha_0}{4}\right). \quad . \quad (27)$$

If the driven gear has n equally-spaced locking shoes, one partial movement occupies the angle $\frac{2\,\pi}{n}$. During an angle of rotation α_0 of the driving gear, the driven gear is accelerated and rotated through the angle β_0. During another angle of rotation α_0 of the driving gear, the driven gear is retarded and rotated through the same angle β_0. The difference $\left(\frac{2\,\pi}{n} - 2\,\beta_0\right)$ is the angle through which the driven gear rotates with constant angular velocity and the driving gear rotates in that period through the angle $\mu\left(\frac{2\,\pi}{n} - 2\,\beta_0\right)$.

One partial movement of the driven gear, therefore, requires a rotation $2\,\alpha_0 + \mu\left(\frac{2\,\pi}{n} - 2\,\beta_0\right)$ of the driving gear, and the gear ratio is

$$\epsilon = \left[2\,\alpha_0 + \mu\left(\frac{2\,\pi}{n} - 2\,\beta_0\right)\right] \div \frac{2\,\pi}{n},$$

or, by (21) and (23),

$$\epsilon = \mu + n\,\frac{4 + 3\,\mu}{\pi}\sin^{-1}\frac{\mu}{2\,(1 + \mu)} - \frac{n\,\mu}{2}. \quad (28)$$

When $n = 1$, a particular case of frequent occurrence,

$$\epsilon_1 = \frac{\mu}{2} + \frac{4 + 3\,\mu}{n}\sin^{-1}\frac{\mu}{2\,(1 + \mu)}. \quad . \quad (29)$$

As in the case of Geneva mechanisms, ε and μ are not identical, ε being always the larger. Either ε or μ can be chosen arbitrarily, within certain limits. To find these limits, the value ε is best considered first. The upper limit of ε is reached when the duration of the uniform motion is increased till the standstill becomes zero. In this case,

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

and

$$\epsilon = 2\pi \div \frac{2\pi}{n} = n,$$

so that

$$\epsilon_{max.} = n. \quad . \quad . \quad . \quad (30)$$

The value of μ corresponding to the maximum of ϵ is obtained from (28) and (30), which give

$$\frac{4 + 3\mu}{\pi\mu} \sin^{-1} \frac{\mu}{2(1+\mu)} - \frac{1}{\mu} = \frac{n-2}{2n}. \quad (31)$$

The lower limit of ϵ corresponds to the smallest possible angle during which the driven gear rotates with constant velocity. That period cannot be eliminated altogether. In Fig. 31, CD is the position of the slot at the commencement of motion, and C′D′ is its position when the driven gear reaches the full angular velocity. That velocity must be maintained at least until the accelerating roller leaves the slot at D″, when the slot occupies the position C″D″.

The driving gear rotates, from the position D to D″ of the driving roller through the angle $2\alpha_0$, and the retardation requires at least another rotation α_0, so that the condition for the minimum of ϵ is

$$\epsilon = 3\alpha_0 \div \frac{2\pi}{n} = \frac{3n\alpha_0}{\pi\ 2} = \frac{3n}{\pi} \sin^{-1} \frac{\mu}{2(1+\mu)}. \quad (32)$$

By combining (28) and (32), the condition for the minimum of μ is given by

$$\frac{1 + 3\mu}{\pi\mu} \sin^{-1} \frac{\mu}{2(1+\mu)} = \frac{n-2}{2n}. \quad . \quad (33)$$

By combining (32) and (33), it is found that

$$\epsilon_{min.} = \frac{3(n-2)\,\mu_{min.}}{2(1 + 3\mu_{min.})}. \quad . \quad . \quad 34)$$

This relation is more convenient than (32), as it does not contain the inverse sine-function. By analogy, the condition for values of μ greater than the minimum is

$$\frac{1 + 3\mu}{\pi\mu} \sin^{-1} \frac{\mu}{2(1+\mu)} > \frac{n-2}{2n}.$$

For $\mu = 0$, this inequality becomes

$$\frac{1}{2\pi} > \frac{n-2}{2n}, \quad \text{or} \quad n < \frac{2\pi}{\pi - 1} \simeq 2\cdot93.$$

Thus, for $n = 1$ or 2, μ can be as small as desired, and even zero. Star-wheel mechanisms, with $\mu = 0$, are shown in Figs. 33 and 34, opposite.

To find the extreme values of μ for a given number of stations, the transcendental equations (31) and (33) must be solved. Table IV, herewith, contains

TABLE IV.—*Extreme Values for External Star-Wheel Mechanisms.*

n.	$\epsilon_{max.}$	$\mu_{max.}$	$\epsilon_{min.}$	$\mu_{min.}$	$m_{max.}$
1	1	0·9388	0	0	∞
2	2	1·8406	0	0	∞
3	3	2·7336	0·0337	0·0241	88
4	4	3·6233	0·5419	0·3943	7
5	5	4·5114	1·0467	0·7696	4
6	6	5·3983	1·5486	1·1483	3
7	7	6·2840	2·0518	1·5280	3
8	8	7·1709	2·5482	1·9092	3
9	9	8·0569	3·0555	2·2911	2
10	10	8·9430	3·5565	2·6731	2

TABLE VA.—*Values of μ in Terms of n and ϵ for External Star-Wheel Mechanims.*

ϵ \ n	1	2	3	4
[illegible]	0·11152	0·10043	0·09121	
[illegible]	0·12767	0·11512	0·10464	
[illegible]	0·14930	0·13483	0·12268	
[illegible]	0·17970	0·16264	0·14821	
[illegible]	0·2256	0·2048	0·18706	
[illegible]	0·3027	0·2762	0·2532	
[illegible]	0·3416	0·3124	0·2869	
[illegible]	0·3650	0·3343	0·3073	
[illegible]	0·4591	0·4226	0·3901	
[illegible]	0·5540	0·5122	0·4747	0·4407
[illegible]	0·5778	0·5350	0·4962	0·4611
[illegible]	0·6176	0·5728	0·5322	0·4952
[illegible]	0·6975	0·6491	0·6047	0·5641
[illegible]	0·7455	0·6951	0·6487	0·6060
[illegible]	0·7776	0·7259	0·6782	0·6341
1	0·9388	0·8813	0·8275	0·7773

the solutions for the most usual numbers of stations. In the case of four stations, for instance, the maximum value of ε is 4, and the corresponding value of μ is 3·623 (Fig. 27). The minimum value of ε is 0·5419, and the corresponding value of $\mu = 0·3943$ (Fig. 28). The values of μ and ε increase as the number of stations increases. Figs. 35 and 36,

MECHANISMS FOR INTERMITTENT MOTION.

TABLE VB.—VALUES OF μ IN TERMS OF n AND ϵ FOR EXTERNAL STAR-WHEEL MECHANISMS.

ϵ \ n	2	3	4	5	6	7	8	9	10
1·5	1·3567	1·2892	1·2248	1·1633					
2·0	1·8406	1·7641	1·6901	1·6185	1·5484				
2·5		2·2466	2·1654	2·0863	2·0090	1·9334			
3·0		2·7336	2·6477	2·5633	2·4800	2·3984	2·3185		
3·5			3·1341	3·0470	2·9577	2·8715	2·7866	2·7034	
4·0			3·6233	3·5317	3·4392	3·3504	3·2620	3·1741	3·0878
4·5				4·0200	3·9267	3·8342	3·7418	3·6513	3·5609
5·0				4·5114	4·4150	4·3203	4·2261	4·1329	4·0400
6·0					5·3983	5·2994	5·2009	5·1000	5·0069
7·0						6·2840	6·1837	6·0834	5·9850
8·0							7·1709	7·0675	6·9663
9·0								8·0569	7·9520
10·0									8·9430

TABLE VI.—EXTERNAL STAR-WHEEL MECHANISMS.

μ	α_0 deg.	α_0 min.	ϕ_0 deg.	ϕ_0 min.	β_0 deg.	β_0 min.	$\frac{r_1}{a}$	$\frac{r_2}{a}$	$\frac{s}{a}$	$\frac{\rho_0}{a}$	$\left(\frac{d\beta}{d\alpha}\right)_0$	$\left(\frac{d^2\beta}{d\alpha^2}\right)_{\alpha_0}$	$\alpha_{max.}$ deg.	$\alpha_{max.}$ min.	$\left(\frac{d^2\beta}{d\alpha^2}\right)_{max.}$
0·00	0	0	45	0	32	42	1	0	0	0	∞	∞	0	0	∞
0·02	1	7	44	9	32	9	0·9804	0·01961	0·01922	0·02759	50·00	2,575	0	38	3,338
0·04	2	12	43	21	31	36	0·9615	0·03846	0·03698	0·05387	25·00	662·6	1	16	834·8
0·06	3	15	42	34	31	5	0·9434	0·05660	0·05340	0·07891	16·67	302·9	1	54	382·5
0·08	4	15	41	49	30	34	0·9259	0·07407	0·06859	0·10280	12·50	175·1	2	32	219·1
0·10	5	13	41	6	30	5	0·9091	0·09091	0·08264	0·12561	10·00	115·1	3	9	142·5
0·12	6	9	40	24	29	36	0·8929	0·10714	0·09566	0·14741	8·33	82·06	3	45	101·3
0·14	7	2	39	43	29	9	0·8772	0·12281	0·10773	0·16827	7·14	61·85	4	20	75·65
0·16	7	55	39	4	28	42	0·8621	0·13793	0·11891	0·18822	6·25	48·55	4	54	58·93
0·18	8	45	38	27	28	17	0·8475	0·15254	0·12927	0·2074	5·56	39·31	5	28	47·41
0·20	9	34	37	50	27	52	0·8333	0·16667	0·13889	0·2257	5·00	32·61	6	2	39·10
0·22	10	21	37	14	27	27	0·8197	0·18033	0·14781	0·2432	4·54	27·59	6	35	32·86
0·24	11	6	36	40	27	4	0·8065	0·19355	0·15609	0·2601	4·17	23·72	7	7	28·06
0·26	11	51	36	7	26	41	0·7937	0·2063	0·16377	0·2764	3·85	20·67	7	39	24·32
0·28	12	34	35	35	26	19	0·7813	0·2187	0·17090	0·2920	3·57	18·22	8	10	21·32
0·30	13	15	35	4	25	57	0·7692	0·2308	0·17752	0·3070	3·33	16·23	8	41	18·87
0·32	13	55	34	33	25	36	0·7576	0·2424	0·18793	0·3214	3·13	14·56	9	11	16·85
0·34	14	35	34	4	25	16	0·7463	0·2537	0·18936	0·3353	2·94	13·17	9	41	15·16
0·36	15	13	33	36	24	56	0·7353	0·2647	0·19463	0·3487	2·78	11·99	10	10	13·74
0·38	15	50	33	8	24	37	0·7246	0·2754	0·19954	0·3616	2·63	10·98	10	39	12·52
0·40	16	26	32	41	24	18	0·7143	0·2857	0·2041	0·3740	2·50	10·10	11	8	11·47
0·42	17	1	32	14	23	59	0·7042	0·2958	0·2083	0·3861	2·38	9·343	11	36	10·57
0·44	17	35	31	49	23	41	0·6944	0·3056	0·2122	0·3978	2·27	8·676	12	4	9·767
0·46	18	8	31	24	23	24	0·6849	0·3151	0·2158	0·4090	2·17	8·088	12	31	9·069
0·48	18	48	31	0	23	7	0·6757	0·3243	0·2191	0·4198	2·08	7·565	12	58	8·450
0·50	19	11	30	36	22	50	0·6667	0·3333	0·2222	0·4303	2·00	7·099	13	25	7·900
0·52	19	42	30	13	22	34	0·6579	0·3421	0·2251	0·4405	1·92	6·681	13	52	7·409
0·54	20	12	29	51	22	19	0·6494	0·3506	0·2277	0·4504	1·85	6·305	14	18	6·966
0·56	20	41	29	29	22	3	0·6410	0·3590	0·2301	0·4599	1·79	5·964	14	43	6·567
0·58	21	9	29	8	21	48	0·6329	0·3671	0·2323	0·4691	1·72	5·655	15	8	6·207
0·60	21	37	28	47	21	33	0·6250	0·3750	0·2344	0·4780	1·67	5·373	15	33	5·879
0·62	22	4	28	27	21	19	0·6173	0·3827	0·2362	0·4867	1·61	5·115	15	57	5·580
0·64	22	30	28	7	21	5	0·6098	0·3902	0·2380	0·4951	1·56	4·879	16	21	5·306
0·66	22	56	27	48	20	52	0·6024	0·3976	0·2395	0·5033	1·52	4·662	16	45	5·055
0·68	23	21	27	29	20	38	0·5952	0·4048	0·2409	0·5113	1·47	4·461	17	9	4·824
0·70	23	46	27	11	20	25	0·5882	0·4118	0·2422	0·5190	1·43	4·275	17	33	4·611
0·72	24	10	26	53	20	12	0·5814	0·4186	0·2434	0·5265	1·39	4·103	17	56	4·414
0·74	24	33	26	35	19	59	0·5747	0·4253	0·2444	0·5337	1·35	3·943	18	19	4·231
0·76	24	56	26	18	19	47	0·5682	0·4318	0·2453	0·5407	1·32	3·794	18	42	4·062
0·78	25	19	26	1	19	35	0·5618	0·4382	0·2462	0·5476	1·28	3·656	19	4	3·904
0·80	25	41	25	44	19	23	0·5556	0·4444	0·2469	0·5543	1·25	3·526	19	26	3·757
0·82	26	2	25	28	19	11	0·5495	0·4505	0·2476	0·5608	1·22	3·404	19	48	3·619
0·84	26	23	25	12	19	0	0·5435	0·4565	0·2481	0·5671	1·19	3·290	20	9	3·491
0·86	26	44	24	57	18	49	0·5376	0·4624	0·2486	0·5733	1·16	3·182	20	30	3·370
0·88	27	4	24	42	18	38	0·5319	0·4681	0·2490	0·5794	1·14	3·081	20	52	3·256
0·90	27	24	24	27	18	28	0·5263	0·4737	0·2493	0·5852	1·11	2·986	21	13	3·149
0·92	27	43	24	12	18	17	0·5208	0·4792	0·2496	0·5909	1·09	2·896	21	34	3·049
0·94	28	2	23	58	18	6	0·5155	0·4845	0·2498	0·5964	1·06	2·811	21	54	2·954
0·96	28	21	23	44	17	56	0·5102	0·4898	0·2499	0·6019	1·04	2·730	22	14	2·864
0·98	28	39	23	30	17	46	0·5051	0·4949	0·2500	0·6071	1·02	2·654	22	34	2·779
1·00	28	57	23	17	17	37	0·5000	0·5000	0·2500	0·6123	1·00	2·582	22	54	2·699
1·1	30	22	22	14	16	51	0·4762	0·5238	0·2494	0·6364	0·909	2·270	24	29	2·355
1·2	31	39	21	16	16	9	0·4545	0·5455	0·2479	0·6578	0·833	2·021	26	2	2·084
1·3	32	50	20	23	15	30	0·4348	0·5625	0·2457	0·6770	0·769	1·820	27	30	1·866
1·4	33	55	19	34	14	54	0·4167	0·5833	0·2431	0·6943	0·714	1·654	28	53	1·688
1·5	34	55	18	49	14	21	0·4000	0·6000	0·2400	0·7099	0·667	1·514	30	12	1·540
1·6	35	50	18	7	13	50	0·3846	0·6154	0·2367	0·7241	0·625	1·395	31	28	1·414
1·7	36	42	17	29	13	22	0·3704	0·6296	0·2332	0·7371	0·588	1·294	32	42	1·308
1·8	37	30	16	53	12	55	0·3571	0·6429	0·2296	0·7489	0·556	1·206	33	52	1·216
1·9	38	15	16	19	12	30	0·3448	0·6552	0·2259	0·7598	0·526	1·129	35	0	1·136
2·0	38	57	15	48	12	7	0·3333	0·6667	0·2222	0·7698	0·500	1·061	36	5	1·065
2·2	40	13	14	50	11	24	0·3125	0·6875	0·2148	0·7875	0·455	0·9461	38	8	0·9481
2·4	41	20	14	0	10	47	0·2941	0·7059	0·2076	0·8030	0·417	0·8536	40	3	0·8542
2·6	42	20	13	15	10	13	0·2778	0·7222	0·2006	0·8164	0·385	0·7773	41	50	0·7774
2·8	43	14	12	34	9	42	0·2632	0·7368	0·19391	0·8281	0·357	0·7134			
3·0	44	3	11	58	9	15	0·2500	0·7500	0·18750	0·8386	0·333	0·6592			
3·2	44	47	11	25	8	50	0·2381	0·7619	0·18140	0·8478	0·313	0·6126			
3·4	45	27	10	55	8	27	0·2273	0·7727	0·17562	0·8561	0·294	0·5721			
3·6	46	4	10	27	8	6	0·2174	0·7826	0·17013	0·8635	0·278	0·5366			
3·8	46	38	10	2	7	47	0·2083	0·7917	0·16493	0·8702	0·263	0·5052			
4·0	47	9	9	38	7	29	0·2000	0·8000	0·16000	0·8764	0·250	0·4774			
4·2	47	38	9	16	7	12	0·19231	0·8077	0·15533	0·8819	0·238	0·4524			
4·4	48	5	8	56	6	57	0·18519	0·8148	0·15089	0·8870	0·227	0·4298			
4·6	48	30	8	37	6	42	0·17857	0·8214	0·14668	0·8917	0·217	0·4094			
4·8	48	53	8	20	6	29	0·17241	0·8276	0·14269	0·8961	0·208	0·3909			
5·0	49	15	8	4	6	17	0·16667	0·8333	0·13889	0·9001	0·200	0·3740			
5·2	49	35	7	49	6	5	0·16129	0·8387	0·13528	0·9038	0·192	0·3585			
5·4	49	54	7	34	5	54	0·15625	0·8437	0·13183	0·9072	0·185	0·3442			
5·6	50	12	7	21	5	44	0·15152	0·8485	0·12856	0·9105	0·179	0·3310			
5·8	50	29	7	8	5	34	0·14706	0·8529	0·12543	0·9135	0·172	0·3188			
6·0	50	45	6	56	5	24	0·14286	0·8571	0·12245	0·9162	0·167	0·3075			
6·2	51	0	6	45	5	16	0·13889	0·8611	0·12239	0·9190	0·161	0·2969			
6·4	51	15	6	34	5	8	0·13514	0·8649	0·11688	0·9215	0·156	0·2870			
6·6	51	28	6	24	5	0	0·13158	0·8684	0·11427	0·9238	0·152	0·2778			
6·8	51	41	6	14	4	52	0·12821	0·8718	0·11177	0·9260	0·147	0·2691			
7·0	51	53	6	5	4	45	0·12500	0·8750	0·10938	0·9280	0·143	0·2610			
7·2	52	5	5	56	4	38	0·12195	0·8781	0·10708	0·9300	0·139	0·2533			
7·4	52	16	5	48	4	32	0·11905	0·8809	0·10487	0·9319	0·135	0·2461			
7·6	52	27	5	40	4	26	0·11628	0·8837	0·10276	0·9337	0·132	0·2393			
7·8	52	37	5	32	4	20	0·11364	0·8864	0·10072	0·9353	0·128	0·2329			
8·0	52	47	5	25	4	15	0·11111	0·8889	0·09877	0·9370	0·125	0·2268			
8·2	52	56	5	18	4	9	0·10870	0·8913	0·09688	0·9385	0·122	0·2210			
8·4	53	5	5	11	4	4	0·10638	0·8936	0·09507	0·9400	0·119	0·2154			
8·6	53	13	5	5	3	59	0·10417	0·8958	0·09332	0·9413	0·116	0·2102			
8·8	53	21	4	59	3	54	0·10204	0·8980	0·09163	0·9427	0·114	0·2052			
∞	0	0	0	0	0	0	0	1·0	0	1·0	0	0			

MECHANISMS FOR INTERMITTENT MOTION.

Fig. 31.

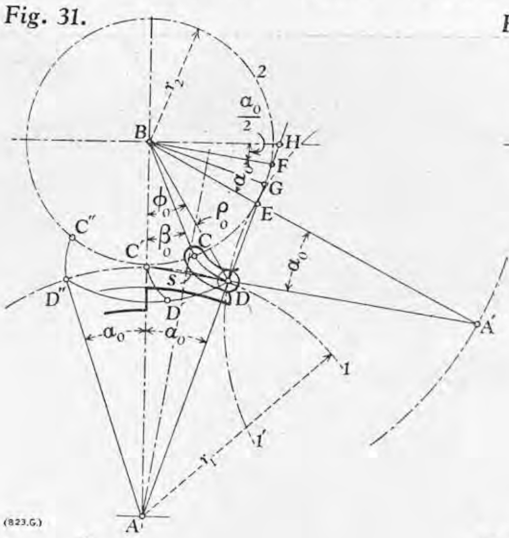


Fig. 32.

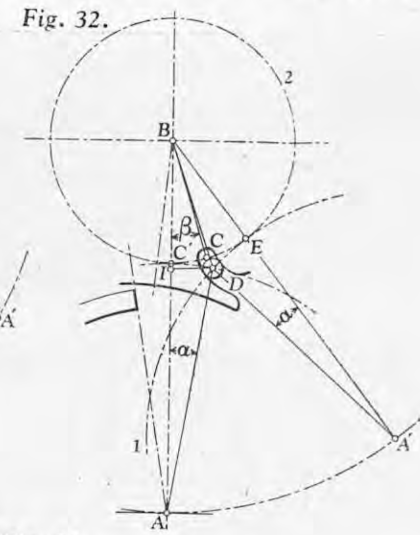


Fig. 33.

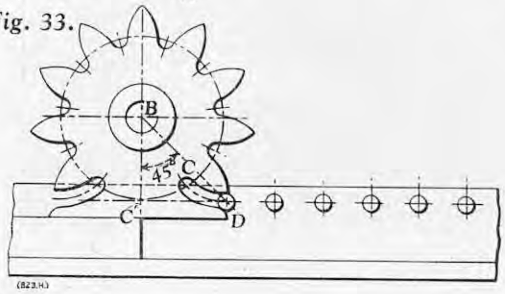


Fig. 34.

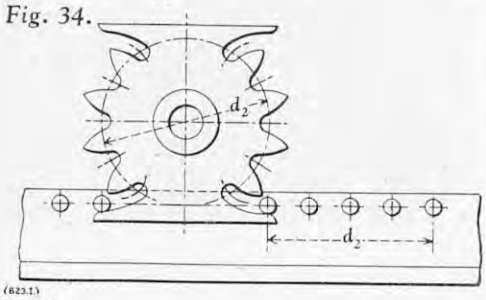


Fig. 35.

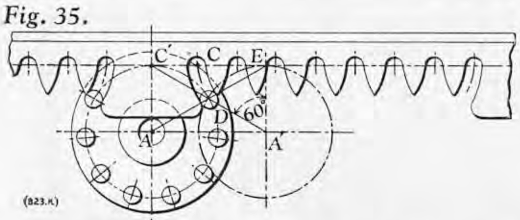
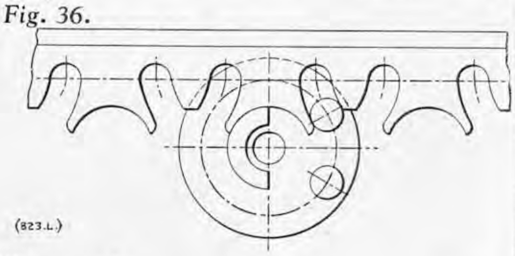


Fig. 36.



above, show mechanisms where n, μ, and ϵ, are infinite. The rack-like gears in Figs. 33 and 34 are the driving members, but they are the driven ones in Figs. 35 and 36.

Although investigations of geometrical and kinematic properties are best based on the ratio μ of the pitch radii, the movement of an intermittently rotating shaft is usually specified by the ratio ϵ of the angles of rotation of the driving and driven gears. In such investigations, μ must be determined by (28), but Table V, opposite, subdivided as V_A and V_B, makes the solution of the transcendental equations unnecessary as it contains the ratios ϵ likely to be met in practice. The relation between ϵ and μ, expressed by (28), is such that ϵ is not a round number if a round value is chosen for μ, and vice versa. Round values of μ are advantageous because the layout of the elements for imparting the uniform motion is then simplified. In the many cases where a slight departure from the required value of ϵ is unobjectionable, it is advisable to adopt a round or convenient fractional value for μ, which is very near to the required value.

As an example, suppose that gears are to be designed for imparting one full revolution to the driven shaft during one-third of a revolution of the driving shaft. The ratio ϵ is $\frac{1}{3}$, and n is 1. Table V indicates that $\mu = 0{\cdot}3027$. It will be found from a slide rule, or by means of a table of decimal equivalents of fractions, that the ratio $\frac{23}{76} = 0{\cdot}30263$ approximates closely to the requirements.

The duration of motion, expressed as a fraction of one revolution of the driving gear, is

$$\nu = \frac{1}{2\,\pi}\left[2\,\alpha_0 + \mu\left(\frac{2\,\pi}{n} - 2\,\beta_0\right)\right].$$

and since

$$\epsilon = \frac{n}{2\,\pi}\left[\pi 2\,\alpha_0 + \mu\left(\frac{2\,\pi}{n} - 2\,\beta_0\right)\right],$$

it follows that

$$\nu = \frac{\epsilon}{n}. \quad . \quad . \quad . \quad (35)$$

When $n = 1$,

$$\nu_1 = \epsilon_1. \quad . \quad . \quad . \quad (36)$$

The extreme values of δ are

$$\nu_{\text{max.}} = \frac{\epsilon_{\text{max.}}}{n}. \quad . \quad . \quad . \quad (37)$$

$$\nu_{\text{min.}} = \frac{\epsilon_{\text{min.}}}{n}. \quad . \quad . \quad . \quad (38)$$

It has been found that the motion occupies the angle $2\,\alpha_0 + \mu\left(\frac{2\,\pi}{n} - 2\,\beta_0\right)$ of the driving gear. The driven gear, therefore, must be locked during the remaining part of one revolution, that is, during the angle

$$\gamma = 2\,\pi - \left[2\,\alpha_0 + \mu\left(\frac{2\,\pi}{n} - 2\,\beta_0\right)\right]$$

$$= 2\left[\pi\left(1 - \frac{\mu}{n}\right) - \alpha_0 + \mu\,\beta_0\right]. \quad (39)$$

When $n = 1$,

$$\gamma_1 = 2\,[\pi\,(1 - \mu) - \alpha_0 + \mu\,\beta_0]. \quad . \quad (40)$$

The angles γ and γ_1 are also the angles included by the locking drum. As in the case of Geneva mechanisms, the radius of the locking drum can be chosen arbitrarily.

If μ has been determined, as in the example given, and the distance between centres has been chosen, the design data α_0, β_0, ϕ_0, r_1, r_2, s, and ρ_0, are either evaluated by means of the relevant formulæ or taken from Table VI, opposite, which contains these values in narrow steps of μ; intermediate values can be obtained by linear interpolation. All these design data are independent of the number of stations n.

The gear-ratio ε, the proportion of motion in one revolution of the driving shaft ν, and the angle over which the locking drum extends γ, depend on the number of stations, and may be evaluated from (28), (35), and (39).

As a further example, the design of a star wheel mechanism, which imparts a quarter revolution to the driven gear during a quarter revolution of the driving gear, will be considered. The distance between centres a is assumed to be 8 in. A mechanism of the required type is shown in Fig. 26. Table V indicates that, for $\varepsilon = 1$ and $n = 4$, $\mu = 0{\cdot}7773$. A replacement of μ by $\frac{7}{9} = 0{\cdot}7778$ is unobjectionable.

By (20), $\sin\frac{\alpha_0}{2} = 0{\cdot}21875$, hence $\alpha_0 = 25$ deg. 16 min.

By (22), $\phi_0 = 45$ deg. $- \frac{3}{4}\,\alpha_0 = 26$ deg. 3 min.

By (23), $\beta_0 = 90$ deg. $- \left(\frac{39}{7} \times 12{\cdot}633\right)$ deg. $=$ 19 deg. 37 min.

By (24), $r_1 = 4{\cdot}5$ in.

By (25), $r_2 = 3{\cdot}5$ in.

By (26), $s = 1{\cdot}969$ in.

By (27), $\rho_0 = 7 \cos 51$ deg. 19 min. $= 4{\cdot}375$ in.

These values can also be obtained from Table VI by interpolation.

By (28), $\varepsilon = 1{\cdot}002$.

The discrepancy between the calculated and specified values of ϵ is due to the modification of μ, and means that the motion occupies 90 deg. 1 min. instead of 90 deg.

By (35), $\nu = \frac{1}{4}$ (disregarding the slight difference between ε and 1).

By (39), $\gamma = 269$ deg. 59 min., which differs from the correct angle of 270 deg. by the same small amount as the angle of motion above. The angle can be made exactly equal to 270 deg.

Table VI does not fully determine the relevant dimensions in the cases $\mu = 0$, and $\mu = \infty$. When $\mu = 0$, the centre line of the slots is a part of an involute. The angle α_0 (C′AD in Fig. 31) is zero. The distance C′D, in Fig. 33, can easily be determined, however, since the angle C′BD is 45 deg. Thus, C′D is equal to the radius r_2 of the driven gear. The same result is also obtained by the graphical determination of s = C′D. Readers who are surprised at the value of the angle β_0, for $\mu = 0$, should remember that

$$\beta_0 = \frac{\pi}{2} - \frac{\alpha_0}{2}\left(\frac{2 + 3\,\mu}{\mu}\right) = \frac{\pi}{2} - \frac{\alpha_0}{2}\left[1 + \frac{2\,(1 + \mu)}{\mu}\right]$$

$$= \frac{\pi}{2} - \frac{\alpha_0}{2} - \frac{\frac{\alpha_0}{2}}{\sin\frac{\alpha_0}{2}},$$

which assumes, for $\alpha_0 = 0$, the value $\left(\frac{\pi}{2} - 1\right)$ radians, or 32 deg. 42 min.

When $\mu = 0$, the angle γ of the locking drum is zero, the locking shoe is flat, and its length can be chosen to suit requirements. It is, therefore, also possible to omit the means for locking altogether, and allow the accelerating roller to begin acting at the moment when the retarding roller is leaving its slot. Such a case is shown in Fig. 34. Designing and machining a gear as shown in Fig. 34 ($\mu = 0$, $n = 2$) is simplified by the fact that the distance between the centres of the first and last rollers of each group is equal to the pitch diameter of the driven gear.

It has already been found that μ can assume the value 0 only if n is 1 or 2. Figs. 33 and 34, therefore, represent the only possible types of gear, if modifications in the duration of locking are left out of consideration.

When $\mu = \infty$, the centre line of the slots is a part of a cycloid. The angle β_0 (C′BD in Fig. 31) is zero, and the distance C′C in Fig. 35 is $r_1\left(\sqrt{3} - \frac{\pi}{3}\right)$ $= 0{\cdot}68485\ r_1$, where r_1 is the pitch radius of the driving gear. This result can easily be verified, since C′E $= r_1\sqrt{3}$, and CE $= \frac{r_1\,\pi}{3}$. The mechanism of Fig. 35 is representative of the extreme case without standstills. Fig. 36 represents the other extreme where the period of uniform motion is reduced to a minimum, that is to $\alpha_0 = 60$ deg., and the motion and standstill each occupy 180 deg.

(To be continued.)

LOW TEMPERATURE PHYSICS: CORRIGENDUM.—We have been advised by the Pergamon Press, Ltd., 2, 3 and 5, Studio-place, Kinnerton-street, Knightsbridge, London, S.W.1, that, owing to unforeseen circumstances, it has become necessary to raise the price of their recently published book, "Low Temperature Physics," by F. E. Simon and others, from 15s., as given on page 732 *ante*, to 21s.

WASTE-HEAT RECOVERY PLANT.

In the present era of fuel scarcities and rising costs, methods of economising in the consumption of fuel are assuming ever greater importance. The world's fuel resources are far from being exhausted and the discovery of new sources of power is always a possibility, but the fact remains that the available energy in nature has been consumed in a prodigal fashion ever since the industrial revolution. By the ubiquitous use of the internal-combustion engine alone, enormous quantities of energy are squandered annually as heat in exhaust gases and engine-cooling systems. Much of the energy, it is true, is in the form of low-grade heat and is, therefore, difficult to recover economically but, in certain cases, it can be extracted without prohibitive cost and used to advantage.

An interesting example of a modern waste-heat recovery system in which the exhaust heat from a Diesel engine is used for space heating is provided by an installation at the factory of Messrs. R. Pasold and Company, Limited, at Langley, Buckinghamshire. The factory itself is a modern one and produces a well-known brand of knitwear, the plant and machinery employed for the purpose being in themselves of considerable interest. Within the past year the factory has been extended by the erection of a building which has provided some 24,000 sq. ft. of additional space for the knitting department, for fabric and yarn storage and for an engineering workshop. Part of the interior of the new knitting department is illustrated in Fig. 1, on this page. A boiler house and power house have also been built. The factory buildings have reinforced-concrete barrel-type roofs, so that roof trusses and other obstructions liable to harbour dust are absent.

The boiler house contains two Lancashire boilers supplied by Messrs. Danks of Netherton, Limited, Dudley. These provide steam and hot water for processing and also for heating the older part of the factory which is equipped with a radiator system. The power house contains a Diesel engine driving a generator which supplies the factory with electricity alternative or additional to that available from the supply mains. Besides this, the waste heat from the Diesel engine is a source of space-heating for the new buildings. The engine and generator are shown in Fig. 2.

The Diesel engine is a naturally-aspirated Mirrlees J.8 engine having eight cylinders and capable of delivering 420 brake horse-power at 600 r.p.m. on the standard 12-hour rating. The rated fuel consumption at full load is 0·365 lb. per brake horse-power per hour. The engine is directly coupled to a Brush alternator which generates three-phase, 50 cycles per second current at 400 volts, the maximum output being 325 kVA at 0·9 power factor. There is an automatic voltage regulator of the carbon-pile type.

The waste-heat recovery plant is housed in the adjoining boiler house and is illustrated in Fig. 4, opposite, the arrangement of the plant and the space-heating installation being shown diagrammatically in Fig. 3. The principal parts of the installation, apart from the engine *a*, are the waste-heat boiler *b*, the water cooler *c* and the lubricating-oil cooler *d*, all supplied by Messrs. Mirrlees, Bickerton and Day, Limited, Hazel-grove, Stockport, and the heat-exchanger *e* and water-circulating pumps *f* and *g* supplied by Messrs. Sulzer Brothers (London), Limited, 31, Bedford-square, London, W.C.1, who also designed the system.

The Diesel engine and the Spanner "Swirlyflow" waste-heat boiler form a heat source in which, under normal operating conditions, the temperature of the engine cooling-water is raised by 20 deg. F. The boiler alone is capable of recovering 304,000 B.Th.U. of heat per hour from the exhaust gases of the engine when the latter is running at 75 per cent. of its full load. Under maximum-temperature conditions, the water entering the engine at the circulating pump *h* is at 140 deg. F. and that leaving the waste-heat boiler at the point denoted T_2 is at 160 deg. F. The corresponding minimum values are 90 deg. F. and 110 deg. F. The exhaust gases from the engine enter the boiler at the top, through the pipe *i*, pass down through a nest of tubes to a header-chest at the base of the boiler and return through a single pipe having an extension which forms the exhaust to atmosphere. The water from the engine cooling jacket enters the boiler at a point just above the bottom tube-plate, flows round the tubes, and out at the top of the boiler.

When space-heating of the factory buildings is not required, although the engine is in use, the valves *k* and *l*, in Fig. 3, are closed and the water leaving the boiler passes through the swing-check valve *m* to the water cooler *c*, from which it returns to the engine. The cooler is of the Spanner type and, at normal rates of circulation, is capable of cooling 4,400 gallons of engine jacket-water from 160 deg. F. to 140 deg. F. during the passage of 5,000 gallons of cooling water at 60 deg. F. The cooling water is drawn from the storage and feed tanks *n* and *o* and is discharged to the drain. Its rate of flow through the cooler is governed by the automatic valve *p*, the setting of which is determined by the temperature T_3 of the engine-cooling water at the exit from the cooler. When the space-heating system is in use, the cooler is not normally required.

The maximum allowable temperature in the space-heating tubes, which are embedded in the concrete floor of the new building, is 110 deg. F., so that, when the temperature of the water leaving the waste-heat boiler exceeds this value, it must be reduced. This is accomplished at an automatic three-way mixing valve *q*, where some of the return flow from the heating system is mixed with feed water after passing through the non-return valve *r*. The fall in temperature through the heating circuit is 20 deg. F., so that the temperature of the returning water is not higher than 90 deg. F. It will readily be appreciated that, when the heating system is turned on, the temperature of the water in the heating tubes will rise to an equilibrium value and that, when the feed water is at 160 deg. F., a smaller quantity of hot water will be admitted to the system at the valve *q*, and a greater quantity of the return flow, than would be the case were the temperature lower. The lower limit is reached when the feed water is at 110 deg. F. There is then no return flow into the system at the valve *q*, the whole of the returning water, which is then at 90 deg. F., passing through the valve *l* to the engine. If for any reason, the temperature of the hot feed-water at *q* were less than 110 deg. F., another heat source, to be described later, would come into operation.

In the normal event, when the water leaving the waste-heat boiler is at a temperature higher than 110 deg. F., the return water, which is at 90 deg. F., is not sufficiently warm to be fed to the engine. This state of affairs is corrected, however, by the admixture with the return flow of part of the water leaving the waste-heat boiler. In fact, owing to the action of the automatic valve *q* as the temperature rises, the reduced flow of hot water through *q* is compensated by a greater flow of the same water through the non-return valve *m* into the return circuit, thus raising the temperature of the water fed to the engine. In any case, the volume of water passing through the engine in unit time does not depend on the quantity circulated round the space-heating system in the same period, but is governed by the water-circulating pump *h*, which is belt-driven from the engine crankshaft.

WASTE-HEAT RECOVERY FOR FACTORY HEATING.

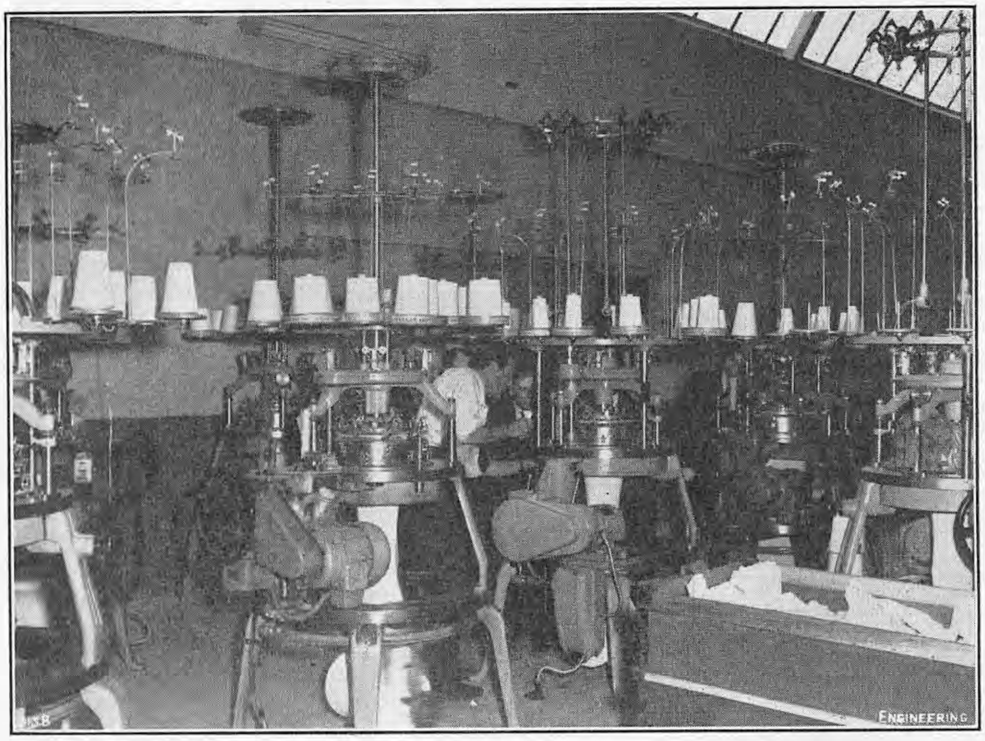


Fig. 1. Knitting Department, Heated by Waste Heat.

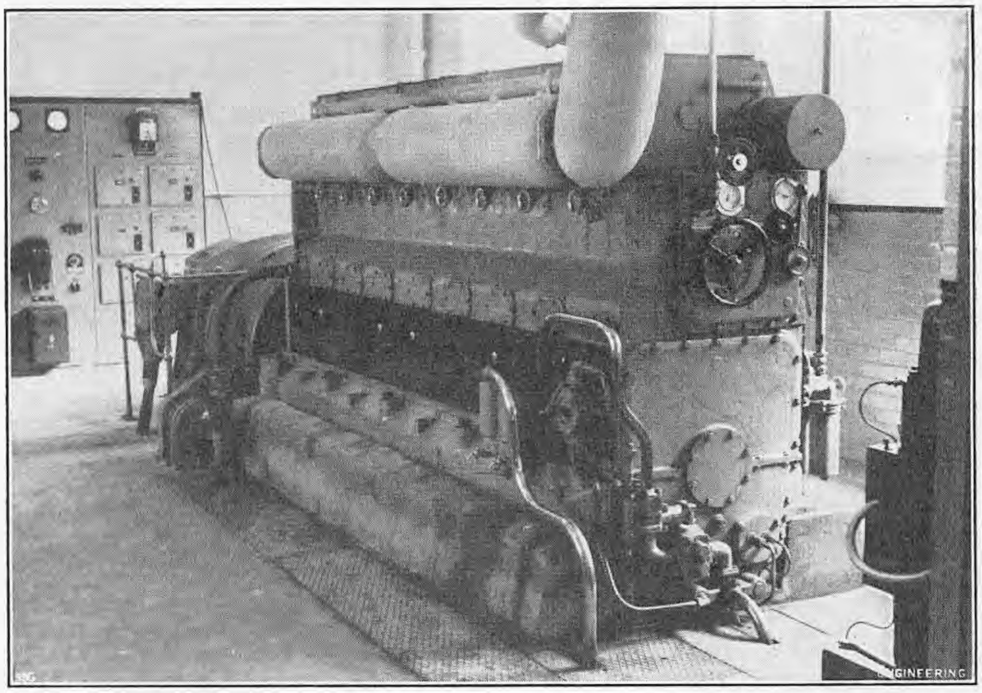
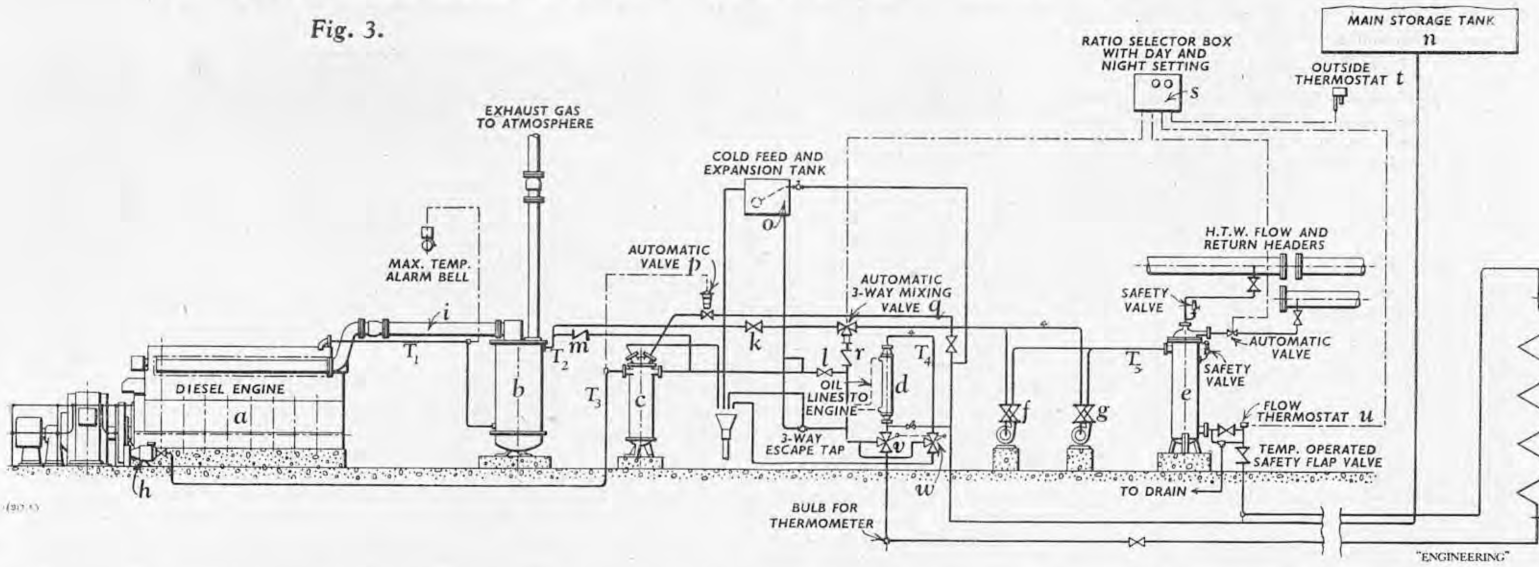


Fig. 2. Diesel Engine and Generator in Power House.

WASTE-HEAT RECOVERY PLANT AT KNITWEAR FACTORY.

Fig. 3.



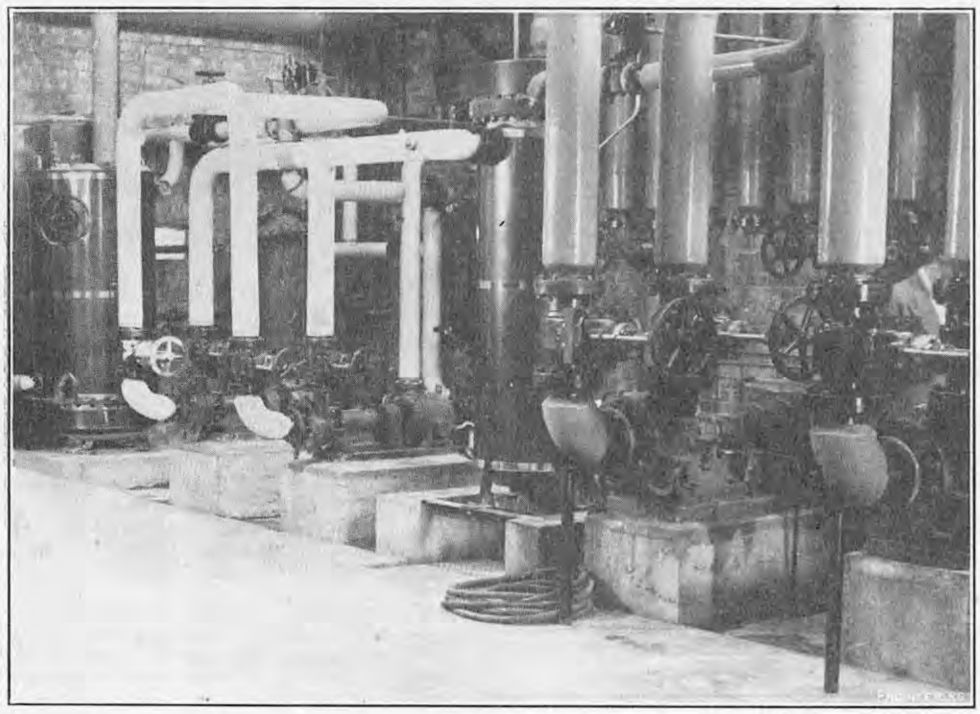


FIG. 4. WASTE-HEAT RECOVERY PLANT.

When the inlet-water temperature is too high, it is reduced in the water cooler.

The automatic valve *q* is controlled through a selector box *s* from an external thermostat *t*. The action of the latter depends on the ambient-air temperature, so that the amount of space-heating is regulated automatically in accordance with the prevailing conditions. At the minimum air-temperature for which the space-heating system was designed, namely, 30 deg. F., the output of heat from the system is 914,000 B.Th.U. per hour.

As already mentioned, the space-heating is not wholly dependent on the running of the engine; the system can function without the latter, all the heat required being supplied to the water at the heat exchanger *e*. This takes in water under pressure and at 340 deg. F. from the Lancashire boilers and is capable of a maximum heat transfer of 1,300,000 B.Th.U. per hour. Under full-load conditions in the space-heating circuit, the water returns to the boiler at 280 deg. F., approximately. At other times, the heat exchanger can supplement the heat derived from the engine when this is insufficient owing to the fact that the engine is running at light load. The quantity of boiler water passing through the heat exchanger is controlled automatically by means of a thermostat *u* at the outlet-pipe to the space-heating system. The ultimate control is an automatic valve in the hot-water intake pipe.

The water is circulated round the space-heating circuit by means of one or other of the two Sulzer pumps *f* and *g*, one pump acting as a stand-by. Each pump is rated at 3 h.p., rather less than this amount of power being required to circulate the water under the maximum flow conditions of 45,000 lb. of water per hour. As already mentioned, a floor area of approximately 24,000 sq. ft. is heated, and, for this purpose, 19,000 ft. of ¾-in. tubing are embedded in the concrete flooring. The circuit comprises a number of sections of approximately equal length, each of which is fed from a ring main and discharges into a similar main, the points of intake and discharge being located so that the water has to traverse the same total length of main in each case. The tubes forming each section are arranged in parallel lines spaced 15 in. apart, alternate pairs of ends being connected to form a continuous chain of hairpin loops. The flow through each section is controlled by two valves in series. One of these is an on-off and regulating valve by which the section may be isolated or supplied from the main, as desired. The second valve is pre-set, so that when the other is fully open in each case, an even distribution of heating throughout the building is obtained. The normal velocity of flow through the tubes is approximately 1 ft. per second.

One part of the system remains to be mentioned. This is the engine lubricating-oil cooler *d*, in Fig. 3. Normally, the oil is cooled by the return-flow water which enters the cooler through the three-way valve *v* and re-enters the circuit through the valve *w*. These valves are mechanically connected, however, and are controlled manually, there being only two positions of the control lever. When the lever is in the second position, the flow of return water to the cooler through the valve *v* is stopped and the cooler is supplied instead with water from the feed tanks, subsequently conducted to the drain through the valve *w*, which, likewise, is then closed to water in the return circuit. It is impossible therefore, at either setting of the control, for water to leak out of the space-heating circuit, although a small loss inevitably occurs at valve and pump glands. Any such loss is made up from the feed tank *o*, which is replenished through a ball valve. This tank also serves to fill up the system initially and acts as an expansion tank. Its outlet is connected to the return circuit at two neutral points in the latter. In the absence of leakage, there is no flow into or from the feed tank connections at these points. The feed tank also imposes a 14-ft. static-pressure head of water on the system.

Besides such provisions as have already been mentioned, there are a number of others, including a bell giving warning of excessive temperatures, safety valves, air vents and drainage cocks. The water temperature is measured at a number of points which are indicated by the letter T, with a suffix, in Fig. 3. The valves are displayed on an instrument board in the boiler house. Various parts of the waste-heat recovery plant may be identified in Fig. 4. The waste-heat boiler is on the extreme left and, on its right, in the background, the water cooler. The Sulzer circulating pumps are in the centre foreground with the heat exchanger on their right. Part of the high-temperature boiler-water control system is also visible. It has been estimated that the plant when operated during the four winter months will effect an annual saving in fuel costs of from 800*l*. to 1,000*l*.

FLYING DISPLAY AND EXHIBITION AT FARNBOROUGH.—The Society of British Aircraft Constructors, Ltd., 32, Savile-row, London, W.1, inform us that their flying display and exhibition at Farnborough will be open only to guests of the Society on Tuesday, Wednesday and Thursday, September 2, 3 and 4, and that a preview of the display for the Press and technicians in the industry has been arranged for the preceding Monday, September 1. The general public will be admitted on Friday, Saturday and Sunday, September 5, 6 and 7. Tickets for these days will be obtainable in advance from Auto-Parks, Ltd., 1, Maclise-road, London, W.14. (Telephone: SHEpherds Bush 5385.)

PREMIUMS FOR TECHNICAL WRITING.—In November, 1951, as reported previously in ENGINEERING (vol. 172, page 672), the Radio Industry Council intimated their intention to institute a scheme of awards to authors, in order to encourage the writing and publication of articles on technical subjects related to radio and electronics. The panel of judges appointed by the Council hope to make the first awards in respect of articles published between January 1 and June 30, 1952. The results will be announced at the National Radio Show, which is to be held at Earls Court, London, from August 26 to September 6, and cheques will be presented there to the prizewinners. An average of six premiums a year, of 25 guineas each, are offered. Authors of published articles, or editors publishing them, are invited to submit for consideration articles published during the first six months of this year. Full particulars of the competition may be obtained from the Secretary, Radio Industry Council, 59, Russell-square, London, W.C.1, to whom, also, articles submitted for consideration should be sent not later than July 7, 1952. The judges are Professor Willis Jackson, Imperial College of Science and Technology, London, and four members of the Radio Industry Council, namely, Mr. P. D. Canning, chairman of the Technical Directive Board, Mr. W. M. York, chairman of the Public Relations Committee, Mr. T. E. Goldup, a member of the Technical Directive Board, and Vice-Admiral J. W. S. Dorling, C.B., director of the Council.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

BURNBANK FOUNDRY SCHOOL, FALKIRK.—A new foundry school for apprentices in the light-castings industry was opened at Burnbank, Falkirk, on June 3, by Mr. William Rennie, chairman of Federated Foundries Ltd. Employers in the industry have given 5,000*l*. towards the project. More than 300 students have been enrolled.

DEVELOPMENTS AT GRANGEMOUTH.—An indication of the growing importance of Grangemouth as an industrial district was provided on June 3, when the local Dean of Guild Court approved plans involving an expenditure of more than 240,000*l*. This will provide for extensions to the I.C.I. factory, the installation of a processing plant for wood refuse at a sawmill, and the building of over 100 houses for incoming key workers at the new oil refinery.

FORTH-RIVER PURIFICATION BOARD.—The Department of Health for Scotland propose to establish a Forth-River Purification Board for the area comprising the rivers Avon, Carron, Forth, and Leven, together with their respective tributaries and certain other streams. This was reported to Stirlingshire Public Health Committee at Stirling on June 5, when it was decided to invite the interested local authorities to a joint discussion.

HOPES OF RAISING WRECK OF DESTROYER.—Negotiations are once again proceeding, with the Ministry of Transport, representing the French Government, with a view to having the wreck of the French destroyer Maillé Brézé raised, Lt.-Col. H. Campbell, deputy chairman, Clyde Lighthouses Trustees, stated in Glasgow on June 4. The operation would be long and difficult, he added, but it was hoped that preliminary investigations would be completed soon. The vessel sank in April, 1940, when a torpedo warhead exploded on the deck and the ship caught fire.

LOCH AWE PASSENGER VESSELS.—A new pleasure boat, Lady of Lorn, was launched on Loch Awe on June 3 to take the place of the Countess of Breadalbane which was recently transported, partly by road, for service on the Clyde. Built at Gourock in 1940 and used for a time as a private yacht, the Lady of Lorn was taken by rail to Loch Awe station, from Oban, and then hauled by two tractors along the main road at the Pass of Brander to the anchorage formerly used by the Countess of Breadalbane.

CLEVELAND AND THE NORTHERN COUNTIES.

LANDING OF AMERICAN STEEL AT MIDDLESBROUGH.—The Belgian ship Stavelot, which is bringing over most of the American steel for North of England clients, recently unloaded a cargo of 3,400 tons at Middlesbrough Docks very expeditiously, despite occasional delays. The rate of unloading averaged 300 tons per gang per shift, though work was at times hampered by the failure to bring wagons alongside the ship as quickly as they were needed.

STELLA TO CARLISLE POWER-TRANSMISSION LINE.—The Ministry of Fuel and Power has approved plans by the British Electricity Authority for the construction of 250 pylons from Stella, Co. Durham, to Carlisle, despite opposition from several quarters, especially from farmers who claimed that the pylons would damage good farming land. The pylons will be erected at intervals of 350 yards and will carry 275,000-volt lines. When a public inquiry was held into the scheme, some months ago, objectors suggested an alternative route. Despite the Ministry's decision, farmers and local authorities in the South-Tyne area, where objection to the scheme has been strong, have decided to continue to oppose the route selected for the line. Mr. R. Speir, M.P. for Hexham, is taking up the matter with the chairman of the British Electricity Authority.

WHITEHAVEN SULPHURIC-ACID AND CEMENT PLANT.—At the cutting of the first sod for a new sulphuric-acid and cement-making plant at Whitehaven, for Solway Chemicals, Ltd., it was stated that the plan to erect the plant had been mooted about 18 months ago, when sulphur supplies from the United States were restricted. The new Whitehaven plant, costing 2,000,000*l*., will be in production in about two years and will employ between 200 and 300 men. Solway Chemicals, Ltd., is a subsidiary firm of Marchon Products, Ltd., which began production at Whitehaven about 12 years ago and now has 700 employees making various chemical products. Sulphuric acid is needed for these products and when sulphur supplies from America were cut, a serious crisis arose. It was then learned that there were supplies of anhydrite, from which sulphuric acid and cement can be produced, in the vicinity, and a scheme was prepared for building a plant. The works will produce 75,000 tons of sulphuric acid annually and a similar amount of cement. Supplies of anhydrite will be obtained by drift mines from two seams which, it is estimated, will last about 50 years. Provision has been made for production at the new plant to be doubled if necessary.

ANHYDRITE MINING, CUMBERLAND.—A drift is being driven into a hillside at Long Meg, Little Salkeld, Cumberland, for the mining of anhydrite for the production of sulphuric acid. A small quantity of the mineral is already being produced, and, within a few years, output will be raised to about a quarter of a million tons per annum. The operations are being carried out on behalf of the Long Meg Plaster and Mineral Co. Ltd., a subsidiary of British Plaster Board, Ltd.

WEAR EXPORT STATISTICS.—Coal and coke shipments from the River Wear in April amounted to 278,429 tons, an increase of 8,657 tons on last year, but 44,353 tons less than in April, 1938. For the first four months of this year the total was 1,078,838 tons, an increase of 50,939 tons on 1951, but 407,290 tons below the 1938 figure. This year's shipments included 242,359 tons sent to foreign ports, or about 100,000 tons more than were dispatched last year.

LOCOMOTIVE BUILDING ON N.E. COAST.—Opening a new works sports ground at Darlington, Brigadier J. Storar, chairman of Stephenson & Hawthorn, Ltd., Darlington and Newcastle-on-Tyne, said that his firm had more locomotive orders in hand than at any other time in their history. Every year, he said, the firm ploughed back a large proportion of its profits into developments, so that they were always equipped to face the ever-increasing competition.

EXPLOSIVES STORE, HIGH CALLERTON.—Plans have been approved for the erection of an explosives store for Imperial Chemical Industries, Ltd., to hold 300 tons of explosives, at High Callerton, Northumberland. The building is being erected by Sir R. McAlpine & Sons, Newcastle-on-Tyne.

NORTH-EASTERN TRADING ESTATES.—According to recently-issued statistics, the number of men and boys employed in factories administered by the North Eastern Trading Estates, Ltd., has increased by 188 since January 5, 1952. The number of women and girls employed, on the other hand, has fallen by 566. The total number employed is about 1,136 more than was the case a year ago. Moreover, the rate of unemployment is 2·9 per cent., which is below the rate for development areas as a whole.

LANCASHIRE AND SOUTH YORKSHIRE.

THE LATE SIR SAMUEL OSBORN.—We announce with regret the death, which occurred on June 10 at his home at Grindleford, of Sir Samuel Osborn, LL.D., J.P., president of Samuel Osborn & Co., Ltd., Clyde Steel Works, Sheffield. Sir Samuel, who was in his 88th year, was the second son of the founder of the firm and entered the business in 1882, becoming successively a partner, director, the chairman, and finally president of the organisation. Besides his career in industry, he had a notable record of public service in his native city, becoming Lord Mayor of Sheffield in 1912, an office held by his father 21 years before. He was a man of wide interests and took a prominent part in schemes of education, culture, religion and the welfare of young persons. He was knighted in 1941. We hope to publish a memoir on his career in our next issue.

THE FUTURE OF THE STEEL INDUSTRY.—Referring to the proposed Iron and Steel Board which it is intended shall supplant the Iron and Steel Corporation, the Minister of Supply, Mr. Duncan Sandys, disclosed at Sheffield that one of the questions to be decided was exactly what was to be understood by the steel industry and where the line was to be drawn between the basic and the ancillary processes. Deputations and representations had been received from sections of the industry but he felt that, before arriving at any final decision concerning the Government's proposals, he should see for himself the various processes involved.

OPENCAST MINING.—The development of opencast coal mining is proceeding apace. In a recent four-week period, in Yorkshire, the total output averaged 46,054 tons a week, representing a 40 per cent. increase on the weekly average output for the previous four-week period. The Santingley site has now been worked out, but the Gillcar and Whiston sites have begun to produce coal.

OIL-REFINERY EQUIPMENT.—A second heater-charge surge tank from the works of Newton, Chambers & Co., Ltd., Thorncliffe, Sheffield, has been dispatched by road to the Llandarcy oil refinery, South Wales. It is of mild-steel welded construction, 36 ft. long, 12 ft. in diameter and weighs 20 tons.

IMPORT RESTRICTIONS.—Sheffield industrialists affected by the Australian import cuts have become reconciled to restricted business after hearing Mr. R. G. Menzies, the Australian Prime Minister, state that the crisis is not yet over and that the worst might yet be to come. Mr. D. A. Palmer, President of the Sheffield Cutlery Manufacturers' Association, was among those who heard Mr. Menzies, and he recognised that the contraction in trade was likely to last for a considerable time and that the future of the cutlery industry depended, to a large extent, on how many orders were received from markets other than Australia.

THE MIDLANDS.

CROP SPRAYING BY HELICOPTER.—The use of a helicopter for crop spraying has spread to Shropshire, where the method has been tried to speed up work which had been delayed by bad weather. The first spraying was satisfactory, and an experiment has now been tried by spraying one-half of a field and leaving the other half unsprayed, in order to compare the results. The results of the experiment is now awaited; if it is successful, it is probable that a helicopter will be stationed at Shifnal permanently. It has been shown already that spraying from the air affords a considerable saving in time compared with the normal method of working from the ground.

COAL PROSPECTS.—Mr. I. W. Cumberbatch, chairman of the West Midlands Division of the National Coal Board, in a report on the Division's activities in the first 21 weeks of 1952, states that a total of 7,584,704 tons of coal was raised, an increase of 140,000 tons on the same period last year. The number of men employed at the coal face had risen by nearly 500, and the improvement in recruiting made the prospect of more coal at the end of the year promising, in spite of the five-day week.

AIR FREIGHT FROM BIRMINGHAM.—The air exchange opened at Birmingham by Air Liaison, Ltd., is now receiving reports from private aircraft-operating companies in Great Britain on freight journeys and available space, and 150 Birmingham firms are being informed of the capacity available. As a result, air freight is being handled more economically, and aircraft which would otherwise have to make part of a passage without a load are now carrying goods. Freight dispatched from Birmingham under the arrangements made by the new exchange is sent by road to London, and loaded on to aircraft at Northolt or London Airport.

MINING SUBSIDENCE.—A sight which was once common in the Black Country is again to be seen at Brierley Hill, Staffordshire. A church at The Delph, not far from the centre of the town, is being dismantled for demolition as a result of mining subsidence, the engineers having reported that it is impossible to save the building. Only a few small pits are operating in the area, but the subsidence is severe, as the seams are near the surface. Fireclay is the main product, though a small amount of coal is also raised. One small pit, about a mile away from the building which is to be demolished, has, in recent years, been compelled to abandon its own winding-engine house, which fell into a subsidence—"crowning in," as it is called locally. A new winding-engine house has been constructed nearer to the shafts.

THE TALYLLYN RAILWAY.—The Talyllyn Railway, Merionethshire, which is owned by a Birmingham group of narrow-gauge railway enthusiasts, and operated on a non-profit-making basis, has opened for the summer season. The whole of the track from Towyn to Abergynolwyn is now in use. Two saddle-tank locomotives from the abandoned Corris Railway have been brought into service to supplement the original locomotives of the line, dating from 1866, which also remain in use, as do the original Birmingham-built passenger vehicles.

LEA HALL COLLIERY.—Work has commenced on the sinking of the shafts of the new Lea Hall Colliery, near Rugeley, which is intended to produce 6,000 tons of coal a day. The colliery, which is on the Cannock Chase coalfield, will replace the nearby Brereton pit, which has a limited life. The shafts will be 550 yards deep and 24 ft. in diameter. Eventually, much of the coal will be conveyed directly from the pit head to a new power station, which is to be built near the colliery.

THOS. B. WELLINGS & CO., LTD.—The Black Country firm of T. B. Wellings & Co., Ltd., who have two works in the Old Hill district, has been acquired by Warne, Wright & Rowland, Ltd., of Birmingham. T. B. Wellings & Co., Ltd., employ about 400 persons, and are engaged in the manufacture of ships' tackle, largely for export.

MIDLANDS WATER SUPPLY.—The latest scheme of Nottingham Water Committee is the putting in hand of the construction of a 1,000,000-gallon service reservoir in the parish of Cotgrave, Nottinghamshire, on a site of six acres. It is estimated to cost 35,000*l*. Two-thirds of the Water Department's steel allocation has been promised to speed up work on the committee's various projects. A new reservoir is under construction at Red Hill, and, at Halam, also in Nottinghamshire, boreholes are being sunk into the bunter sandstone to a depth of more than 500 ft. The Halam project was originally estimated to cost 750,000*l*.

SOUTH-WEST ENGLAND AND SOUTH WALES.

PACIFIC COAST STEAMSHIP SERVICE.—Messrs. Furness Withy & Co., Ltd., inaugurated a new service between Cardiff, Glasgow and the Pacific Coast last week with the s.s. Brazilian Prince. The service is monthly, sailing from Cardiff chiefly with motor cars and pipes, the latter being for Canadian oil-well development. A full cargo of grain and lumber is to enter Cardiff on this service within the next two months.

RHOOSE AERODROME.—If developed as expected, Rhoose Aerodrome, in the Vale of Glamorgan, will become the major airport for Cardiff and South Wales, Mr. E. John Powell, the county surveyor, has told the Glamorgan County Roads and Bridges Committee. He added that its development was a matter of great importance to the area, industrially and commercially. The aerodrome has been taken over by the Ministry of Civil Aviation, and a South Wales-Dublin passenger service was inaugurated on June 11.

SWANSEA IMPORTS AND EXPORTS.—There has been a continued increase in trade at Swansea docks this year, the tonnage handled, from January 1 to May 18 last, being 4,287,857 tons, compared with 3,125,836 tons in the corresponding period of 1951. During the recent Whitsun week some exceptionally busy days were experienced and, to meet the pressure on one day, 188 dockers were brought in from Cardiff and Barry, bringing the total force engaged on general cargo to 767. Outward cargoes included tin-plates and general goods and inward traffic comprised aluminium, pig iron, scrap, barley and oil.

UNEMPLOYMENT AT MERTHYR.—The loss of the Australian export market is seriously affecting the Merthyr factory of Hoover (Washing Machines), Ltd. On June 6, 300 employees were dismissed on account of the reduction in export trade, and all night-shift work has been discontinued.

WHITSUN ABSENTEEISM AT COLLIERIES.—Absenteeism at the South Wales mines during the Whitsun holiday week, according to preliminary reports, was less than usual. The National Coal Board have stated that the return to work was more satisfactory than it was at Whitsuntide last year, except in the Rhymney area.

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 PRODUCTION ENGINEERS.—*Wolverhampton Graduate Section*: Tuesday, June 17, 7.30 p.m., Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Brains Trust Meeting on "Production Engineering Problems."

ROYAL SANITARY INSTITUTE.—Wednesday, June 18, 10.30 a.m., Central Library, High-road, Tottenham, N.17. Various papers, including "The Utilisation of Town Refuse," by Mr. H. Gurney.

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, June 18, 5 p.m., 49, Cromwell-road, South Kensington, S.W.7. (i) "The Dissipation of Kinetic Energy in the Lowest Layers of the Atmosphere," by Mr. R. J. Taylor. (ii) "Structure of the Upper Westerlies: A Study of the Wind Field in the Eastern Atlantic and Western Europe in September, 1950," by Mr. R. Murray and Mr. D. H Johnson.

GLOSTER GA5 AEROPLANE FOR THE ROYAL AIR FORCE.—On Saturday, June 7, the Secretary for Air, Lord de l'Isle and Dudley, announced that the Gloster GA5 all-weather fighter aircraft had been ordered for service with the Royal Air Force, and its production would have superpriority. The GA5, designed by the Gloster Aircraft Co., Ltd., Hucclecote, Gloucester, will thus become the first delta-wing aircraft to go into operational use. It is powered by two Armstrong Siddeley Sapphire jet engines.

THE BIRTHDAY HONOURS LIST.

The Honours List, which was published on June 5, on the occasion of the official celebration of the birthday of H.M. The Queen, includes the names of engineers and others connected with technical and scientific work and with industry. A previous list of names appeared on page 723, *ante*.

KNIGHT BACHELOR.

Alderman H. W. Barber, J.P., manager, Manchester branch, Johnson and Phillips, Ltd., for political and public services in Southport.

ROYAL VICTORIAN ORDER.

Knight Commander.—Mr. (V.) Michael Barrington-Ward, C.B.E., D.S.O., M.Inst.T., member of the Railway Executive.

ORDER OF THE BRITISH EMPIRE.

Commanders.—Engineer Rear-Admiral C. R. P. Bennett, O.B.E.; Mr. B. G. Dickins, O.B.E., director of technical and personnel administration, Ministry of Supply; Dr. Joseph Proudman, J.P., M.A., F.R.S., Professor of Oceanography, University of Liverpool; Mr. L. M. Milne-Thomson, M.A., F.R.S.E., Professor of Mathematics, Royal Naval College, Greenwich; and Mr. H. E. Snow, O.B.E., deputy director, Anglo-Iranian Oil Co., Ltd.

Officers.—Mr. Michael Broderick, J.P., lately regional director, Midland Region, Ministry of Fuel and Power; Mr. Frank Brookhouse, B.Sc., F.R.I.C., technical advisor to the director of victualling, Admiralty; Mr. Jack Brooks, Ph.D., principal scientific officer, Low Temperature Research Station, Department of Scientific and Industrial Research; Mr. G. W. Chandler, M.M., deputy city engineer and surveyor, Birmingham; Mr. H. G. Davey, M.Sc., A.M.I.Chem.E., F.R.I.C., works general manager, atomic energy production factory, Sellafield, Ministry of Supply; Mr. P. J. Ellis, managing director, R. B. Pullin & Co., Ltd.; Mr. J. M. Ford, B.Sc. (Eng.) (Lond.), M.I.Mech.E., senior principal scientific officer, Admiralty Gunnery Establishment; Mr. E. A. Gardiner, colonial engineering service, Public Works Department, Singapore; Commander (E) J. I. T. Green, Royal Navy; Mr. R. E. Hadley, chief engineer officer, S.S. Velutina, Anglo-Saxon Petroleum Co., Ltd.; Lieut.-Col. J. V. Hall, M.B.E., T.D., R.E.M.E.; Mr. A. C. H. Illston, A.M.I.Mech.E., M.I.Loco.E., deputy chief engineer, mechanical engineering department, office of the Crown Agents for the Colonies; Mr. E. B. Jones, secretary, Cammell Laird & Co., Ltd.; Commander (E) L. E. S. H. Le Bailly, Royal Navy; and Major D. A. Mitchell, R.E.M.E.

Members.—Mr. A. H. Attrill, B.Sc. (Eng.) (Lond.), A.M.I.C.E., civil engineer, Admiralty; Mr. F. F. Batcheldor, works director, Small Electric Motors, Ltd.; Mr. Harry Billbrough, chief engineer, Bagley & Co., Ltd.; Mr. Arthur Brooke, lately with Crofts (Engineers), Ltd.; Mr. J. G. H. Brown, lately with Palmers (Hebburn) Co., Ltd.; Mr. A. G. Child, engineer assistant, Admiralty; Mr. L. H. Clarke, borough engineer, Harrogate; Mr. H. H. Fell, A.M.I.E.E., mechanical and electrical engineer, directorate of works, Air Ministry; Mr. T. J. Gale, M.Sc. (Reading), A.M.I.Mech.E., Pulsometer Engineering Co., Ltd.; Mr. J. F. Galloway, sub-area engineer, South East Scotland Electricity Board; Mr. Ernest Garthwaite, chief engineer, Marconi Instruments, Ltd.; Mr. H. W. Hogben, head of armament section, J. I. Thornycroft & Co., Ltd.; Mr. D. McA. Hunter, assistant shipyard manager, Harland and Wolff, Ltd.; Mr. W. C. Ikeson, technical assistant to the chief mechanical engineer, Iraqi State Railways; Mr. F. W. Jones, Mullard Radio Valve Co., Ltd.; Mr. A. C. Kain, A.M.I.C.E., engineer, Metropolitan Division, Ministry of Transport; Mr. Sydney Kay, A.M.I.Mech.E., director and chief engineer, Cooper Roller Bearings Co., Ltd.; Mr. Alexander Laurie, Brown Brothers & Co., Ltd.; Mr. Duncan Macfarlane, Mirrlees Watson Co., Ltd.; Mr. J. C. Metcalfe, senior ship draughtsman, Cook, Welton and Gemmell, Ltd.; Mr. T. C. Parker, production manager, Vickers-Armstrongs Ltd., Weybridge; Mr. P. H. J. Price, group production engineer, Lancaster group, North Western Gas Board; Mr. James Stockwell, works director, Switchgear and Cowans, Ltd.; Mr. F. P. Tofton, engineer manager, J. S. Doig (Grimsby), Ltd.; Mr. Leonard Turner, lately deputy principal, Coventry Technical College; Mr. A. R. Wakeham, technical officer, Petroleum Division, Ministry of Fuel and Power; Mr. T. S. Watson, assistant engineer manager, Harland and Wolff, Ltd.; Mr. A. W. Watkins, chief engineer, East African Airways, East African High Commission; Mr. John Wood, executive engineer, Research Station, General Post Office; and Mr. R. M. Woofenden, Colonial Engineering Service, assistant engineer, Public Works Department, Federation of Malaya.

PERSONAL.

THE BRITISH INSTITUTION OF RADIO ENGINEERS, 9, Bedford-square, London, W.C.1, announce that H.M. The Queen has been pleased to grant her patronage to the Insitution, in succession to H.M. King George VI, who betame Patron of the Institution in 1946.

MR. E. GRANTER, B.Sc., M.I.C.E., has been elected President of the Institution of Structural Engineers, 11, Upper Belgrave-street, London, S.W.1, for the session 1952-53. He will take office in October.

DR. C. J. MILNER, M.A.(Cantab.), F.Inst.P., son of Dr. S. R. Milner, F.R.S., Emeritus Professor of Physics of the University of Sheffield, and a member of the research staff of the British Thomson-Houston Co., Ltd., Rugby, since 1936, where he is now head of the physics section of the firm's laboratory at Rugby, has been appointed to the Chair of Applied Physics at the New South Wales University of Technology, Sydney, Australia. Dr. C. J. Milner will be taking up his new duties in October.

MR. MARCUS GIRLING (chairman), MR. G. R. SAUNDERS (vice-chairman), MR. R. H. BATES (President), MR. N. F. SPENCE (past-president) and MR. E. L. COTTERELL (vice-president) have been appointed to serve as honorary officers on the Council of the British Cast Concrete Federation, 17, Amherst-road, Ealing, London, W.13, for the ensuing year.

MR. B. L. A. ELLINGS, of the London Division, British Electricity Authority, has been elected chairman of the London Students' Section Committee of the Institution of Electrical Engineers. MR. R. THOMAS, of the Sperry Gyroscope Co. Ltd., has been elected honorary secretary of the Committee.

MR. A. J. SEAR, who is now in his 25th year as a director of W. B. Dick & Co. Ltd., has been appointed managing director, as from July 1.

MR. A. HUDSON DAVIES has been appointed a director of Pilkington Brothers Ltd. He will continue to act as managing director of Fibreglass Ltd., Ravenhead, St. Helens, Lancashire.

MR. S. W. SANGWIN, who has been employed as a manager of Tarslag Ltd. for over 25 years and was appointed a director in 1946, has now been made a joint managing director of the company.

MR. ARNOLD WATSON, general manager of Castrol sales for the last four years, has been elected to the board of C. C. Wakefield & Co. Ltd., 46, Grosvenor-street, London, W.1. He joined the firm in 1929.

MR. S. W. R. BROWN, A.Inst.M.M., and MR. J. R. MUNRO, A.M.I.C.E., have joined the Colonial Engineering Service, the former as an inspector of mines in Uganda and the latter as an assistant engineer in Tanganyika.

MR. A. V. ASHTON, who has been in charge of the Liverpool office of W. P. Butterfield Ltd., Shipley, Yorkshire, has resigned his appointment with the company. As from June 1, his place has been taken by MR. D. F. BALAAM, latterly attached to the firm's London office.

MR. N. MCPHERSON has been appointed a director of the British Aluminium Co., Ltd., Norfolk House, St. James's-square, London, S.W.1. He will continue in his present position as general manager of the company.

MR. E. J. CURWOOD, fleet maintenance engineer of the stratocruiser and constellation fleet of the British Overseas Airways Corporation, has been appointed to act as official-in-charge of the Corporation's base at Filton. In this capacity, he succeeds CAPTAIN D. I. PEACOCK, who, as manager of the fleet, is moving his office to London Airport.

A new company, SPARCATRON, LTD., has been formed by the BATH & PORTLAND STONE FIRMS LTD., to grant licences throughout the world, under the Rudorff and other patents, for the application of a new process of electronic machining of materials. The company has set up laboratories for pure and applied research in this field at Tuffley-crescent, Gloucester.

MESSRS. WENHAM BROTHERS & CO., 21, Bennett's-hill, Birmingham, 2, have been appointed permanent secretaries of the Magnesium Advisory Committee. Communications should be addressed to MR. A. M. M. BURDON-COOPER.

THE VACUUM OIL CO. LTD., have leased 15,000 sq. yds. of land at Hendon Dock, Sunderland, for the purpose of importing, storing and distributing petroleum products of various grades.

As from July 1, the office address of the UNITED KINGDOM TRADE COMMISSIONER IN JOHANNESBURG will be Pritchard House, Pritchard-street, Johannesburg, South Africa. The telephone number will be 23-6561/2 but the telegraphic address will remain unchanged.

WILD-BARFIELD ELECTRIC FURNACES, LTD., Elecfurn Works, Watford By-Pass, Watford, Hertfordshire, announce that MR. J. E. SIMPSON, who came to England from Canada in 1937 and joined the Wild-Barfield organisation in 1946, has returned and opened a Canadian office of the firm at 72, Grenville-street, Toronto, Canada.

CONTINUOUS TUBE-FORMING AND WELDING MACHINE.

BRONX ENGINEERING COMPANY, LIMITED, LYE, WORCESTERSHIRE.

(*For Description, see Page* 737).

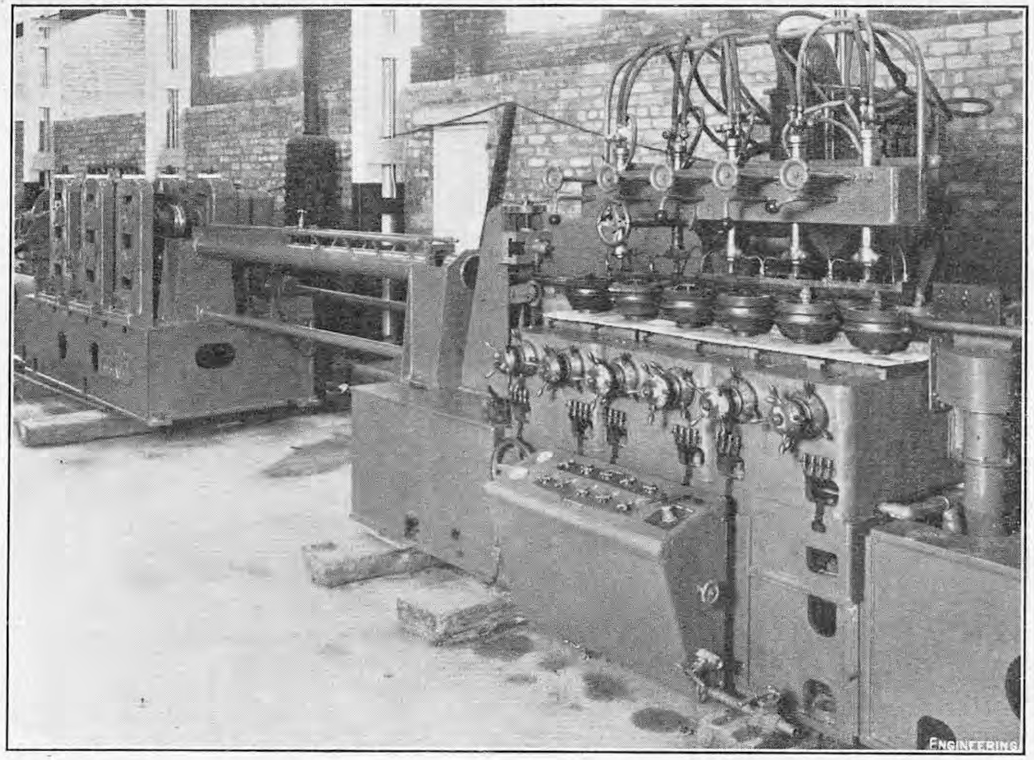


Fig. 3. Welding Head and Sizing Rolls.

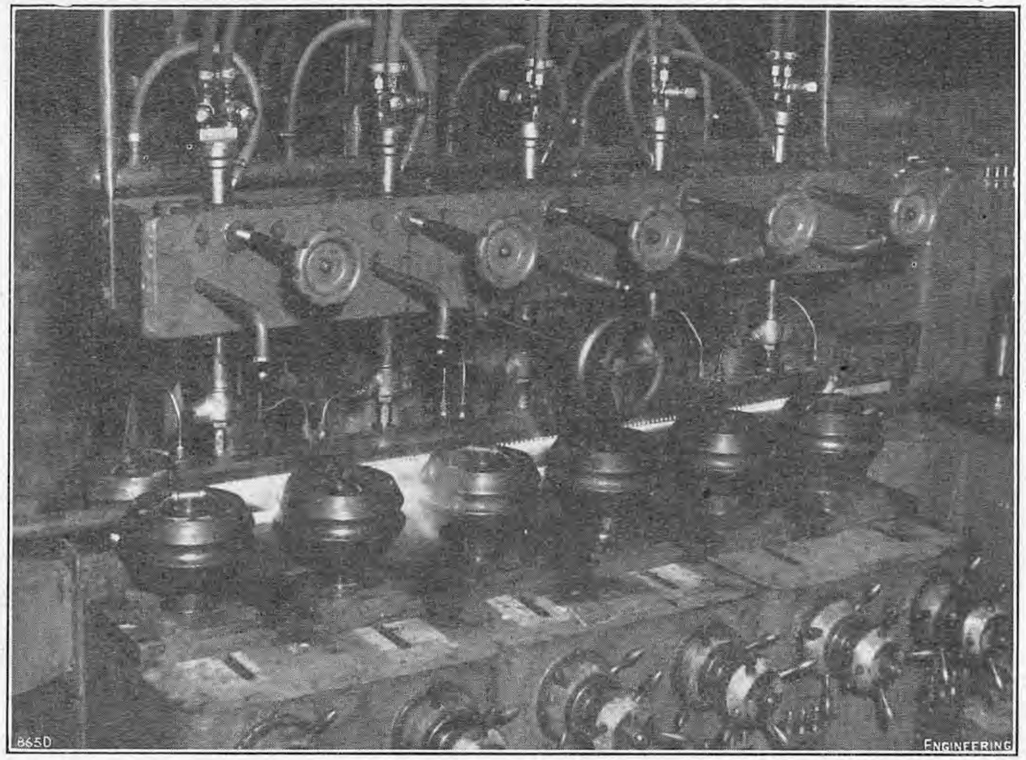


Fig. 4. Welding Head in Operation.

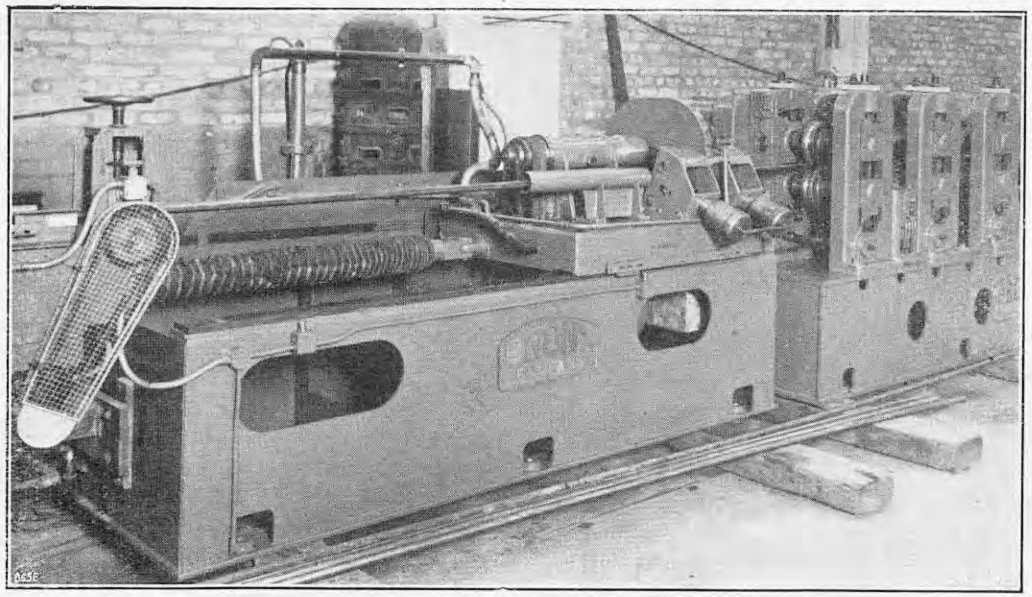


Fig. 5. Flying Cut-Off Unit and Sizing Rolls.

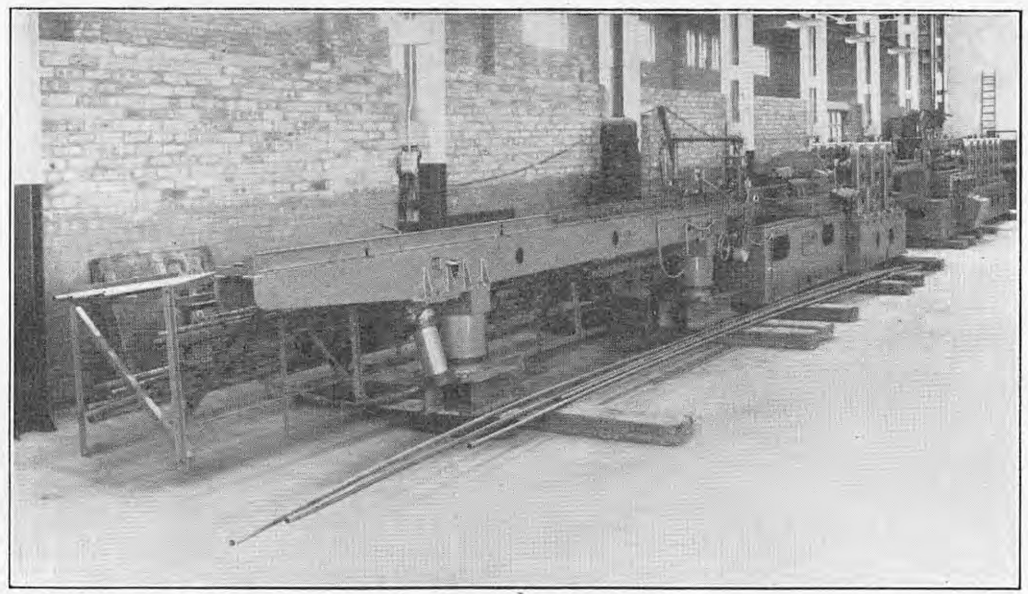


Fig. 6. Discharge Table.

ENGINEERING

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ENGINEERING

FRIDAY, JUNE 13, 1952.

VOL. 173. No. 4507.

ELECTRIC POWER TRANSMISSION AT VERY HIGH VOLTAGES.

It would be surprising if the proceedings of a conference of 1,650 electrical engineers from 35 different countries did not result in the disclosure of a great deal of useful and interesting information. The fourteenth assembly of the Conférence Internationale des Grands Réseaux Electriques (C.I.G.R.E.), which concluded last Saturday in Paris and to which these figures apply, certainly gave rise to no disappointment on that score. The subjects covered by the 121 papers presented ranged from alternators, transformers and circuit-breakers to cables, overhead lines and extra high voltage transmission and included insulating materials, protective apparatus, system stability and telephonic and radio disturbances. Although it would be too much to say that all these communications were of equal value, taken as a whole they gave a good indication of the progress that has been made in this important field since the Conference was established in 1921.

Of the many matters considered, probably that of outstanding interest, although it was not dealt with until nearly the end of the conference, was that of power transmission at very high voltages, that is in the range between 275 and 400 kV. The problems associated with the use of these voltages have been investigated in a number of countries, notably Sweden, France and the United States, but to the first of these must fall the distinction of placing a system operating at 380 kV in service. It is no detraction from this honour to point out that one reason for this is that Swedish industry is mainly concentrated in the south of the country, while the large amounts of water power that are still available for development are situated in the north, a distance of some 600 miles separating the two. To meet this situation a 105-MW station has therefore been erected at Harspranget, the output of which is now being transmitted at 380 kV to Hallsberg with only one intermediate switching station. Full details of the equipment provided for this purpose were given in a paper presented to the conference by Messrs. A. Rusck, B. Rathsman and G. Jancke, who were able to say that the first line began to transmit power at the end of April this year and has since operated satisfactorily.

Although it is probably too early to record that the inevitable teething troubles have been overcome many useful tests on the switchgear and the protective apparatus have been carried out; and some interesting investigations have been undertaken into such questions as the disturbances that may be caused to radio communication systems. That the engineers concerned are in no doubt that the results of their work will be successful is shown by the fact that extensions, amounting in all to about 1,000 miles, are being planned. That the eventual system will be of some magnitude is clear from the estimate that to meet future requirements it will be necessary to transmit 6,500 MW from the north to the south of Sweden, of which 5,500 MW will be transmitted at 380 kV. It has also been calculated that by using series capacitors the load on each line can be increased to about 800 MW, thus enabling this large amount of power to be dealt with by only eight lines.

Although the distances involved in France are not so great as those in Sweden the employment of these voltages is also being considered by French electrical engineers; and some valuable information on the consequent problems has also been collected by them. For instance, as pointed out in a paper by Messrs. E. Scherb and E. Maury, experiments made at the well-known testing station at Chevilly have shown that corona need not be a source of difficulty and that radio interference is no more troublesome at 380 kV than it is at 275 kV. It has also been found that the choice between "bundle" and solid conductors is determined by economic rather than technical considerations and that it is unnecessary, as was formerly thought to be the case, to employ single conductors with diameters in excess of 42 mm. It would, in fact, appear from a report by Mr. P. Sporn on the whole subject of very high voltage transmission, that corona is of less importance than radio interference, the problems connected with which have not yet been finally solved. On the more practical side it would appear that advances have been made in reducing the cost and weight of the towers carrying the lines by making use of high strength steel, while search is being made for economies in other directions.

Mr. Sporn is therefore of the opinion that sufficient work has been done to leave no doubt that the use of a voltage of 400 kV is possible, as is indeed indicated by the results that have been obtained in Sweden. On the other hand, although voltages as high as 440 kV have also been considered work in that direction has not advanced very far, and it is already clear that their use, in some cases at least, would not be economically justified. In the light of this conclusion much interest therefore attaches to a group of papers which were presented at the last moment by a delegation of Russian engineers headed by Mr. Mirolouboff. These papers described two projects: one for supplying Moscow from a water-power station near Kuibyshev, a distance of about 575 miles, and the other for transmitting power to the same city from a second station near Stalingrad, a distance of 625 miles. In both cases it is intended to erect double-circuit lines each with a capacity of some 1,200 MVA and to use 420 kV as the transmitting voltage. It was further announced that these projects formed the first stage in the erection of a very high voltage system which would cover the whole country. Full details of the equipment it was proposed to use were given. It is no exaggeration to say that this communication came as a great surprise to the delegates, both as regards the mode and timing of its presentation. Further comment must perforce be deferred until a report in some language other than Russian is available, although at this stage one point, which is of some importance, may be made.

An implicit, if not explicit, agreement has grown up whereby 380/400 kV is regarded as the maximum voltage which can be satisfactorily employed in practice. To select 420 kV for what will evidently be a very extensive scheme might therefore seem to be to disagree for the sake of disagreeing. Indeed, at first sight, it is a little hard to justify. Unfortunately, the same tendency is evident lower down the scale, since it is being recommended in the United States that the maximum voltage should not exceed 330 kV for both economic and technical reasons. On the face of it, such disparities require some explanation. They may be necessary, but they might easily lead to differences in design and construction which it would be desirable to avoid. It is, therefore, to be hoped that some agreement will be reached on this subject before matters have gone too far.

Such questions are, however, more of future than immediate importance. Indeed, the greater part of the proceedings at the conference consisted of accounts of the steps that are being taken to consolidate ground that has already been won in the field of rather lower voltages. Not the least interesting of these dealt with the design and operation of the circuit-breakers upon which the proper functioning of an electrical transmitting system so largely depends. On the purely technical side, the rate of rise of re-striking voltage, a factor which has interested designers for many years, seems temporarily at least to have yielded first place to an examination of the currents that flow in the arcing chamber after the arc has been extinguished. A group of Belgian engineers presented a paper on this subject in which the effects, good and bad, of this phenomenon were discussed and in which a special shunt for measuring it was described. The matter is of increasing importance as the inflowing capacity rises and, although it is obvious that much more work remains to be done on the subject, it seems clear that some of the existing ideas on so-called indirect testing will have to be revised.

The more practical side of circuit-breaker design was dealt with by Mr. L. Acrow in the course of a paper in which he pointed out that for a number of years manufacturers had attempted to reduce the weight and first cost of this equipment by the use of smaller oil volumes and by air-blast operation. He described some interesting examples of French design in which further advances in this direction had been made by suspending the circuit-breaker from a superstructure and by the use of a unit with two breaks per pole in which each break had a shunt resistor in the form of a distilled-water column. This column was contained in a horizontal porcelain insulator which, in turn, was mounted above a larger porcelain insulator containing the arcing chamber. It was clear from the discussion that these ideas did not receive universal acceptance, mainly on economic grounds. It was agreed, nevertheless, that with the increasing use of higher voltages the search for greater simplicity and reduced weight and bulk in circuit-breakers was a worthy objective.

Although the many other subjects dealt with at the conference cannot be given even cursory mention at this stage, they are of considerable importance. In fact, the proceedings will form a collection of information in a limited, but important, field of engineering, which must be almost unique in its completeness. The majority of the papers make a useful contribution to the existing knowledge of the subject and the remarks made by the various speakers in the discussion were often of equal value. That being so, it is perhaps a pity that some way has still to be found of improving the stage management of the meetings. In any international gathering there is a danger that interpretation will render the proceedings long-winded and wearisome. This difficulty can be overcome largely by the use of simultaneous interpretation, but, unfortunately, the necessary apparatus for this purpose is not available at the Foundation Berthelot, with the result that each contribution has to be dealt with twice. The task of the interpreters, in spite of the fact that they are chosen for their knowledge of the subject, is, moreover, not always lightened by the speakers who might cast their remarks in a form in which they can be easily dealt with, even if they do not provide translations of the principal points in their arguments. They might also remember, for the sake of those who are listening, that a microphone is intended as an aid to, and not a substitute for, audibility. Nevertheless, this year's C.I.G.R.E. may be regarded as a success and will provide a useful stepping stone to a further consideration of the subjects with which it deals.

CONTRACTS FOR WORK, AND EXTENSION OF TIME.

It is comparatively seldom that cases relating to engineering contracts are reported either in the Law Reports, properly so called, or in the daily newspapers. This is partly because, turning as they generally do upon questions of fact, they are of little interest to the lawyer; and, not being sensational, they make no appeal to the general public. Now and then, however, a case does come before the Courts which throws useful light on the interpretation of a clause in some standard form of contract, of which it is desirable to take notice; and here it should be observed that as the "engineering" contract resembles the "building" contract in some important respects, cases relating to the construction of buildings may often be studied with advantage. This affords justification for referring to the case of *Amalgamated Building Contractors, Ltd.* v. *Urban District Council of Holy Cross* (1952) 1 Times L.R.1165, which was decided by Mr. Justice Gorman in March, but was only reported this month. It raised an interesting question as to the power of an architect to grant an extension of time for the completion of works, the contract under consideration being similar in all material respects to those with which many engineers are concerned in relation to works of any magnitude.

The plaintiffs in the above-mentioned case, were employed by the defendant council to erect a number of houses. The contract was in what is called the R.I.B.A. form. The day of completion was (at first) to be February 7, 1948, but on February 19 the architect granted an extension of 12 months, that is to say, until February 7, 1949, on account of causes arising out of clause 18 of the contract, namely, "delay by reason of labour and materials not being available as required." Clause 17 provided that if there was delay which, in the opinion of the architect, could have been avoided, the contractor was to pay damages assessed at 50*l*. per week. There was, in fact, delay. The contractor having brought an action for monies due under the contract, the council counter-claimed for damages for delay, being 50*l*. a week for 15 weeks. What happened was that, in January, 1949, the contractors wrote to the architect asking for a further extension of twelve months. He did not then grant a further extension of time; indeed, he did not do so until after the work was completed on October 20, 1950. Two months after that date, he wrote to the plaintiffs, saying: "The present expiry date is February 7, 1949, and I have decided that an addition of 15 weeks, bringing the completion date to May 23, 1949, would be a fair and reasonable extension." It will thus be seen that, in the opinion of the architect, the work should have been completed by May 23, 1949. That being so, it was considered by the defendants that they were entitled to the penalty of 50*l*. per week for delay.

It was argued, on the other hand, on behalf of the plaintiffs, that the architect had no power to make a retrospective extension; that, at the time he made it, the contract had come to an end, the works having been completed, and that the defendants could not exact the penalty which could only have been awarded pursuant to the contract. Mr. Justice Gorman would not accept this view. He said: "I do not see anything in this clause to say that the architect may not fix a prospective date. If this clause gives, as it does, a right of value, then, unless the clause takes away that right in definite terms, it would not be right to say that, in fact, the right is limited in some way other than would appear from the terms of the contract. The architect has to make a fair and reasonable extension of time for the completion of the work. That means that, if he decided to give three months instead of the time at the back of the schedule, it becomes June 1 or July 1 or whichever is three months from it. Then the contract ends on the particular day on which it has been decided that the contract shall end, and I find nothing here to take away this right if limited to occasions when the time of extension is in the future with regard to the date when the extension is, in fact, granted."

With all respect to the judge, we find it difficult to reconcile this decision with that of Mr. Justice du Parcq (afterwards Lord du Parcq) in the case of *Miller* v. *London County Council* (1934) 50 T.L.R.479. In that instance, a building contract contained provisions under which the date of completion of the work was November 15, 1931. Clause 31 of the contract provided that "it shall be lawful for the engineer if he shall think fit at any time or times by writing under his hand such extension of time for completion of the work and that either prospectively or retrospectively, and to assign such other time or times for completion as to him may seem reasonable." Clause 37 provided for the payment of liquidated damages for delay at a specified rate. The contractor did not complete the works until July 25, 1932, and on November 17, 1932, the engineer issued a certificate granting an extension of time to February 7, 1932, certifying the amount due to the building owner as liquidated damages in respect of the period between February 2 and July 25, 1932. The judge held that the words "either prospectively or retrospectively" did not confer on the engineer a right to fix the extension of time *ex post facto* when the work was completed. They empowered him to wait until the cause of delay had ceased to operate, and then, "retrospectively" with regard to the causes of delay, to assign to the contractor a new date to work to. The extension proper admittedly not having been granted in time, no liquidated damages were payable.

It will be observed that Mr. Justice du Parcq so held, although the engineer was actually empowered to give leave "prospectively" or "retrospectively." That opinion of a very distinguished judge is borne out by something which appears in *Hudson on Building Contracts* (6th edition) at page 359—a work of great authority. Mr. Hudson wrote: "Where there is power to extend the time for delays caused by the building owner, and such delays have, in fact, taken place, but the power has not been exercised, either at all or within the time expressly or implicitly limited by the contract, it follows (unless the builder has agreed to complete to time notwithstanding such delays) that the building owner has lost the benefit of the clause. The contract time has in such case ceased to be applicable, there is no date from which the penalties can run, and, therefore, no liquidated damages can be recovered." It is true that, in the case before Mr. Justice Gorman, the delay was due to "labour and materials not being available as required," but that does not appear to be a material distinction.

NOTES.

ANNUAL REPORT OF THE N.P.L.

THE report of the National Physical Laboratory for the year 1951, which has been published by Her Majesty's Stationery Office (price 3s. net.) surveys work in many scientific fields undertaken at Teddington. The most important change at the Laboratory during the year was the transfer of most of the former Engineering Division to the Mechanical Engineering Research Laboratory at East Kilbride. Another change was the closing down of the Statistics Section of the Mathematics Division to enable the staff to concentrate on the electronic Automatic Computing Engine and on the new differential analyser which was built in Germany. In the relevant section of the report, it is stated that the pilot model of the ACE, which was described in ENGINEERING, vol. 171, page 6 (1951), suffered from numerous teething troubles, particularly in its delay-line storage system. When these were overcome, the equipment was used extensively for solving systems of equations and for computing mathematical tables. The Aerodynamics Division, the report states, was engaged mainly on basic research on problems connected with the design and performance of high-speed aircraft. Progress was also made with the provision of new experimental facilities. The section of the report dealing with mechanical engineering includes details of research work now transferred to Scotland as well as of those remaining portions of the former Engineering Division's work which have now been taken over by other Divisions at Teddington. The former category included research on the fatigue of metals and work on gas cylinders and containers. Work on the creep and fatigue of metals at high temperatures continued at Teddington, but will eventually be transferred to East Kilbride. The work on dead-weight standards of load and on strain gauges was taken over by the Metrology Division, and the Physics Division undertook the investigations on elasticity and the physics of the solid state. The work of the Light Division included the development of new methods of producing diffraction gratings and of forming transparent electrically-conducting films on glass. Besides undertaking fundamental research, the Laboratory continued its important work of maintaining standards and extended its function as a testing establishment.

THE MECHANICAL HANDLING EXHIBITION.

The opening of the 3rd Mechanical Handling Exhibition at Olympia on Wednesday, June 4, was marked by a luncheon at which the Minister of Labour, the Rt. Hon. Sir Walter Monckton, K.C.M.G., K.C.V.O., M.C., Q.C., M.P., was the principal guest and speaker. In the course of his speech, he said that the mechanical handling equipment displayed at the exhibition—unequalled in any part of the world—could reduce fatigue, strain, and the risk of accident; it could increase efficiency; and it could liberate human labour for more productive work. With regard to the first point, namely, improving the physical well-being of the factory workers, it had been estimated that the cost of industrial accidents in this country was about 70,000,000*l*. per annum. Many of these accidents were due to the sheer tiredness of a man; he would not admit that a heavy job was beyond his capacity, and if the work was continuous he reached the stage where he did not hear well, see well, or react quickly. The proportion of accidents which were due to handling mishaps was increasing; it was 17 per cent. in 1926, and 27 per cent. to-day. A good half of industrial accidents could be avoided by mechanical handling, provided always that the mechanical handling equipment did not introduce new causes of accidents. On the second point he wished to make—promoting greater efficiency—it had been said that handling added to the cost, but not to the value of products. As much as 80 per cent. of the cost of a product might be handling costs. Regarding the third point, this country could not afford to squander its resources. Mechanical-handling equipment could help to free labour for more productive work, but any changes in methods must be accompanied by the goodwill of the men and women who would have to operate the new methods. Men would be enabled to turn to more skilful work, but there was still a certain latent—sometimes open—hostility to the introduction of mechanical aids. That attitude was not unnatural. Managers sometimes under-estimated the psychological preparation that was needed before a change was made, and they sometimes adopted a defeatist attitude if the men showed distrust. That was wrong; prior to a change, they should seek by consultation the support of the operatives (and of the supervisors, who were often forgotten in such matters). Reasonable men liked to be told reasons. The chair at the luncheon was taken by Mr. Claude E. Wallis, M.B.E., chairman and managing director of Associated Iliffe Press, Limited. Other speakers were Sir Harold Bowden, Bt., G.B.E., chairman of Raleigh Industries, Limited, and Mr. W. Ralph Purnell, O.B.E., President of the Mechanical Handling Engineers' Association.

INSTITUTE OF MATERIAL HANDLING.

At a recent meeting in London attended by 70 representatives of the users and manufacturers of materials handling equipment, it was decided to form an Institute of Material Handling. The chairman of the meeting, Mr. John R. Sharp, said in his opening speech that the meeting had been called by users, who felt that discussion groups should be formed where they could discuss their handling problems and review all the techniques of materials handling. The Institute was not intended to foster trade or business objects. It was decided, after discussion, that membership of the institute should be confined to individuals and should not include firms or corporations. All those engaged in materials handling should be eligible for membership; those joining before June 30 would be founder members. Mr. H. P. Mott was elected chairman of the Institute, and Mr. John Bright deputy chairman. Mr. A. F. Much was appointed treasurer, and a council of 16 members was elected, of whom 12 are users of handling equipment, and four are on the staff of manufacturers. Further particulars of the Institute may be obtained from the secretary, Mr. M. W. Paynter, 20-21, Took's-court, Cursitor-street, London, E.C.4.

WHITWORTH SOCIETY SUMMER MEETING.

It is the traditional practice for the Whitworth Society to hold a summer meeting in some provincial centre. For the past two years, this custom was departed from and the meeting was held in London, but this year a return was made to the more usual procedure and a meeting was held in Southampton on June 5 and 6. The proceedings took the form which may be said to be almost standardised, an informal dinner being held in the evening of the first day and visits of technical interest taking place on the second. The dinner, at which the chair was occupied by Dr. S. F. Dorey, the President, was held at the Polygon Hotel. The main visit, on June 6, was to the Woolston Shipyard and Engineering Works of Messrs. J. I. Thornycroft and Company, Limited, and in the course of it the Society was entertained to lunch by the Company. During this part of the proceedings, Dr. Dorey inducted Sir Henry Guy as President for next year. Before proceeding to Messrs. Thornycroft's, the party paid a visit to the Ocean Terminal at Southampton Docks, an illustrated description of which appeared in our issue of August 11, 1950. In the unavoidable absence of Sir John Thornycroft, the party was welcomed at the shipyard by Captain Villar, the general manager. It was in 1904 that the increasing size of destroyers necessitated the removal of the famous Thornycroft shipyard from Chiswick to Woolston. Since that time, a large establishment has been built up, and not only during the two wars, but between them and since, a range of naval vessels including destroyers, sloops, submarines, minelayers and landing craft has been built as well as civilian craft of many kinds. The engine works are equipped to build steam turbines up to 72,000 s.h.p. on two shafts, water-tube boilers to serve 27,000-h.p. turbines, liquid-fuel burning gear, reciprocating steam engines up to 2,000 h.p. and cast-iron propellers of weights up to 10 tons, and those of manganese bronze up to 32 cwt. Much interest was taken in the aluminium-framed non-magnetic coastal mine-sweepers now under construction. The summer meeting closed with a river trip arranged by Messrs. Thornycroft's on one of their tugs.

EDUCATION FOR INDUSTRY.

The widely-held view that secondary technical schools are inferior to secondary grammar schools is having the effect, according to Mr. H. S. Barlow, M.Sc., F.Inst.P., of retarding efforts to increase the productivity of industry in this country. Mr. Barlow dealt with this problem in his presidential address to the Association of Teachers in Technical Institutions at the 43rd annual conference held at the Borough Polytechnic, London, S.E.1, from May 30 to June 2. The idea persisted, he said, that secondary technical schools were simply trade schools. Given equal opportunities of recruiting pupils, equal standards of buildings, and equal opportunities of maintaining separate identities, the secondary technical schools could produce at least an equal standard of education as the best in any other type of school. There was, however, a risk of subordinating the general aim of forming the whole man to the particular aim of forming the technician or craftsman. Perhaps the most important aspect of the curriculum in such schools was the integration of the teaching of the technical, commercial or art subjects with allied subjects. From any industry, excursions could be made into science, geography, history and languages. Every machine-made article had design, and it was not difficult to lead the pupils into a consideration of form and of æsthetic values. There was an easy path from engineering to the field of general science and to the change of social conditions brought about by the invention of power-driven machines. Referring to the difficulty of recruiting for industry, Mr. Barlow said that, unfortunately, the bias of general education in this country tended to direct able schoolboys from employment in industry. A change of attitude was needed in the schools, as well as among the general public, before technology would come to be recognised as the important and highly respected calling which it was on the Continent and in the United States.

STANDARDISED SCREW THREADS FOR SERVICES' EQUIPMENT.

The Ministry of Defence state that Government departments, with the co-operation of industry, are taking steps to stimulate the widest possible adoption of the Unified system of screw threads for equipment supplied to the three Armed Services. Action has already been taken in the case of new aircraft engines coming into production and ways are being worked out of applying the Unified system of screw threads to airframes and aircraft equipment. The Admiralty have already adopted the system for some types of armament and other equipment, and they regard the wide adoption of Unified standards as a development to be pursued as vigorously as practicable. The Ministry of Supply are to ensure a wide application of the Unified system to equipment and stores for the Army. In the past year or so the need for a common standard and unification has become increasingly manifest and agreement has been reached throughout the Services and industry on British Standards for bolts and nuts with Unified threads (B.S. 1768 and 1769), and for screw-thread gauge tolerances (B.S. 919), screwing taps (B.S. 949), and spanners for use with Unified bolts and nuts (Amendment No. 1 to B.S. 192). Provision is also being made for the range to be extended below $\frac{1}{4}$ in. diameter for screws for attachment of components. This work has facilitated the production in this country of screwing tackle for the agreed ranges of sizes and pitches for nuts, bolts, and screws, and of corresponding spanners in the Unified range, and these are now becoming available for reasonable delivery. The policy of the Service Ministries is to adopt the Unified screw-thread system as general practice, even for items of an essentially commercial nature. The Ministries hope, therefore, that manufacturers will be encouraged to turn over to a more general adoption of the Unified screw-thread system, so as to bring commercial and Service practice into line.

LETTERS TO THE EDITOR.

THE ECONOMICS OF FUEL AND POWER.

To the Editor of Engineering.

Sir,—I have noted the letter by Mr. H. M. Peacock on page 689 of your issue of May 30, commenting on your editorial of May 16, in which you dealt with the economics of fuel and power, taking as a basis certain figures which I had produced at the annual luncheon of the Institute of Fuel. I should like to make one or two comments on this letter.

There is, of course, no disagreement about the possible improvement in overall efficiency which could be obtained with the use of back-pressure turbines for heat and electricity supply, provided there were a suitable demand for the heat. This depends largely on the cost in relation to other methods of providing heat. For process steam, there are already many such installations and quite a large proportion of the larger ones are operating in parallel with the public supply. For the wider distribution of heat to housing estates, etc., the incidence of capital cost on the heat distribution system is much greater and, further, consumer reactions must be known. The Pimlico scheme is being studied with great interest with this in mind. Two other schemes were prepared in great detail by local authorities and abandoned because the resulting costs to consumers were considered too high. The present time of acute capital shortage is not the most appropriate to carry out such installations.

Mr. Peacock quotes certain very generalised figures for gas and coke production which may well be correct for certain carbonisation plants. He is, however, comparing them with the national overall figures for electricity supply, which take into account all generating plants operated by the B.E.A., large and small, new and old. To get a fair comparison, it is necessary to take the whole gas production of the country and to know the average calorific value of the coal carbonised and also of the resulting coke and other by-products. The only suitable statistics available are given in the *Ministry of Fuel and Power Digest*, and even they are not complete for the purpose in mind. Analysis of these figures with reasonable assumption for the missing factors supports the figures given in your editorial of May 16.

I do not follow Mr. Peacock's analogy of the furniture factory. I cannot think he would wish to assess the efficiency of such a factory on a thermal basis, since this is no part of its purpose. If the basis were efficiency in the use of materials for furniture manufacture, then I suggest he would count as a loss the timber made unsuitable for that purpose. I agree that the tar used for road making is valuable material but as it is not used for its thermal value I still consider that it should be counted as a loss in assessing the efficiency of gas production. In my view, this difficulty only confirms the inadequacy of thermal efficiency as a sole basis of comparison between gas and electricity.

The British Electricity Authority do not, of course, question the need for fuel economy, but they do urge that national policy cannot be decided on this one ground alone. It must take into account other factors, such as cost, convenience, smoke pollution, etc. Each individual consumer will attach different weight to the various factors involved, but I suggest that, by and large, freedom of choice by consumers will strike a fair balance between the competing fuels. That is why the British Electricity Authority advocate the principle that each fuel and power industry should not seek to secure any privileged position but should manage its own affairs on a sound commercial basis.

Yours faithfully,
J. Hacking,
Deputy Chairman (Operations),
British Electricity Authority.

British Electricity House,
Great Portland-street,
London, W.1.
June 9, 1952.

HYDRAULIC LOCK.

To the Editor of Engineering.

Sir,—I am indebted to Mr. J. E. C. Stringer for the information given in his letter in your issue of May 30, on page 689, *ante*. Although his results indicate a general tendency for the locking force due to dirt to increase with oil pressure, it is clear that there is no direct relationship between the two.

With reference to the comparison of the plain and grooved pistons, Mr. Stringer ignores the fact that eccentric locking is attributed to lack of geometrical truth of the surfaces, i.e., to the existence of an overall axial taper. The influence of surface micro-finish is probably only secondary.

Yours faithfully,
D. C. Sweeney.

Buswell & Sweeney, Limited,
Metro Works,
Bolton Street,
Bordesley,
Birmingham, 9.
June 6, 1952.

MECHANICAL HANDLING EXHIBITION.

(*Concluded from page* 710.)

In this issue we conclude our description of some representative exhibits at the third Mechanical Handling Exhibition at Olympia, which closes tomorrow. Many machines of considerable interest have been on view, of which it has only been possible to select a few for description.

Radio Control for Cranes.

An exhibit that has attracted great attention is a three-motion overhead travelling crane displayed by the Vaughan Crane Company, Limited, West Gorton, Manchester, 12, remotely controlled by radio by an operator who sees before him on a television screen the motions of the load being handled. This system of control, known as Vestrad, has been developed by the Vaughan company, in conjunction with the Ministry of Supply and Messrs. Heenan and Froude, Limited, for use in industrial processes where it is not practicable to deal at close quarters with the materials being handled. The television camera recording the crane movement is supplied by Messrs. Marconi's Wireless Telegraph Company, Limited, Chelmsford, Essex.

Vestrad radio control comprises two main units, a portable transmitter worn by the operator, and the receiving unit panel on the crane. The operator, who has in front of him a television screen, controls the crane from a small portable push-button panel which he carries or which can, alternatively, be mounted on a light two-wheel trolley or can be fixed. Transmission is on the closed-loop system, and may be made from any point within the area of the crane gantry, and up to 20 ft. or 30 ft. outside this area. Independent carrier waves with frequencies of 52, 56 and 61 kilocycles per second, control respectively the hoisting, travelling and traversing motions of the crane, simultaneously if desired. The loop aerial is carried round the crane gantry. The receiving unit panel comprises amplifiers, selectors and tuned relays to deal with the tone sources superimposed on each carrier wave. A post-office type uni-selector relay controls the contactor gear of each crane motion. Induction-type limit switches are provided to prevent overrunning.

Automatic Conveyor Control by Punched Cards.

An interesting development in mechanical handling is the automatically-controlled conveyor feed-line installation introduced recently at the Austin Motor Company's car-assembly plant at Longbridge, near Birmingham. The sub-assemblies, which arrive at a central marshalling area from the individual factories, are automatically selected and delivered by a Hollerith punched-card system in their correct sequence to the final assembly line. A model illustrating the principle of selection at Longbridge is displayed on the stand of Messrs. George W. King, Limited, Hitchin, Hertfordshire, who installed the dual-duty overhead-conveyor system at the Austin works in co-operation with Hollerith Electrical Accounting Machines. Messrs. King are also showing examples of their conveyors, and conveyor tracks; a range of electric and hand-operated chain-pulley blocks, including a new light-weight geared hand chain block which can lift 1,120 lb. for an applied effort of 42 lb., and an ingenious grab for handling paper reels and sorting them vertically. The grab mechanism consists of a hinged friction clutch mounted on a cylinder which is lowered into the bore of the paper reel. The clutch is engaged by the weight of the reel itself: as the hoisting action is applied, through a scissor linkage, to an operating spindle passing through the centre of the cylinder, a hardened cone mounted on the spindle forces the faces of the friction clutch outwards against the inner face of the reel so that the latter is held firmly and can be manœuvred.

Bottle-Crating Machine.

Crawley Industrial Products, Limited, 46-48, Wellesley-road, Croydon, Surrey, are showing a pneumatically-operated machine for crating bottles, developed in the first place for the brewing industry. The machine consumes 6 cub. ft. of free air per minute and requires an operating pressure of 40 lb. per sq. in. It has an output of 600 to 650 dozen bottles per hour, of 300 cases containing 24 half-pint bottles per hour. The bottles are carried into the machine by a conveyor driven by a $\frac{1}{2}$-h.p. geared motor. As they enter the machine, they are automatically marshalled into lanes and then pass on to a marshalling table, which rises to present the bottle necks to gripper heads which grip the bottles pneumatically. The marshalling table then returns to its original position to receive the next set of bottles. The empty crates are brought into the machine on another conveyor, and are prevented from entering by an arrester mechanism which opens automatically when a full crate has been discharged, and allows the crate to pass on to an elevating cradle. The gripper-head carriage shifts to a position over the crate-elevating cradle so that the bottles are aligned over the cells of the crate, the latter being held by an aligning device on the elevating cradle. The cradle rises, offering up the crate through a height sufficient to receive the bottles and ensure that they are resting on the base of the crate before the grippers are released. The crate-elevating cradle is then tilted so that the crate slides on to the discharge conveyor, and the gripper head carriage returns to its position over the marshalling table. A de-crating machine, similar in principle, is also available, most of the parts being interchangeable with those of the crating machine.

10,000-Lb. Fork-Lift Truck.

Messrs. Coventry Climax Engines, Limited, Widdrington-road Works, Coventry, are showing a range of Diesel-engined lift trucks, including two flame-proof trucks developed for use in refineries and chemical works, where there is a fire hazard from explosive atmospheres. One of the flame-proof vehicles is a drum-carrier lift truck, fitted with spark-arresting gear and a water quench tank, for handling inflammable materials in open areas. The other is a fork-lift truck with a lifting capacity of 2,000 lb. at 15-in. load centres, and a maximum lift of 9 ft. It is powered by a two-cylinder four-stroke water-cooled Diesel engine fitted with an exhaust-spark arrester and a water quench tank. Two other new fork-lift trucks on view include a truck of 2,000 lb. load capacity at 20-in. centres, driven by a two-cylinder Coventry Diesel engine, with a maximum lift of 12 ft. and a turning radius of 6 ft.; and a large truck with a lifting capacity of 10,000 lb. at 20 in. from the heel of the forks, and a maximum lift of 50 in. The tilting range is from 10 deg. back to 3 deg. forward. It is fitted with a four-cylinder four-stroke Coventry Diesel engine, and the gearbox provides four speeds forward and reverse, ranging from 2·4 m.p.h. in bottom gear to 13·9 m.p.h. in top gear. Power-assisted steering is provided and the vehicle has a turning radius of 12 ft. Hydraulically-operated Girling brakes are fitted. The firm also show two- and four-cylinder Diesel power units, and a $12\frac{1}{2}$-cub. ft. power-operated shovel.

EXHIBITS AT THE MECHANICAL HANDLING EXHIBITION.

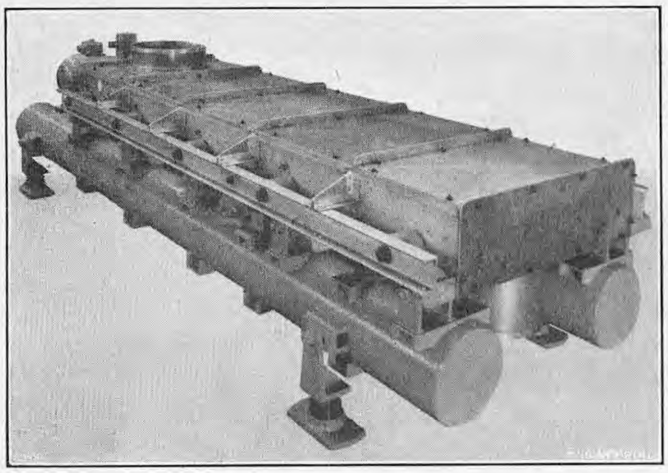


FIG. 16. ENCLOSED VIBRATORY SCREEN; GEORGE DRIVER AND SON, LIMITED.

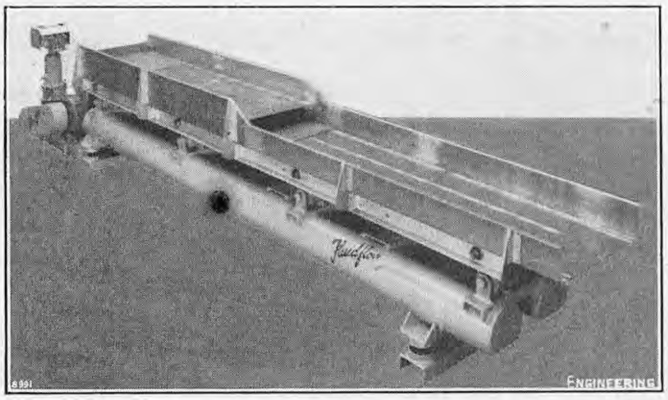


FIG. 17. FEEDER CONVEYOR, WITH AUTOMATIC FEED MECHANISM; GEORGE DRIVER AND SON, LIMITED.

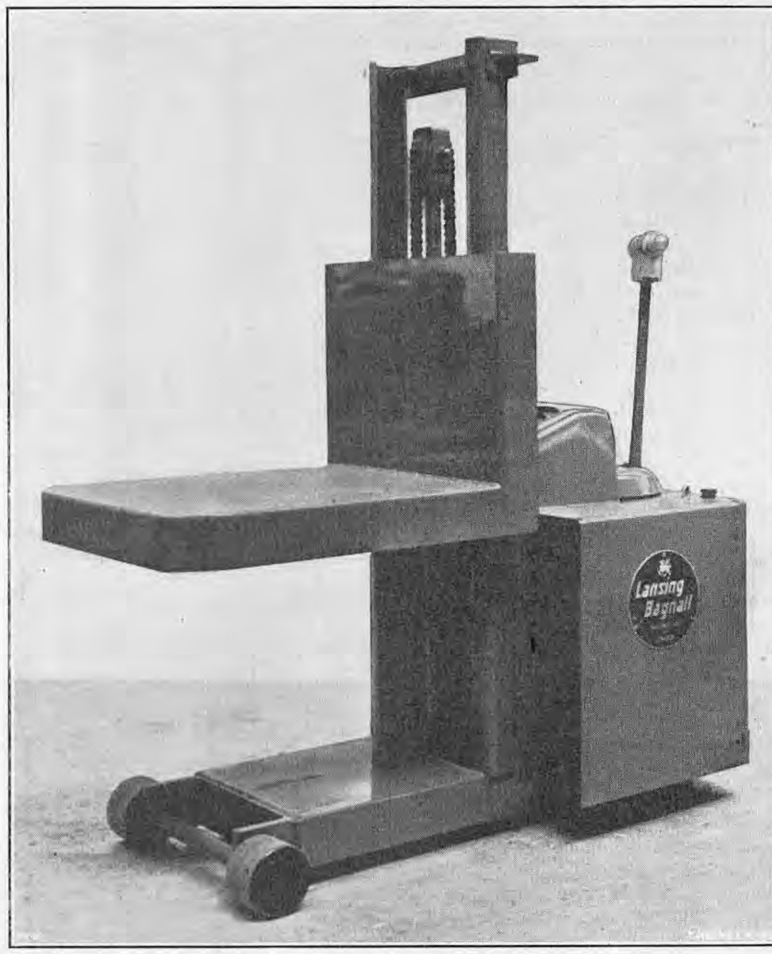


FIG. 18. DIE-HANDLING TRUCK; LANSING-BAGNALL, LIMITED.

ELEVATING TRUCK WITH AUTOMATIC BRAKING.

Messrs. Brush Coachwork, Limited, Loughborough, Leicestershire, are showing examples of their battery-operated electric industrial tractors and elevating trucks. One of the latter is fitted with their new automatic braking system in which the traction drive is controlled by a single pedal. When the pedal is released, a spring-loaded brake is applied. As the pedal is depressed, the braking force is progressively reduced until, after half the pedal travel, the brake is completely released. The second half of the travel operates the controller for the traction motor. The leverage is arranged so that the spring load can be overcome by a reasonable foot pressure, which decreases as the pedal is depressed, so that only a light foot pressure is required to hold the pedal fully depressed in the driving position.

SYNCHRONISED HYDRAULIC JACKS.

Messrs. Power Jacks, Limited, Valetta-road, London, W.3, are exhibiting their new Synchro-jacks, comprising a pair of hydraulic jacks fed by the same hydraulic pump and arranged to work in synchronism. The jacks are unequal in size, the primary jack, which is connected directly to the pump pressure line, being of larger diameter than the secondary jack. The area of the secondary piston is, in fact, equal to the small area of the primary piston, i.e., the area of the annulus between the primary cylinder and piston rod. Fluid displaced by the primary piston during its pressure stroke acts on the face of the secondary piston, which is therefore raised simultaneously through the same height as the primary piston, even though the loads on the two jacks may be unequal.

CONVEYOR BELTING.

Examples of industrial hose and conveyor belting specially developed for use in coal mines is being exhibited by several firms, including the British Tyre and Rubber Company, Limited, Herger House, Vincent-square, London, S.W.1, who are showing the Super Pitmaster belting developed for use with 200-h.p. drive heads for exceptionally heavy colliery work; the Goodyear Tyre and Rubber Company (Great Britain), Limited, Bushbury, Wolverhampton, who show a belt for use with coal-fine loaders and bottom belt conveyors; and the Dunlop Rubber Company, Limited, Cambridge-street, Manchester, 1, who are showing a working section of a mine conveyor unit fitted with a flameproof polyvinyl-chloride belt, also suitable for handling foodstuffs. The Dunlop company will also show for the first time a water jib hose, adopted by the railways instead of riveted leather hose, for carrying water to the engine tender. Under freezing conditions, the rubber hose retains its normal shape whereas the leather hose tends to collapse.

HYDRAULIC VIBRATORY CONVEYORS AND FEEDERS.

Messrs. George Driver and Son, Limited, Abbeydale-road, Wembley, Middlesex, who manufacture vibratory equipment in which a hydraulic transmission provides the vibratory action, are showing examples of screening conveyors, feeders, helical elevators, and automatic weighing and filling machines. An enclosed vibratory screen of the wire-mesh type is illustrated in Fig. 16, and Fig. 17 shows a feeder conveyor equipped with an automatic feed mechanism for operating in conjunction with an automatic weighing machine. The movement of the hopper on the weighing machine actuates solenoids which control the motion of the conveyor, providing a coarse-feed rate, a "dribble" feed as the hopper is nearly filled, and stopping the conveyor when the correct weight has entered the hopper. After discharge of the latter the conveyor motor is automatically switched on.

As in all Driver conveying equipment, the conveyor trough, constructed in a high-strength light alloy, is supported on springs on a base, which can be resiliently mounted to isolate the supporting structure. Pressure impulses, at the natural frequency of the system, are provided by a hydraulic plunger pump driven by an electric motor, and are transmitted through a pipeline of fluid to a receiver piston making contact with the trough on its forward stroke, and thus setting the trough in vibration in such a way that the material is propelled forward. A valve in the hydraulic line gives a wide range of control over the amplitude of the vibration and it is claimed by the manufacturers that larger amplitudes, and therefore higher feed rates, are possible with hydraulic excitation than with other forms of high-frequency vibrators.

DIE-HANDLING TRUCK.

Messrs. Lansing-Bagnall, Limited, Basingstoke, Hampshire, are showing examples of their industrial tractors, including a new Diesel-driven tractor, with a four-cylinder Perkins P 4 Diesel engine developing 62 brake horse-power at 2,000 r.p.m., with a maximum draw-bar pull of 4,500 lb. They are also showing many examples of their wide range of trucks, included a new hand-operated 1-ton pallet truck with a hydraulic lifting system operated by the steering handle; a power-jack truck, for raising vehicles with a vertical lift ranging from $9\frac{1}{2}$ in. low to a maximum of 27 in.; and a 1-ton electrically-operated truck, developed for transporting and lifting dies, a photograph of which is reproduced in Fig. 18.

It is fitted with their standard pedestrian power unit, which embodies the traction drive and brake, ball-track steering, hydraulic lifting mechanism, and the control gear. Batteries are fitted on each side of the power unit behind heavy steel doors secured with quick-release locks. The mast assembly comprises an electrically-welded structure of heavy channel-section steel members. The platform carriage runs on hardened-steel roller bearings inside the mast channel. Adjustable rollers, similarly mounted, resist the side thrust. The platform,

EXHIBITS AT THE MECHANICAL HANDLING EXHIBITION.

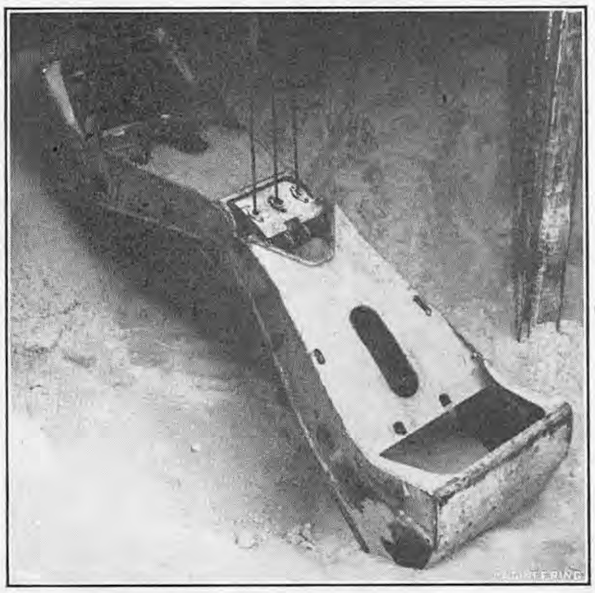


Fig. 19. Scraper Grab; Priestman Brothers, Limited.

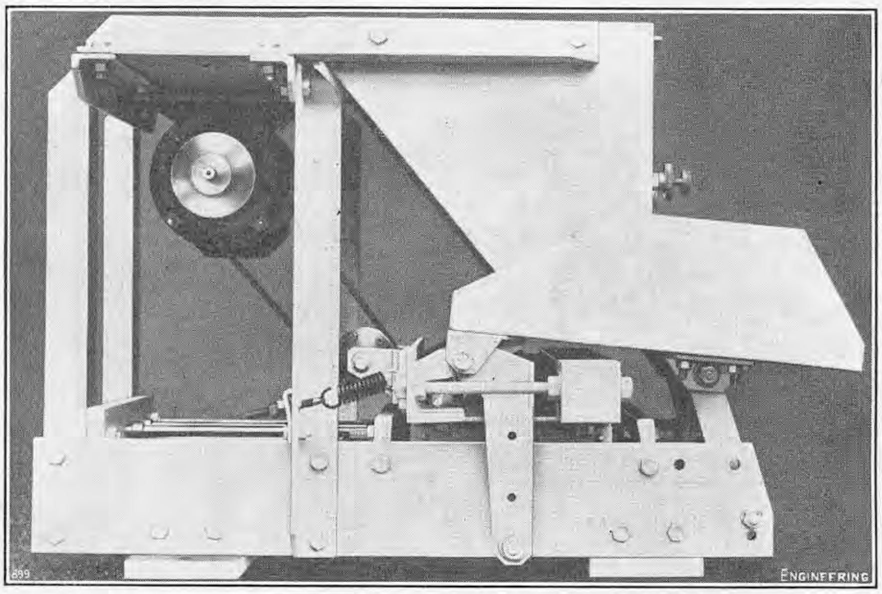


Fig. 20. Vibratory Feeder; Simon Handling Engineers, Limited.

which measures 27 in. by 30 in., has a lowered height of 6 in. and can be raised to 52 in. by a heavy-duty single-extending hydraulic ram in the mast, operated by an electrically-driven pump and controlled, through a solenoid switch, by a push-button. The lowering speed is regulated by a screw release valve.

Scraper Grab with 19-ft. Spread.

Messrs. Priestman Brothers, Limited, Holderness Engineering Works, Hull, are showing a Priestman-Voorwinde grab of 70 cub. ft. capacity, which is to go into service with the Tyne Improvement Commission, for handling iron ore. It has a specific volume from 10 cub. ft. to $17\frac{1}{2}$ cub. ft. per ton, and operates from a four-rope 10-ton crane. It can also operate from a two- or three-line crane. This type of grab has been widely used on the Continent for many years, but has only recently been introduced in this country. The jaws of the Priestman-Voorwinde grab, a photograph of which is reproduced in Fig. 19, are integral with the grab arms. The lips are in cast manganese steel. On account of its rigidity and simple construction, maintenance costs are low. As may be appreciated from Fig. 19, the open height of the grab is considerably less than that of the normal clamshell grab—it is, in fact, 4 ft. 11 in.—and, therefore, in unloading a ship it can be slid under the coamings or between decks at an early stage in the discharge, so that the level of the cargo can be kept constant. The grab, which weighs 97 cwt. empty, has a spread of 19 ft. and the jaws are 7 ft. 7 in. wide. With the jaws closed, the height is 10 ft. 8 in.

Vibratory Feeder.

Messrs. Simon Handling Engineers, Limited, Cheadle Heath, Stockport, are demonstrating a closed-air circuit pneumatic conveying system in which the conveying air is continually recirculated so that no dust or fumes can escape to atmosphere, and the material being handled is protected from contamination. They are also showing a typical vacuum pump for pneumatic-conveying installations, and models of a 300-ton per hour floating pneumatic grain-discharging plant, two of which have been constructed for the Port of London Authority, and a 150,000-ton terminal grain elevator at Buenos Aires. Also on view is a new type of vibratory feeder, known as the Velofeeder, which can operate over a wide range of feed rate and can handle a large variety of materials, including those with high moisture content or with other characteristics that render them difficult to handle. It has a high maximum output and a low power consumption.

A photograph of the Velofeeder is reproduced in Fig. 20. The "stroke" over which the feed-tray vibrates can be varied from practically zero to a maximum of nearly $\frac{1}{4}$ in. at a frequency of 1,850 vibrations per minute. The motion of the tray is produced by a $\frac{1}{8}$-h.p. motor driving a small eccentric weight which produces impulses in an "anvil" arranged to oscillate between two springs. On its backward movement, the anvil collides with a rubber pad on the vibrating feed tray, which oscillates between two further springs, the arrangement of the springs and mountings being designed so that the two masses—the anvil and the feed tray—oscillate in opposition. The force of the impact, which determines the amplitude of vibration of the feed tray, is regulated by altering the distance between the two masses, which is carried out by turning a handwheel. The rate of flow can thereby be controlled with great precision. The machine is practically self-balancing and transmits little or no vibration to the frame. The Velofeeder is available with a variety of sizes and types of tray, and can be provided with remote control, or with an electronic servo-controller to adjust the feed rate in proportion to any measurable variant. It

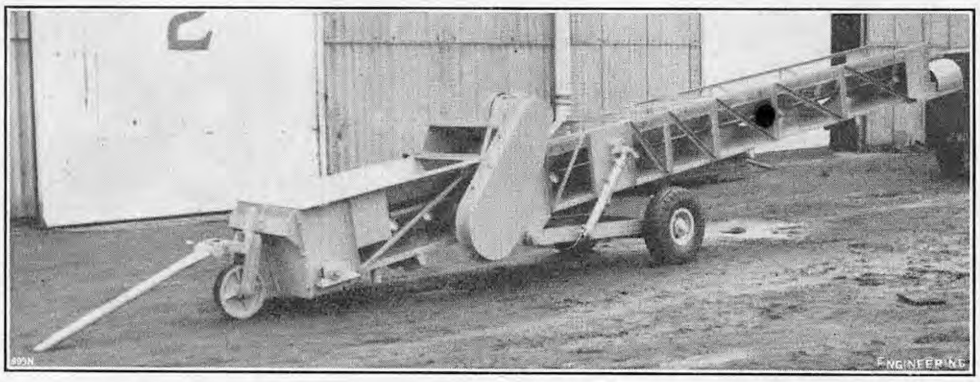


Fig. 21. Light Mobile Stacker; Crone and Taylor, Limited.

Fig. 22. Transportable Conveyor; Fourways (Engineers), Limited.

can be used, for example, to maintain a constant temperature in dryers and roasters by automatically regulating the feed.

LIGHT MOBILE STACKERS.

Messrs. Crone and Taylor, Limited, Sutton Oak, St. Helens, Lancashire, are showing examples of their mobile stackers, a mobile bag-filling machine, a standard sectional fixed conveyor, and a mobile disintegrator. Their 40-ft. Supermobile bulk stacker, with a 24-in. belt, is on view at the exhibition fitted with an electric motor; it is also available with a two-cylinder Diesel engine. The delivery height may be varied from 7 ft. 6 in. to 24 ft. by power-operated hydraulic jacks in 55 seconds. The machine is capable of stacking 100 tons of 2-in. stone per hour. Also on view is their 25-ft. light mobile stacker with an 18-in. belt, for handling loose materials, illustrated in Fig. 21. It is intended for factory and works use, but not for towing for long distances on the road. It is available with an electric motor or with a Diesel or petrol engine. It can stack coal up to 3-in. size at a rate of up to 30 tons per hour. The height can be adjusted by two hydraulic rams, operated by a hand-pump, from 3 ft. 2 in. to 13 ft. in two minutes. Another recently-developed stacker on view is their 25-ft. machine for stacking bags and packages. The overall width of the machine is less than 4 ft., so that it is suitable for use in restricted warehouse passages. It will handle packages up to 2 cwt. at the rate of 60 tons per hour. It is provided with power-operated hydraulic rams for adjusting the height between 5 ft. 9 in. and 16 ft. 8 in.

TRANSPORTABLE CONVEYOR.

Messrs. Fourways (Engineers) Limited, Thornwood Common, Epping, Essex, are showing a range of portable conveyors for handling pieces up to 3 cwt. Fig. 22 shows their J.E. transportable hinged conveyor capable of carrying a unit load of 2 cwt., and a maximum load of 8 cwt. In this machine a continuous track passes over both booms, and the drive is arranged so that the booms can be operated independently by hydraulic jacks. The conveyor may be electrically driven or fitted with a petrol engine. It is available in two sizes with lifts ranging from 1 ft. 3 in. to 10 ft. 6 in. and 12 ft., respectively.

Among many other interesting exhibits at the Mechanical Handling exhibition may be mentioned the 18,000-lb. Freightlifter heavy-duty fork-lift truck shown by Messrs. Shelvoke and Drewry Limited, Letchworth, Hertfordshire; marshalling gear and wagon tipplers demonstrated by Messrs. Strachan and Henshaw, Limited, Steelhoist Works, Victoria-road, St. Philips, Bristol, 2; an electrically-driven machine for tipping and emptying up to 360 milk churns in one hour, and a 1-ton portable telescopic jib crane exhibited by Messrs. J. W. Flower and Company (Engineers), Limited, Eclipse Works, Wimborne, Dorset. Messrs. Conveyors (Ready Built) Limited, Cainscross Works, Stroud, Gloucestershire, are showing a new bulk hopper discharger incorporating a conveyor, and their new Z-type combined elevator-conveyor unit which operates on a single continuous chain. A belt vulcaniser, for repairing canvas or rubber belting, fitted with a thermostatically-controlled heating pad, is on view on the stand of Messrs. Stenor Limited, 37, Kew Foot-road, Richmond, Surrey. A range of geared electric motors, from $\frac{1}{8}$ h.p. to 27 h.p., and reduction gearboxes, one of which has a reduction ratio of 7,000 to 1, are shown by Messrs. Electropower Gears, Limited, Kingsbury Works, Kingsbury-road, London, N.W.9, together with their new magnetically-operated friction-disc brake designed for motors up to 2 h.p. The Aldersley Engineering Company, Limited, Aldersley-road, Tettenhall, Wolverhampton, are showing a new pre-cleaner and aspirator for grain, in addition to a range of chain and worm conveyors, bucket elevators, grain dryers, and storage bins. To reduce the multiplicity of steel wire ropes that are at present called for, the British wire-rope industry has recently put forward recommendations for standard sizes, forms of construction, and specifications for wire ropes; examples of some of the standard constructions are displayed by British Ropes, Limited, Carr Hill, Balby, Doncaster.

THE NEWCOMEN SOCIETY.

THE Newcomen Society ("for the Study of the History of Engineering and Technology") commonly selects as the venue for its summer meeting some centre from which to tour the surrounding area in search of old types of machinery or scientific apparatus, sites of former industrial activities in which specialised technologies and handicrafts are involved, or considerable engineering works of some antiquity, such as early canals, railways, and fen drainage systems. This year, the centre chosen was the city of York and a part of the East Riding of Yorkshire, extending almost as far as Hull. When York was first suggested, it may be remarked, some doubt was expressed whether there remained in that area sufficient material of engineering historical interest to provide a three days' programme; but a preliminary inquiry, initially conducted in York itself through Mr. G. F. Willmot, curator of the Yorkshire Philosophical Society, and Mr. C. J. Minter, O.B.E., the city engineer, and in the eastern part of the county by a member of the Newcomen Society, Mr. Leslie Downs, M.A., managing director of Messrs. Rose, Downs and Thompson, Limited—whose engineering business was established in Hull in 1777—indicated that there was much more to be seen than could be covered in the limited time available.

A party of some 56 members and ladies gathered in York on the afternoon of Wednesday, June 4, where, at the Mansion House, they were received by the Rt. Hon. the Lord Mayor (Alderman C. W. Wright), who was accompanied by the Lady Mayoress, the Sheriff (Mr. F. Shepherd) and the Sheriff's lady, and were shown the unique collection of the city's civic plate. On the following morning, they visited the pumping station of the York Waterworks Company, where they were received by the chairman of the company (Mr. G. Y. Johnson) and the chief engineer (Mr. H. Whitehouse, M.I.W.E.). Most of the city's water supply is now delivered by Mather and Platt centrifugal pumps, some driven by electric motors and others by Vickers-Petter Diesel engines; but, in recognition of the Society's historical interests, the only remaining steam plant—a Worthington triple-expansion pumping engine installed in 1907—was shown in steam. This engine has cylinders 16 in., 25 in. and 42 in. bore by 24 in. stroke, with pump plungers 22 in. and 23 in. in diameter for the high-lift and low-lift engines, respectively. At the normal speed of 28 strokes per minute, the pumping engine delivers 5,000,000 gallons a day. The horse-power is 246 and the working steam pressure is 100 lb. per square inch. The makers' drawings were also on view, together with drawings of an earlier engine designed by John Smeaton, and of its successor, by Hawks, Crawshay and Company, of Gateshead. Also on view were some wooden water pipes, originally laid in Walmgate.

The next visit was to the works of Messrs. Cooke, Troughton and Simms, Limited, where the party was received by Mr. J. Simms Wilson and Mr. P. D. Scott-Maxwell. The business was established in Fleet-street, London, in 1688, by John Worgan, maker of mathematical instruments, coming eventually into the hands of Edward Troughton, F.R.S. (1753-1836), who was joined in 1826 by William Simms, F.R.S. Thomas Cooke (1807-1868) founded a separate business in York in 1837 as a maker of telescopes. It came under the control of Vickers Limited in 1916, as did that of Troughton and Simms some years later. The two firms were amalgamated in 1922. Many relics of both undertakings were displayed for examination by the Newcomen Society, who also saw two circular dividing engines at work (one dated 1867 and the other 1908) and witnessed the modern processes of "blooming" lenses, alloy plating with tin and copper, the polishing of microscope lenses, etc.

The afternoon of June 5 was spent in the Castle Museum and the Railway Museum. At the Castle Museum, under the guidance of the curator, Mr. R. Patterson, and the assistant curator, Mr. C. M. Mitchell, the members were able to study in detail the various craftsmen's workshops—tanner, currier, comb-maker, smith, wheelwright, etc.—which are the latest extensions of this admirable folk museum. The visit to the Railway Museum was rather complicated by the fact that this collection is housed in two separate buildings, nearly half a mile apart; the party's coaches deposited their occupants at the "heavy" section, where the historic locomotives are displayed, whereas others, who had gone from the Castle Museum on foot, saw only the documentary section. In the evening, the Society's annual dinner was held at the Royal Station Hotel, the members and guests—who included the Lord Mayor and Lady Mayoress, the Sheriff and the Sheriff's lady—being received by the President of the Society, Mr. J. Foster Petree, and Mrs. Petree. During the evening, Mr. C. M. Mitchell described the rise and decline of some of the vanished trades of York, a subject of which he had made an intensive study.

On Friday, June 6, the party proceeded in two motor coaches in the direction of Hull, halting to inspect the water mill at Welton, with its iron wheel (dating from 1861), 36 ft. in diameter and 3 ft. wide, which, when working, drove the mill from a rack on its periphery. The water is led to the wheel by a siphon pipe—a most unusual feature. They then visited the windmill at Skidby, reputedly the last working windmill in Yorkshire. Both windmill and watermill are owned by Messrs. J. G. and B. Thompson, Limited, of Hull, whose managers, Mr. Russell and Mr. Ling, respectively, acted as guides to their mills. From Skidby, the party proceeded to the Springhead pumping station of the Kingston-upon-Hull water undertaking, to which they had been invited by the water engineer, Mr. T. H. Jones, M.I.C.E. Here they enjoyed to the full an unexpected pleasure. They had known that, in addition to two James Simpson rotative engines, a triple-expansion Worthington pumping engine and a Hawthorn Davey horizontal duplex set, there was a 90-in. Cornish engine, made in 1876 by Bells, Lightfoot and Company, of Newcastle-on-Tyne; but it was understood that this engine was not working—indeed, that the staff of the undertaking no longer included any driver of Cornish engines. For the special benefit of the Society, however, Mr. Jones had "borrowed" a Cornish-engine driver from London, from the Metropolitan Water Board, by courtesy of the Board's chief engineer, Mr. H. F. Cronin, M.I.C.E.; so that they were able to see this stately engine pumping at the rate of a steady 5,000,000 gallons a day. The engine, of 300 h.p., has a stroke of 10 ft. 6 in. and works at ten strokes a minute, using steam at 100 lb. per square inch. The beam is 40 ft. long and weighs about 40 tons.

After lunch at Cottingham, the party went on to Beverley, to visit the shipyard of Messrs. Cook, Welton and Gemmell, Limited, where they were received by the chairman, Mr. Harold E. Sheardown. In this shipyard, which constructs trawlers, small tankers, etc., up to about 750 tons gross, the vessels are launched sideways into the River Hull. It was not possible for the Newcomen members to witness a launch (though some had entertained hopes of doing so); but several vessels were nearly ready for launching and one was in the water, being fitted out. These were duly inspected, and the various trades of a modern shipyard were seen in operation. On the return journey to York, the members were hospitably entertained by Mr. Leslie Downs and Mrs. Downs at their home, King's Mill House, Great Driffield—a relatively modern house, constructed on the site of a former water mill, the "pedigree" of which is traceable back to the Domesday Book. This concluded the official programme (so far as anything connected with the Newcomen Society can be termed "official"); but a number of the members, who were staying in York on the Saturday, were able to visit the museums of the Yorkshire Philosophical Society, by courtesy of Mr. G. F. Willmot, and to see, among many other exhibits, the mechanically-propelled wheel chair of General Lord Fairfax, of Civil War fame, which was constructed about 1670 and embodies various ingenious mechanisms.

THE LATE MR. A. H. M. JACOB.—We note with regret the death on June 3 of Mr. A. H. M. Jacob, an executive director of W. T. Henley's Telegraph Works Co., Ltd. He was a Companion of the Institution of Electrical Engineers and had been with the company since 1906.

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.

Electrodes for Metal-Arc Welding of Steel.—A revision of B.S. No. 639 supersedes the 1935 edition. The specification relates to covered electrodes of No. 12 S.W.G. ($\frac{3}{32}$ in.) and thicker sizes for the metal-arc welding (by hand operation) of mild steel of welding quality. It is divided into three parts, the first specifying the general requirements for all types of covered electrodes. The second part specifies additional requirements for normal penetration electrodes for use in one or more welding positions. Part three specifies additional requirements for electrodes of the deep penetration type for close unprepared butt welding in the flat position and for fillet welding in the flat and horizontal-vertical positions. A comprehensive scheme for testing electrodes is laid down. [Price 4*s*., postage included.]

Colour Code for Thermocouple Twin Compensating Cables.—A new specification, B.S. No. 1843, provides a system of colour-coding for twin compensating cables for thermocouples which will indicate the nature of the thermocouple with which the compensating cable is intended to be used and also the polarity of the individual conductor. Five thermocouple combinations are covered, namely, copper *v.* constantan; nickel/chromium *v.* constantan; iron *v.* constantan; nickel/chromium *v.* nickel/aluminium; and platinum/rhodium *v.* platinum. [Price 1*s*., postage included.]

Enamelled Round Copper Wire.—A further specification in the series relating to covered wires for winding coils for electrical apparatus has been published. This B.S. No. 1844, applies to round copper wire insulated with a synthetic varnish based on a vinyl acetal resin. All sizes of wire from 0·002 in. to 0·160 in. diameter, commonly in use, are included. Four classes differing in the thickness of the insulation are provided for and these are designated fine (F), medium (M), thick (T), and extra thick (X), respectively. The specification contains details regarding the enamel insulation, the elongation of the enamelled wire, and the continuity of the covering. It includes also methods of test for the measurement of the conductor diameter and the overall diameter, for the hardness of the enamel, the electric strength, and for the continuity of the covering. [Price 4*s*., postage included.]

Bitumen Road Emulsion for Penetration and Surface Dressing.—A second revision of B.S. No. 434, originally issued in 1931 and revised for the first time in 1935. It specifies the requirements for bitumen road emulsion for penetration (grouting and semi-grouting) and surface dressing. Emulsions for special purposes, such as tack-coat, retread, and curing concrete, are excluded. The specification covers the composition of the emulsion, requirements for the bitumen used in its manufacture, the proportion of emulsifying agent, the sampling of the emulsion for testing, and the determination of such quantities and properties as the water content, the residue on sieving, storage stability, the coagulation of the emulsion at low temperatures, and the viscosity of the emulsion. In the present revision, the opportunity has been taken to introduce a sedimentation test to supplement the test for storage stability already available, and to include a permissive clause in the specification for bitumen to allow for the adjustment of its consistency so as to improve the performance of the material in cold, damp weather. A second part has been added to the specification to include a lability test. [Price 4*s*., postage included.]

Methods of Testing Raw Rubber.—A further section of the revision of B.S. No. 902 has been issued. This, which now constitutes Part 1 of B.S. No. 1673, covering methods of testing raw rubber and unvulcanised compounded rubber, relates to sampling. The method given for the sampling of bales of rubber are such that the portion submitted for testing will provide results which will give a reliable indication of the quality of the whole of the rubber which the test portion represents. An appendix relating to the assessment of the quality of homogeneous lots of raw rubber by a statistical technique, is included. [Price 2*s*., postage included.]

Power Rating of High-Frequency Induction Heating Equipment.—A new specification, B.S. No. 1799, stipulates the manner in which the power ratings of valve-driven high-frequency induction heating equipment are to be expressed. The significance of output voltage and current and power ratings, and examples of the methods of output power measurement, are given in appendices. The specification has been prepared to enable uniformity of practice to be achieved in the power rating of valve-driven high-frequency induction heating equipment, and to give guidance and information on the subject. [Price 2*s*. 6*d*., postage included.]

LABOUR NOTES.

The Ministry of Labour and National Service announced on Monday last that, owing to the need for economy in Government expenditure, eight of the Ministry's eleven appointments offices are to be closed. That at Liverpool was closed on May 30, and those at Birmingham, Bristol, Cardiff, Edinburgh, Leeds, Newcastle-upon-Tyne and Nottingham will close on June 28. From the end of this month, the appointments service for the whole country will operate from the three remaining offices, at London, Manchester and Glasgow. The London office, at 1-6, Tavistock-square, W.C.1, will serve South England, the Midlands and South Wales. The northern office, at Aytoun-street, Manchester, 1, will cover North Wales and the North of England, in general, as far as the southern borders of Yorkshire and Cheshire. The Scottish office, at 450, Sauchiehall-street, Glasgow, C.2, will provide facilities for the whole of Scotland. These three offices will continue their existing services of filling employers' vacancies in cases where these call for professional qualifications and experience, or experience in management or as a senior executive in industry or commerce, and of placing registrants possessing the necessary ability and experience.

Persons whose names are already on the registers of the closing appointments offices are being invited to register at the appointments office covering the area in which they are seeking employment. New applicants for employment of the kind dealt with at appointments offices should write, in the first instance, to the office serving the area in which they live. Unfilled vacancies registered at the appointments offices which are to be closed will be automatically transferred to the appropriate remaining office. Employers desiring to notify new vacancies should write to the appointments office serving their area, or they can, if they prefer, notify their requirements to the local office of the Ministry, which will see that details of the vacancies reach the appropriate appointments office. The London, Manchester and Scottish appointments offices will continue to serve their existing areas by providing interviews for giving advice to juveniles on the choice of a career. They will also continue their placing service for young men and women who are suitable for management-training posts. In those areas where appointments offices are closing, however, special arrangements are being made on a local basis for advice interviews and the placing of trainee executives. In these areas, this work will be carried out at the main employment exchanges at Birmingham, Bristol, Cardiff, Leeds, Newcastle-upon-Tyne and Nottingham.

The annual conference of the National Union of Seamen opened in London on Monday last. Mr. Tom Yates, the union's general secretary, in presenting the annual report, re-affirmed the view of the executive council that Britain's re-armament programme was necessary for the country's defence. He considered that a reduction of expenditure on arms would not materially alter Britain's problems respecting her international balance of payments. The adverse conditions affecting the country's living standards were likely to continue for some months to come and even for a longer period than that. There was no certainty that the transfer of raw materials, machinery and money from armament production would have any real chance of increasing the sale of British goods overseas. Mr. Yates expressed the view that there should be no slackening of efforts to build up strong British defences against aggression, without weakening the "system of European re-armament." He declared that it was his personal conviction that the real solution of the country's economic difficulties lay in the restoration of freer conditions of trade. It was reported that the union now had rather more than eighty thousand members.

Several sections of the staff of the British Overseas Airways Corporation employed at London Airport decided at a mass meeting on Monday last to introduce immediately a ban on all overtime and a policy of working to rule, as a protest against the reported rejection by the management of a wage demand for an increase of 30*s*. a week for skilled tradesmen engaged at the airport. At present, skilled men in the employ of the Corporation receive a basic wage of 7*l*. 15*s*. a week. Some 2,000 sheet-metal workers, maintenance men, electricians, labourers and cleaners, were affected during the early part of this week by the go-slow movement, which was expected to have a serious delaying effect on a number of air lines served by the airport. Employees at Filton and Northolt airports have been invited to take action in support of the men at London Airport.

No agreement has yet been reached between shipbuilding employers and the trade unions on Tyneside, regarding the claim by shipyard maintenance men for extra payment for working during annual holiday periods. Recently, engineering employers decided to make an extra payment of 6*d*. an hour for all hours other than overtime, worked during the holidays. When shipyards and engineering works conceded the employees' claim for two weeks' holiday with pay, the men agreed to give up certain premium days, for which they had been entitled to overtime rates. This decision, however, had an adverse effect on maintenance men, who usually work during the annual holiday periods, and who, as a result, will be paid at normal rates only, except for overtime hours.

A national conference of shop stewards employed in the electricity-supply industry took place at Birmingham last week-end. Delegates from London, Bristol, Birmingham, Carlisle, Warwick, Yorkshire and elsewhere, were present. It was stated after the meeting that, in the event of the British Electricity Authority rejecting the claim for an all-round wage increase of 3*d*. an hour for employees in the industry, which had been presented recently, the shop stewards would serve 21 days' notice to strike, on behalf of the men. The conference also agreed that, if the increase is granted by the B.E.A., the negotiating committee appointed by the trade unions concerned in the industry should be instructed to apply immediately for a further all-round increase of 3*d*. an hour. The statement added that seven days' strike notice would be served on the B.E.A. should any men engaged in the industry be declared redundant before the negotiating committee had been consulted.

A further stage has been reached in the National Coal Board's plan for the recruiting of Italians to relieve the man-power shortage in British pits. It was announced from Yorkshire on Tuesday that 178 Italians had left the Board's training centre at Maltby on that day for Belgium, where employment has been found for them in Belgian collieries. A further party of about 150, including men from Scotland and South Wales, is expected to leave for Belgium in the course of a few days. Another 200 Italians, who have failed to find alternative employment in Britain, have asked to be repatriated and will return to Italy next week. In all, some 2,300 Italians were brought to Britain for employment in the coal-mining industry and about half that number are at present serving in British pits, but the Board has found it impossible to place the remaining 1,100, owing to the refusal of British miners to accept Italian trainees.

About 400 of these 1,100 Italian trainees have now accepted employment in Britain outside the coal-mining industry. It is estimated that the loss to the Board, owing to its inability to place these men in British pits, will be in the region of 200,000*l*., as each man has received several months' training, at a cost of about 100*l*. a head, and the Board is paying the men's fares to and from this country. It has been agreed, also, that the Italians brought to Britain and not found employment in the coal-mining industry shall receive 40,000*l*. in compensation. The Board's director of recruitment and training stated on Tuesday that a fund had been set up to cover every man who was unable to obtain work in the pits, whether he had found a job outside the industry, was going to Belgium, or being repatriated. Each case would be dealt with on its merits and the family responsibilities, if any, of each individual would be taken into account.

A minimum weekly wage of 19*l*. 19*s*. for all miners engaged on piece-rate work, with proportionate minimum wages for other employees in the coal-mining industry, will be among the propositions to be considered at the annual conference of the Scottish area of the National Union of Mineworkers which is due to be held at Ayr from Wednesday to Friday next week. This suggested wage increase is being put forward by the union's Bannockburn branch as an amendment to a motion due to be submitted to the conference by the executive committee for the Scottish area. The committee's motion calls for an increase of 30*s*. a week in the wages of all persons employed "in and about" the coal-mining industry. The union's Castlehill branch is sponsoring a motion demanding an all-round increase of 50*s*. a week, to meet the rising cost of living.

A strike by the 15,000 employees of British Railways at London goods and parcels depots, due to have commenced on Tuesday last, was called off by the National Union of Railwaymen on the previous day, after the Railway Executive had undertaken to issue notices to all its wages staffs at Euston and St. Pancras informing them of its recognition of the N.U.R. as the only negotiating body for conducting negotiations in regard to rates of pay and conditions of service of those staffs. The difficulty had arisen owing to the suspension of 21 porters who had refused to handle parcels brought by vanmen belonging to the Mutual Aid Society, an organisation set up by goods and parcels staffs at Euston who formerly belonged to the N.U.R. The suspended men will be reinstated with full back pay.

FATIGUE STRENGTH IN BENDING AND DIRECT STRESS.

Fig. 1. 0·24 PER CENT. C. STEEL.

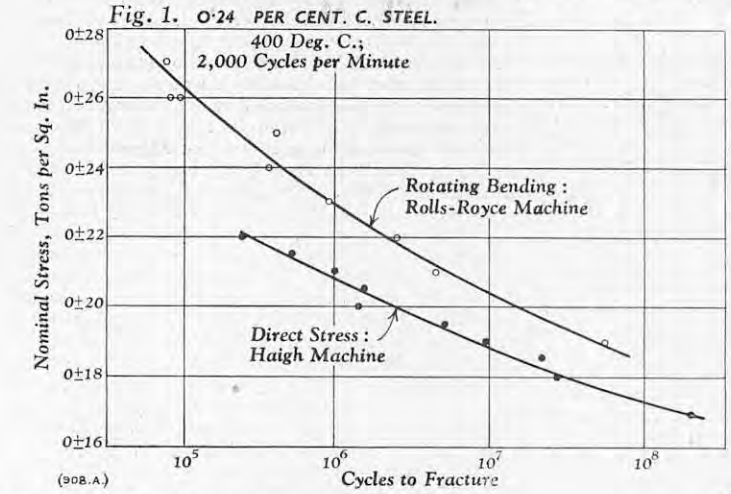


Fig. 2. R.R. 58 ALUMINIUM ALLOY.

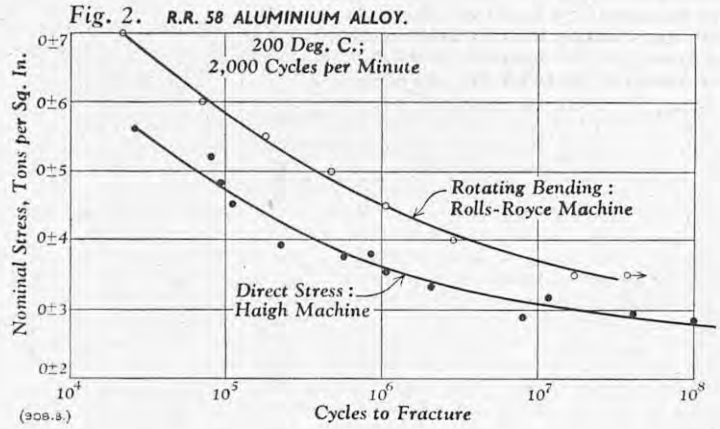


Fig. 3. DYNAMIC STRESS-STRAIN CURVE; 0·24 PER CENT. C. STEEL.

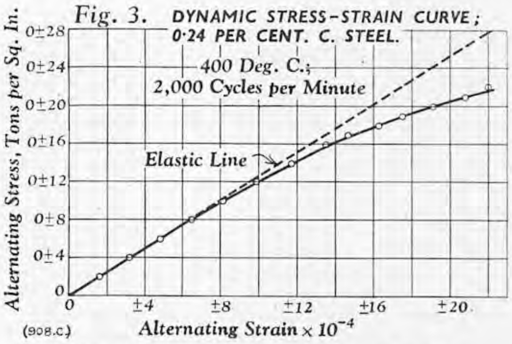


Fig. 4. DYNAMIC STRESS-STRAIN CURVE; ALUMINIUM ALLOY R.R. 58.

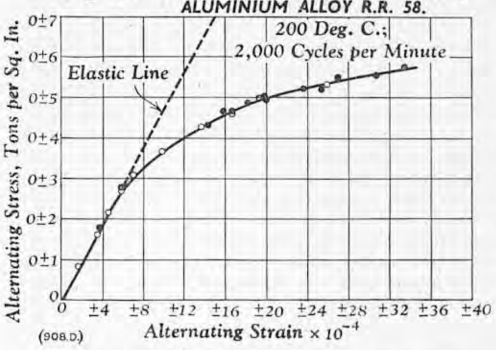


Fig. 5. RELATION BETWEEN NOMINAL STRESS AND MAXIMUM STRESS IN ROTATING BENDING FATIGUE TESTS.

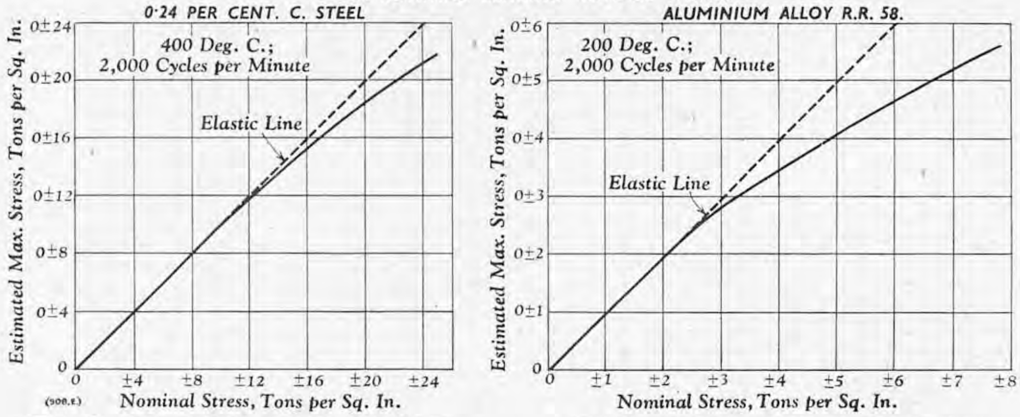


Fig. 6. 0·24 PER CENT. C. STEEL, 400 DEG. C.

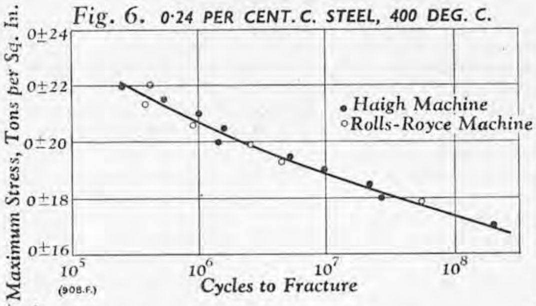


Fig. 7. R.R. 58 ALUMINIUM ALLOY.

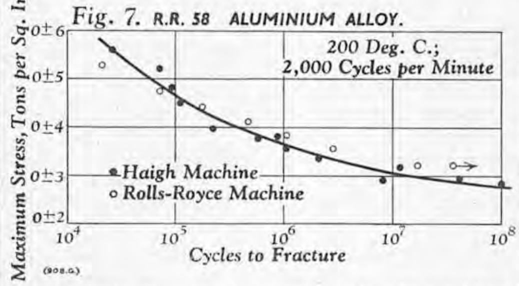
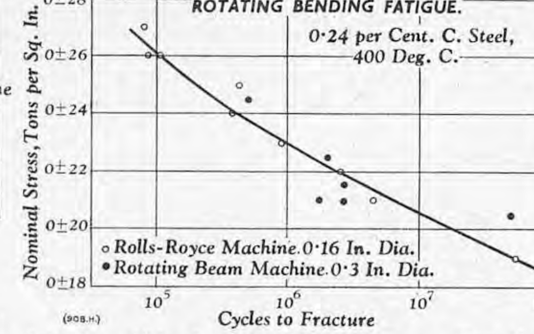


Fig. 8. TESTS ON 2 SIZES OF SPECIMENS IN ROTATING BENDING FATIGUE.



CORRELATION OF FATIGUE STRENGTH IN BENDING AND DIRECT STRESS.*

By P. G. FORREST, B.Sc. (Eng.) and H. J. TAPSELL, A.C.G.I., M.I.Mech.E.

IT is well known that the reported values of the fatigue strength of materials are higher for alternating bending than for alternating direct stress fatigue. One of the reasons for this is the method of stress calculation used in bending-fatigue tests. In these tests, a known bending moment or bending strain is applied to the test-piece; the maximum stress is then calculated by assuming that the test-piece deforms elastically. If, however, plastic deformation occurs in the highly stressed fibres, the stress will be less than the calculated figure. Gough† showed that the ratio $\frac{\text{fatigue strength in direct stress}}{\text{fatigue strength in rotating bending}}$ varied from 0·8 to 1·0 for various materials at air temperature. (A ratio of 1·0 might be obtained for those materials which have a fatigue limit of about the same value, or below the elastic limit.) In order to compare the stresses causing fatigue failure in bending and direct stress, it is thus necessary to estimate the maximum stress occurring in the bending tests. This is possible if the dynamic stress-strain relation at the appropriate cyclic speed is known for the material.‡ A similar procedure was first adopted by W. Mason,§ who obtained a dynamic stress-strain curve from tests on hollow tubes in alternating torsion and used it to estimate the stress distribution in a solid bar under alternating torsion.

A dynamic stress-strain curve may be obtained from a test in a direct-stress fatigue machine by measuring the strain of a test-piece for increasing values of the stress range. In applying such a curve to estimate the maximum stress in a bending fatigue test, a number of assumptions have to be made. In the work described herein, it is assumed that the strain for a given stress range will remain constant during a fatigue test. On some materials, which are known to be structurally stable at the test temperatures, it is found that, for a given stress range, the strain quickly settles down to a value which remains constant throughout most of the test, although increasing rapidly just before fracture. By measuring the strain for increasing values of the stress range on one test-piece, the material is subjected to a small amount of cyclic stressing at each stress range; it is considered reasonable to assume that this has no appreciable effect on the strain for higher stress ranges. It is further assumed that, in the bending fatigue tests, each fibre behaves independently, and that the stress-strain relation for the fibres is the same as that obtained in the direct stress test.

In a rotating bending-fatigue test, a known bending moment is applied to the test-piece. This bending moment is equal to $2\int_0^r f\,b\,y\,dy$, where f is the stress, b is the width of the section a distance y from the neutral axis, and r is half the diameter of the test-piece. The relation between the stress and the strain is given by the dynamic stress-strain curve, so that, assuming the strain is proportional to y, the integral can be solved by numerical integration for a particular value of the maximum strain. By repeating the integration for various values of the maximum strain, the relation between "nominal" stress (i.e., that stress calculated from the bending moment, assuming elastic conditions) and actual stress may be obtained. For reversed bending tests of constant amplitude of deflection, this relation may be obtained directly from the dynamic stress-strain curve.

During a research which is in progress on the fatigue strength of materials at elevated temperatures, to study the effect of cyclic speed, the effect of different types of loading, the effect of temperature, etc., some results have become available in both bending and direct stress on a normalised 0·24 per cent. carbon steel at 400 deg. C. and a fully softened aluminium alloy, R.R. 58, at 200 deg. C., both of which are structurally stable at the respective temperatures. In addition, dynamic stress-strain curves have been obtained and a correlation of the results has been made.

The steel, which was in the form of a bar 1 in. in diameter and was normalised, showed the following analysis: C, 0·24 per cent.; Si, 0·244 per cent.; S, 0·011 per cent.; P, 0·019 per cent.; Mn, 0·545 per cent.; Ni, 0·028 per cent.; Cr, trace. The tensile data were as given in Table I, on page 758.

The R.R.58 aluminium alloy contained Cu, 2·10 per cent.; Ni, 1·27 per cent.; Mg, 1·44 per cent.; Fe, 1·09 per cent.; Si, 0·23 per cent.; Ti, 0·05 per cent.; Al, balance. The material, in 1-in. diameter bar, was first heat-treated at the solution-treatment temperature of 530 deg. C., followed by air cooling to room temperature. It was then annealed at 360 deg. C. for two hours and

* Communication from the National Physical Laboratory. Abridged.

† *Fatigue of Metals*, by H. J. Gough, C.B., D.Sc., F.R.S.

‡ "Fatigue at High Temperatures," by H. J. Tapsell: Symposium on High-Temperature Steels and Alloys for Gas Turbines. *Jl. Iron and Steel Inst.*, 1951, page 169.

§ *Rept. of Brit. Assoc.*, 1923, page 386.

cooled at 10 deg. C. per hour to 100 deg. C., to bring it to the fully softened condition. The tensile data are given in Table II, below.

The tests were carried out in a Haigh direct-stress fatigue machine and in a Rolls-Royce cantilever single-point loading rotating bending-fatigue machine. Each machine was run at a frequency of 2,000 stress cycles per minute on both materials. The carbon-steel test specimens were 0·20 in. in diameter for the direct stress tests and 0·16 in. in diameter for the bending stress tests. For the aluminium alloy, the specimen diameters were 0·25 in. and 0·30 in., respectively. Figs. 1 and 2 show the endurance curve obtained; for the bending tests, nominal stresses are plotted.

During some of the Haigh machine tests, a mirror extensometer was fitted to the test-piece, so that a measure of the strain could be made while the test was proceeding. It was noted that, for both materials tested, the strain remained practically constant throughout the major portion of the test, increasing rapidly just before fracture. The dynamic stress-strain curves obtained in the Haigh machine are shown in Figs. 3 and 4, on page 757. A single test was made on the carbon steel, and two tests on the aluminium alloy. From these curves, the relation between the maximum stress and the nominal stress in the bending tests has been calculated by the method described (Fig. 5, on page 757). In Figs. 6 and 7, on the same page, the estimated maximum-stress endurance curves are plotted for the rotating bending-fatigue tests, allowing for stress redistribution in bending, and are compared with the direct stress endurance curves. Evidently, almost all the difference between the results in bending and in direct stress, for both materials tested, is due to stress redistribution. The stresses in the Haigh machine tests were measured indirectly in the usual manner, making use of a calibration curve; the probable error was ± 5 per cent. Another factor which might cause lack of close correlation is size effect. Although it is usually found that little or no size effect exists in direct stress on plain specimens,* considerable size effect is found to occur for some materials in rotating bending, particularly for small sizes.†‡ Direct evidence is required, therefore, for any particular material and temperature.

Some indirect evidence concerning size effect has been obtained on the 0·24 per cent. C steel. In addition to the tests in the Rolls-Royce machine on test-pieces of 0·16 in. diameter, a stress endurance determination was made in a rotating-beam fatigue machine, also at 2,000 cycles per minute, on test-pieces of 0·30 in. diameter. A comparison of the results is shown in Fig. 8, herewith. Although the results on the rotating-beam machine are few and show considerable scatter, there is no evidence of a size effect on this material at this temperature. It is probable that size effect would depend upon the stress gradient existing at the point of maximum stress. This gradient depends on the slope of the dynamic stress-strain curve, and the size effect would probably be smaller, the greater the stress redistribution. Further tests are in progress on other materials and at different temperatures. So far, these tests indicate that stress redistribution does not always account for the whole difference between the results in bending and direct stress. Such divergence might be expected if a material is structurally unstable at the test temperature, for then the dynamic stress-strain relation would not remain constant with time.

* "The Size Effect in Fatigue of Plain and Notched Steel Specimens loaded under Reversed Direct Stress," by C. E. Phillips and R. B. Heywood, Ph.D., *Proc.I.Mech.E.*, vol. 165, page 113 (1951).

† D. Morkovin and H. F. Moore, *A.S.T.M.*, 1944.

‡ Research Committee on Fatigue, *A.S.T.M.*, 1941.

TABLE I.—TENSILE DATA FOR 0·24 PER CENT. CARBON STEEL.

Temperature, Centigrade.	E, Lb. Per Square Inch.	Limit of Proportionality, Tons Per Square Inch.	0·1 Per Cent. Proof Stress, Tons Per Square Inch.	Ultimate Tensile Strength, Tons Per Square Inch.	Elongation on $4\sqrt{A}$, Per Cent.
Air temperature	$29 \cdot 8 \times 10^6$	18·5	19·0	32·1	40
400 deg.	$27 \cdot 8 \times 10^6$	4·4	10·4	28·7	46

TABLE II.—TENSILE DATA FOR R.R. 58 ALUMINIUM ALLOY.

Temperature, Centigrade.	E, Lb. Per Square Inch.	Limit of Proportionality, Tons Per Square Inch.	0·1 Per Cent. Proof Stress, Tons Per Square Inch.	Ultimate Tensile Strength, Tons Per Square Inch.	Elongation on $4\sqrt{A}$, Per Cent.
Air temperature	$10 \cdot 7 \times 10^6$	1·4	3·6	12·3	26
200 deg.	$10 \cdot 0 \times 10^6$	1·0	3·6	7·2	45

THE INSTITUTE OF BRITISH FOUNDRYMEN: PRESIDENTAL ADDRESS.*

By DR. C. J. DADSWELL, B.Sc.(Eng.), Ingénieur E.S.F., M.I.Mech.E.

A QUESTION raised at our fourth Foremen's Training Course seemed to me to require an answer which it was not possible to provide in the time available. A foundry was described in which a somewhat difficult casting had been made in small quantities, not reaching three figures a day, by skilled moulders, with considerable physical effort on their part. Eventually, by some modification to the moulding technique, and, more particularly, to the organisation of work, and by the addition of some mechanical equipment of a relatively inexpensive nature, the output, with fewer and less skilled men in the team, increased to ten times the previous figure per day. One of the questioners was worried about the effect of mechanisation on the operators and the thought that it had deprived the skilled moulder of skilled work, even though he was assured that the displaced moulders had been transferred to work where their skill was still required.

There are several lessons to be learnt from an analysis of this question and the answer. It is wrong to assume that mechanical aids to production, simple or comprehensive, necessarily make those who operate them unhappy when they are not able to exercise their original craftsmanship. While it is not often that we in the foundry go to the extreme of the motor-car assembly line, Henry Ford and other authorities have shown that the employee on mass production is not inevitably unhappy. We need not go deeply into the economics and the psychology of this situation, but by observation I have some experience in this matter and know it to be right; with the proviso, as is always the case, that one cannot generalise and the conditions must be such that the operators are able to work steadily and with a physical exertion which is not injurious to health.

I mentioned mechanical aids to production. I want to make it clear that I do not necessarily refer to handling methods, by machinery of a most elaborate nature. Plants described as "fully mechanised" are in few cases completely mechanised, as it is all a question of degree. After all, mechanisation has existed throughout the ages in the form of simple mechanisms; in fact, much modern mechanisation is none other than the application of the simple mechanisms which we are taught as fundamentals of applied mechanics, but they are applied in varying degrees and nowadays with motive power rather than human power added to the mechanism, until one can reach the extreme stage when the only human agency is that of pressing a button.

You may think that what I say is incompatible with our motto "Science hand in hand with Labour." To my mind, what I am trying to express is completely in keeping with this marriage of science and labour. As foundrymen, our primary objective is to make good castings, castings which will hold their place with the products of competitive industries and will enable users to make their final products economically attractive to their own customers. If, therefore, in order to meet these demands it is necessary to use labour which is not trained to do a hundred and one skilled jobs, but to become specialised in doing a few, we must not assume that this specialised labour is unhappy. It has been proved in other trades that the labour is otherwise and that the economic standard of the operative can rise because he participates, through his increased productivity in a greater contribution to the total quantity of goods available for the use of mankind.

At the Foremen's Conference the questioner said, "What of the two displaced skilled moulders?" The answer, as stated above, was that they had been found other skilled jobs to do. I believe that, in spite of mechanical aids to production and the removal of the need of skill in the operators of the mechanical devices, there will continue to be a need for skilled craftsmen. At the Conference, I pointed out that there were as yet no alternative ways of making moulds and cores for some of the castings illustrated by one of the lecturers, other than by the use of craftsmen. There will remain a need for craftsmen for work of accuracy and in small quantity which is dependent on the skills of the individual.

I will not develop the possibility, in which I believe, of "breaking down" operations, even in what we call jobbing work, and the upgrading of operators from one skill to another as is now practised in America, rather than having only one form of recruitment by youth apprenticeship in all branches of a craft—which is so often the sole qualification for what we call "skilled tradesmen." We are not yet sufficiently enlightened to accept alternative means of upgrading and of advancing in stages from one skill to another during the lifetime of a foundryman; the seeds have been sown and it is already a matter of discussion. It will take time to develop further. I would give you a thought, however, in that, with increasing time spent on general education for all people, there is less time left to train a citizen to become an all-round craftsman in a wide number of skills by the time he reaches the age to take his full place as part of the productive world. Hence, by force of our modern desire to educate more thoroughly, we may eventually enable the operative to develop from stage to stage in specialisation within crafts after the age at which we now expect him to have become fully qualified.

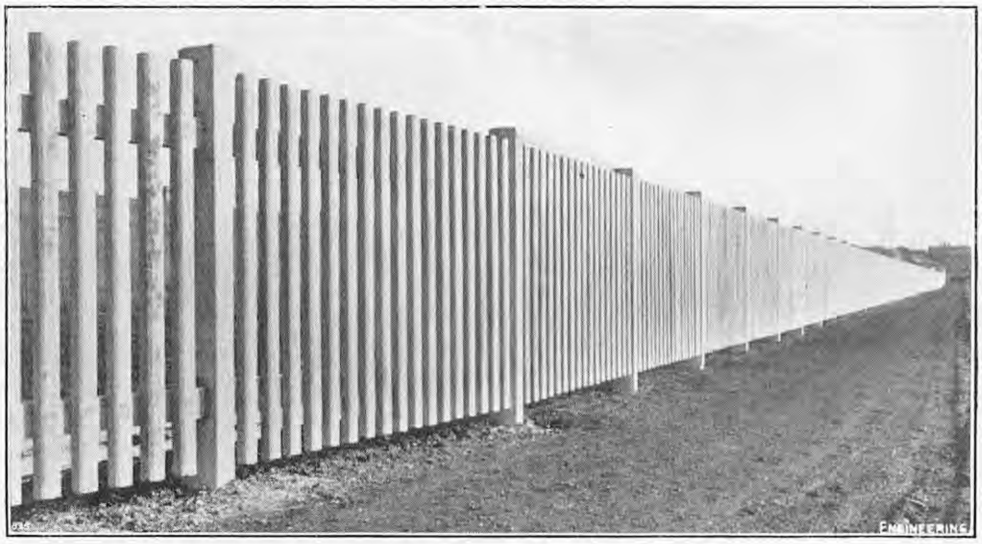
I referred to the jobbing foundry and, here again, I think there is misconception. I would suggest that this is the foundry where we still have scope for improvement, as compared with other branches of our industry. Mechanisation, elaborate or simple, is not difficult to apply, given the type of product to which it is suited and imagination and economic conditions to justify it. It is much more difficult to improve the economic conditions for owner and employee in the jobbing foundry, unless it is tackled in just as analytical a way as when embarking on series production. There are many so-called jobbing foundries in which enlightened ideas prevail, but I feel that there are still many which could change their outlook with advantage.

I do not consider it difficult for them to achieve improvement if they can understand the proper approach. We have done a lot of talking concerning comparing notes, writing lectures, and showing lantern slides of mechanised foundries. We have not done nearly so much to help the management and technicians in the jobbing foundries. This has been repeatedly impressed on my mind at our Foremen's Courses, and, this year, the organisers tried to break away from the stress on mechanisation by having some examples of controlled quality in jobbing foundries. The method of approach was nothing more than the keeping of records, doing simple investigations, making deductions from records, with no elaborate statistical analysis other than logic based on causes and effects. Anyone can undertake this, whether with the aid of a laboratory or with a simple organisation. My one fear in listening to the papers on this subject was that their reference to the laboratory might make people think that such control and development could only take place if a foundry had a laboratory full of technicians. The mental processes involved and the scientific knowledge required, however, were those which a foundryman, who has studied as he should have studied, would be able to undertake, the principal factor of all being analytical thought. In the small foundry, perhaps "captive" to an engineering organisation, it may be thought that no staff is required other than the foreman who runs the foundry floor. I suggest that we give him the help of a man who has time to develop ideas for tooling, however improvised they may be, give them the money to have proper equipment, melt up moulding boxes which should have been scrapped years ago, and encourage them to keep simple statistics of the "reasons, why's and wherefore's" of what happens.

When I was considering the final draft of this address, I read the pre-print of a paper for this conference entitled "Methods Employed in the Production of Heavy Iron Castings." I was impressed by the similarity of the authors' views with those I had already written, and by their reference to "analytical approach." I commend this paper to you, remembering that its principles are applicable to the large jobbing

* Entitled "A Sense of Proportion;" delivered on Wednesday, June 11, 1952, at the 49th annual conference of the Institute of British Foundrymen, held at Buxton and Sheffield. Abridged.

PRESTRESSED CONCRETE FENCING.



foundry making large castings or to the small jobbing foundry making any size of casting. The jobbing foundry is the most interesting of all. Logical thought and scientific management can be applied, and should be applied, to it just as much as to any other foundry. It will train our craftsmen of the future and it will absorb those who have been trained.

CONTRACTS.

GEORGE H. ALEXANDER MACHINERY, LTD., Coleshill-street, Birmingham, have secured an order from the United States Government for honing equipment and internal measuring apparatus for use on the production of cylinders for the American Navy.

SWAN, HUNTER, AND WIGHAM RICHARDSON, LTD., Wallsend-on-Tyne, have obtained a contract, valued at 200,000*l.*, for the renewal of the centre tanks of the 5,500-ton oil tanker, Yenangyaung, belonging to the Burmah Oil Co.

WILLIAM GRAY & CO., LTD., West Hartlepool, have obtained orders for six vessels, namely, three 10,000-ton cargo motorships for Mr. N. G. Livanos, of the Piræus, Greece, one 12,500-ton cargo steamer for Mr. S. Livanos, London, one 10,000-ton steamer for Panama owners, and one 3,450-ton steamer for owners in Oslo, Norway.

LEONARD FAIRCLOUGH, LTD., Chapel-street, Adlington, Lancashire, have been given the contract to provide sidings and to carry out earthworks and drainage, fencing and ash ballasting at Hartford Junction, Wallerscote, on the London Midland Region of British Railways.

LEYLAND MOTORS, LTD., Leyland, Lancashire, among other orders, are to suppy 32 of their underfloor-engined "Royal Tiger" Diesel-driven omnibuses for the African services of the Public Utility Transport Corporation of South Africa. The vehicles have a wheelbase of 20 ft. 4 in., and an overall length of 35 ft. Another order is for a large tipping vehicle for Puzey and Diss Motors, Ltd., Rhodesia. The machine has a wheelbase of 15 ft. 6 in., and the all-steel end-tip body, built by Bromilow & Edwards, Ltd., is 18 ft. long by 7 ft. 6 in. wide, and has a level loading capacity of 12 cub. yards.

MARCONI'S WIRELESS TELEGRAPH CO., LTD., Chelmsford, Essex, have received orders to deliver two further medium-power television installations to the British Broadcasting Corporation, one installation to be used as a standby at Sutton Coldfield and the other for future use elsewhere. The order comprises two 5-kW vision transmitters and two 2-kW sound transmitters, with associated equipment.

SMITH'S DOCK CO., LTD., Middlesbrough, have received an order from the Burnett Steamship Co., Ltd., for a cargo steamer of 5,500 tons, the delivery of which is expected in 1955. The propelling machinery will consist of triple-expansion engines driven by superheated steam and working in conjunction with a Bauer-Wach exhaust turbine.

PALMERS (HEBBURN) CO., LTD., Hebburn-on-Tyne, have received an order from the Blyth Harbour Commissioners for the construction of a steel-framed goods shed 120 ft. in length and about 47 ft. in width.

WILLIAM DOXFORD & SONS, LTD., Sunderland, have received an order from J. and C. Harrison, Ltd., London, for two cargo motorships of 11,000 tons deadweight carrying capacity. The engines, which are also to be supplied by Messrs. Doxford, will give the ship a speed of $13\frac{1}{2}$ knots.

PRESTRESSED CONCRETE FENCING.

PRESTRESSED CONCRETE fencing is being used for the first time in this country on any significant scale by the Metropolitan Water Board, at Chingford, Essex. In 1950, the Board sought an improved type of fencing for their recently-completed William Girling reservoir, which has a capacity of 3,600 million gallons. The fence had to be attractive in appearance, cheap to maintain, resist damage by irresponsible persons, be reasonable in first cost and use the minimum of steel. Several types and designs were prepared by the Board in order to give the maximum scope to potential suppliers while suiting their individual manufacturing methods. The design selected (and shown in the accompanying illustration) was developed after close collaboration between the new-works engineer of the Board and his department and Dow-Mac (Products), Limited, Tallington, near Stamford, Lincolnshire, who were responsible for the manufacture of the units. The fencing consists of posts at 9-ft. intervals with top and bottom rails spanning between them which support 17 pales to each bay. All the units are prestressed. The wires are pre-tensioned, i.e., stretched before the concrete sets, so that the prestress is transmitted to the concrete by the bond between it and the wires.

The posts are 8 ft. 9 in. long, $7\frac{1}{2}$ in. deep from back to front, $4\frac{1}{2}$ in. wide on the face and $4\frac{3}{4}$ in. at the back. Through slots, which are tapered from each face to the centre, are formed in the posts to take the top and bottom rails. Two $\frac{1}{2}$-in. diameter holes are provided above the top rail to take the supports for two strands of barbed wire, should they be found necessary. The posts are designed to be set 2 ft. 9 in. into the ground. Each weighs 308 lb. and is prestressed with six 10-s.w.g. wires. The rails are 8 ft. $11\frac{1}{2}$ in. long, 5 in. deep, $2\frac{1}{2}$ in. wide at the top and $3\frac{1}{2}$ in. at the base. A shallow rebate on the underside at each end enables them to be fitted to the posts. Each rail is pierced with 17 holes for the fixing bolts of the pales; the holes are recessed on one side to accommodate the bolt head. Tolerance in these holes allows for the proper alignment of the pales. Each rail weighs 129 lb. and is prestressed with eight 10-s.w.g. wires. The pales are 5 ft. 5 in. long, 2 in. thick and $3\frac{1}{4}$ in. wide at the back, tapering slightly towards the front and chamfered at the front edges. They are fixed to the rails by electro-galvanised hexagon-head mild-steel $\frac{3}{8}$-in. bolts and nuts, and bitumen paste is placed round the holes in the rails before bolting up the palings as a further protection for the bolts. Each pale is provided with two holes, recessed on one side, to take the fixing bolts, and the recessed holes are filled in with a semi-dry grout.

Each pale weighs 36 lb. and is prestressed by four 10-s.w.g. wires. They are designed to withstand a static central point load of 200 lb. applied horizontally midway between supports. Tests showed that they met the design requirements with a deflection of $\frac{1}{16}$ in. and no cracking. The first fine crack appeared at 30 per cent. over-load and it closed on reduction of the load to 166 lb. Total failure took place under a load of 470 lb. Provision is made in the design for changes of level, and the design of the slotted posts enables corners of quite small radius to be negotiated. Internal and external right-angled corners are turned by using two standard posts, while obtuse angles, both internal and external, are turned by using a standard post and special splayed rails. A total length of $3\frac{1}{4}$ miles of fencing is being supplied.

FUEL AND METAL.*

By PROFESSOR R. J. SARJANT, O.B.E., D.Sc., A.R.C.Sc., D.I.C.

To the foundryman, the most important fuel is undoubtedly coke. The requirements of his metal-melting practice demand specific properties in the fuel used. Ideally, it must be capable of producing the highest practicable temperatures. There must be uniformity of performance, and there are metallurgical requirements as to temperature of casting and chemical and physical properties of the metal produced which are of prime importance. Other essential criteria of efficient practice are a required rate of output determined by the temperature levels operating, and economy of materials, which is dependent on both plant and process.

In considering the characteristics of the fuel demanded for its satisfactory service in the cupola one cannot exclude some consideration of that important body of knowledge which has been built around the question of the physical characters of blast-furnace coke. There is an equivalence of requirement in the need in both cases for a specific property called "hardness" with absence of fissuring, and stress, too, upon the importance of size and uniformity of quality. In the combustion of coke the reactivity to oxygen is an important criterion in the determination of the operative temperature of the fuel bed. Again, in both processes there enters, perhaps to varying degrees, the reactivity of the coke to carbon dioxide, since the product of this reaction, namely carbon monoxide, may lead to loss of potential heat in the effluent gases. In the blast furnace these factors may not be of equal significance for two reasons: one, that the temperature of the melting zone may be above the temperature at which the coke may be able to burn to carbon dioxide; the other, that the carbon monoxide produced is an essential element in the major function of the furnace, namely, the reduction of iron ore.

SHORTAGE OF COKING COALS.

In the production of the best metallurgical cokes, there enters an important element in the parentage of the constituents of the coking slacks. While modern research is being devoted earnestly towards bringing into service the less effective coking coals, in order to widen the range of availability of serviceable coals, the situation, that reserves of good coking coals are being rapidly depleted, cannot be ignored. At the same time, therefore, there are problems of prime urgency facing both the coke manufacturer and the foundryman. It is a welcome sign of the times that these two parties are collaborating in works-scale investigations into the assessment of the pertinent factors of cupola operation and the determination of the properties which are really required in a good foundry coke. It is necessary to be able to specify the needed properties in the coke for the guidance of the coke manufacturer. It is perhaps remarkable that no satisfactory solution of the problem of foundry coke specification has yet been found. The American Society for Testing Materials specification goes back to 1916, and yet the question has been so beset with cupola variables and conflictions of evidence as to the validity of such specifications that the A.S.T.M. abandoned attempts at revision in 1947. In this country, opinion at present is equally sceptical.

The difficulties do not lie in any inability to sample the coke and apply to it a whole series of detailed tests. There have been developed over the last few decades a multitude of such tests. The problem lies rather in the determination of the required combination of properties and the significance to be applied to the inter-relation of the individual tests. Any combustibility test, for example, if such must be used, is limited in its applicability since so many factors come into the question of assessment, namely, rate of combustion, dimensions of the fuel bed, particle size, concentration of oxygen in the gas stream, and temperature. A test which serves to predict behaviour at one range of temperature will not necessarily also predict behaviour within another range. In the cupola this question of temperature becomes a major factor, which is determined primarily by the reactivity of the coke for a given set of operative conditions. A low reactivity is required in foundry coke to give high thermal release, since it involves preferential combustion to CO_2 rather than CO, and delay in the solution of carbon in carbon dioxide. As far as may be evident at present, the critical requirements for a foundry coke are, uniform size; high strength and hardness; low reactivity; and low ash and sulphur. Of these, popular opinion tends to regard size and strength as the prime criteria at present, but the author's view is that the importance of reactivity has been under-estimated, because the specific relation of reactivity to temperature has not been sufficiently appreciated. Our attention

* Edward Williams Lecture for 1952, delivered on Wednesday, June 11, 1952, at the 49th annual conference of the Institute of British Foundrymen, held at Buxton and Sheffield from June 10 to 13, 1952. Abridged.

at the University of Sheffield has been particularly drawn to this subject in a wider programme of research, which has had as its objective the contribution of fundamental knowledge on the mechanism of coke formation. Such an objective naturally includes the study of the coal involved, the operative conditions of carbonisation and the properties of the resultant coke.

THE CONSTITUTION OF COAL.

In the first category, investigations have now entered a field in which the author had the privilege of working with Professor W. A. Bone at South Kensington, in 1919, on the solvent action of coal with pyridine. Since those days, numerous investigations by many workers have followed in that field. To-day, the problem still remains unsolved.

In realising that the most practical outlook on fuel problems must be supported by an adequate treatment of their fundamental aspects, there has been introduced into this part of our programme a new combination of older and newer techniques. The older solvent extraction, speeded up by the use of ultrasonic treatment, has been followed by the use of chromatographic adsorption and infra-red spectrometry. The objective has been to obtain all the possible information about the range of coals being brought into service in the investigation of the relation between carbonising conditions and the properties of the resultant coke. In the earlier work carried out some few years ago the solvents used were phenol and chloroform. Now, with the application of the ultrasonic booster, we have had to return to pyridine. The use of the earlier solvents followed by chromatographic separations with activated alumina in the adsorption column revealed interesting tentative relationships when the infra-red absorption technique was applied to eluents from a critical group of coals. These had been chosen on the basis of the knowledge of the behaviour of the industrial cokes, made from the coals, when used in blast furnaces, cupolas and lime kilns. The earliest work in this programme was carried out by D. K. Datta, the development of the ultrasonic technique by A. G. Mertins and now Dr. W. A. Kirkby and J. R. A. Lakey are working on a range of coals, confining attention particularly to the separate banded constituents, the clarain, vitrain and durain as well as the coking slack. Interesting relationships are being found between coal extract, rank and the coking characters of the banded constituents. In many respects they are confirming and extending Datta's conclusions, finding more complex spectra in coals of higher rank, as well as significance in the intensity of the absorption bands. The subject is rather academic for an audience of practical foundrymen interested primarily in the application of coke in an industry already sufficiently burdened with metallurgical complexity. The work requires skill of a special order and obviously results in such a specialised field must emerge slowly. Nevertheless it must interest the members of the Institute to know that such lines of inquiry are being pursued, since it is hoped that the ultimate results will have a bearing on an important material they use.

It is known that many factors associated with the coal are contributory in determining the properties of the resultant coke. Thus there are the well-known chemical factors, composition, the nature of the banded constituents and the mineral impurities, physical factors such as the size of the coking slack, specific surface, friability, bulk density, plastic and swelling properties and pressure development on heating. Again a weathered coal is useless for coke manufacture. The coke-oven manager has his problems in the oven conditions, in the uniformity of heating, the nature of the time-temperature cycle during carbonisation and the multitude of mysterious changes going on inside the oven. An extensive literature exists on this subject alone. Not the least important, the coal-preparation plant, is a contributory factor in the supply of properly-sized coal, of adequate cleanliness and correct moisture content.

CARBONISING CONDITIONS AND COKE PROPERTIES.

For investigations into the correlation of carbonising conditions and coke properties, two carbonisation units have been constructed at the University, one a low-temperature retort and the other an experimental coke oven. In these units investigations are made of the influence of coal characteristics, and of temperature and time on the properties of the resultant coke. We are particularly interested in the behaviour of the coal as it passes through the so-called "plastic range," that is when the coal is melting, and in an imaginative sense the foundations of coke structure are being laid. For this purpose an effective technique for measuring the detailed changes of temperature within the oven has been developed and a new method of thermal analysis, based on the finite difference equation used in our earlier work on the variable flow of heat. The application as it is used in this problem was worked out by our mathematician, P. H. Price.

Since the carbonisation work applied in a university laboratory must be limited in size it has only been possible to go up to charges of the order of 100 lb. of coal, and therefore the normal methods of testing the physical properties of the coke have not been applicable. New methods suited to the conditions have had to be found. It has long been apparent that the tests which are used to determine the physical properties of coke are largely empirical. As long ago as 1920, the author had applied the American drop test to the routine testing of coke in works practice. This particular machine was probably the first machine adopted as a routine appliance in this country for the purpose. Long before reports were appearing from other research organisations to indicate its value as a means of indicating in a broad way what might serve as a hot melting coke, this relationship had been established in the works with which the author was associated, with a recognition also of the limitations of the test as a scientific index of the industrial value of the coke.

Our present objectives are, however, more fundamental in character. We are seeking for causes rather than for indications of effects. This inquiry led to the

Fig. 1.

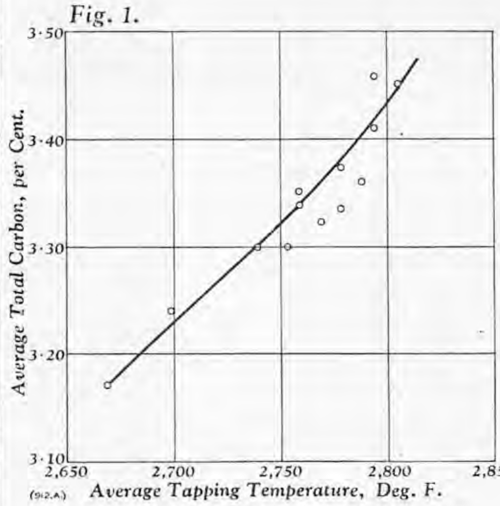
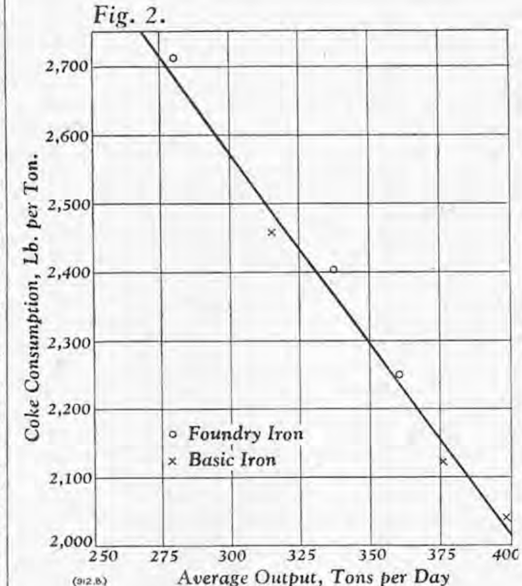


Fig. 2.



development of an impact test in which the energy of translation of the coke against a breakage plate could be measured accurately and varied over a range. It could thus provide a truly scientific criterion of the impact energy required to produce breakage on a comparable basis. A machine, operated by means of a powerful spring, the compression of which could be varied and accurately measured, was developed by J. E. Littlechild. This spring operates a light-alloy tray from which a suitably-sized sample of coke is projected against a metal plate. The shattered coke falls back into the tray. It may be subjected to further impact or it may be removed from the tray for size analysis. With increasing impact energy the criterion which expresses a linear relationship with energy input is a value named the cracking coefficient. It involves the square of the weights of the particles involved. The impact energy, in ft.-lb., is plotted against the cracking coefficient and the slope of the curve is an index of the physical property of the coke revealed by this test. It has been called the degradation factor and is expressed in terms of per cent. degradation per ft.-lb. of impact energy applied.

REACTIONS IN THE CUPOLA.

Conclusions from the calculation of the equilibrium constants, from which variations of gas composition with temperature may be deduced, indicate that only such properties of coke that may affect the temperature in the crucible are important in determining the quality of the iron. Work done by H. V. Johnson and J. T. MacKenzie in the United States on foundry cupolas has shown that the quantity ($C + 0{\cdot}3$ Si) is nearly a linear function of hearth temperature. The American research workers, D. E. Krause and H. W. Lownie, have shown that there is a close relationship between carbon content and tapping temperature, as may be seen in Fig. 1, herewith.

C. M. Tu, H. Davis and H. C. Hottel* found that the rate of combustion of carbon at temperatures prevailing in the blast furnace is roughly proportional to the absolute temperature. In the cupola the rate at which carbon is consumed is a function of rate of oxygen supply and the conditions in the shaft, particularly that of penetration. The coke must be burnt at a rate in agreement with the mass of the coke added between charges. Otherwise the bed height will change and conditions of stability be upset, giving rise to unsuitable composition of the iron. With this limitation in mind, certain other features, namely, the relationships between the rate of driving, the temperature and the coke quality observed in blast furnaces are noteworthy. Thus the blast furnace is like many other machines, more efficient the harder the driving. That master of metallurgical science of his day, J. W. Richards,† produced the interesting data shown in Fig. 2, on this page. Data relating to blast furnace practice published in vol. 134 of the *Journal of the Iron and Steel Institute* (1936) by W. J. Brooke, H. R. B. Walshaw and A. W. Lee, and afterwards correlated in the United States by M. A. Mayers and H. C. Landau, showed that the production rate was significantly related to the shatter test or to the Cochrane drum test, and the coke rate to the shatter index, the production rate and the blast temperature. That the hanging tendency in a blast furnace may be associated with flooding of the coke column below the fusion zone of the furnace has been recently suggested by the American writer J. F. Elliott, R. A. Buchanan and J. B. Wagstaff. The interesting point from their analysis of the problem was that flooding tendencies would be increased by higher gas velocity, and by a more viscous slag, and decreased by large uniformly sized coke. The relationship of size grading to performance has been repeatedly shown. Different sized coke may be used, but size grading must be close, giving good permeability.

Less systematic investigation of this character has been made into cupola practice, but the above deductions are apparently applicable to such, for H. E. Blayden, W. Noble and H. L. Riley, working with a small experimental cupola, showed that, in agreement with practice in full-scale furnaces, the use of high blast rates and large coke tended to improve melting efficiency. Small coke gave rise to the endothermic production of carbon monoxide. Beehive coke gave the best results. The significance of high mechanical strength in the coke is thus abundantly apparent. An increase of coke size has also been shown to have certain metallurgical effects, namely, less sulphur pick up, an increase in silicon loss, a decrease in carbon pick up, and an increase of manganese loss and speed of melting.

The significance of a size of coke of uniformity and defined value, in relation to the diameter of the cupola, may be deduced from the known behaviour of gases flowing through packed solids. It is recognised that the tuyères must have critical dimensions to give adequate penetration and distribution of the air. From fundamental investigations it is known that bed voidage plays an important role. Operating with a third-power relationship, a small change in void volume produces a marked change in the resistance offered to the flow of gas. The surface area per unit volume, which increases as the particle size decreases, affects both the resistance to flow and the character of the combustion. As a rough approximation, the resistance to flow will depend directly upon some function of gas velocity and inversely as the diameter of the coke for properly sized fuels. There is a relation between metal temperature, melting rate per unit of cupola cross-sectional area, and air rate. Differences in reactivity cause a shift with respect to metal temperatures.

Noteworthy is also an attempt to determine the coefficient of heat transfer in a cupola and the time required to melt the metal. This, a truly formidable task, has been made by N. Czyzewski following up the work of Osann. Based on experimental trials, the coefficients of heat transfer and the melting times have been related to the gas velocity, the temperature, the

* *Ind. Eng. Chem.*, vol. 26, page 769 (1934).

† *Trans. Am. Inst. Min. and Met. Engrs.*, vol. 6, pages 372-5 (1917).

FUEL AND METAL.

Fig. 3.

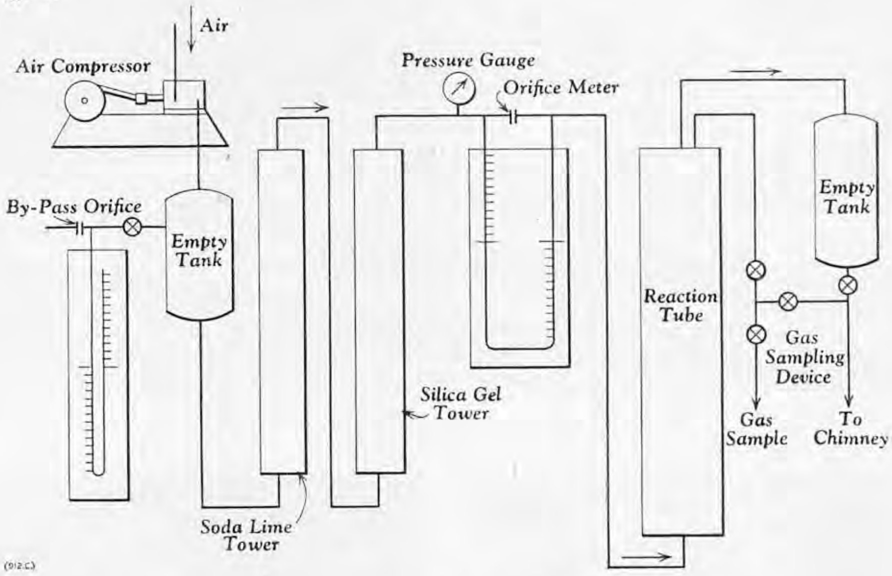
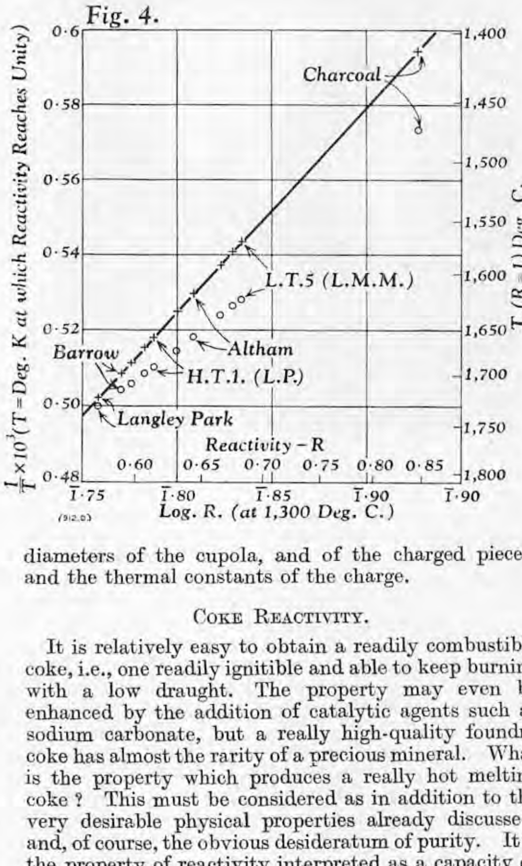


Fig. 4.



diameters of the cupola, and of the charged pieces, and the thermal constants of the charge.

COKE REACTIVITY.

It is relatively easy to obtain a readily combustible coke, i.e., one readily ignitible and able to keep burning with a low draught. The property may even be enhanced by the addition of catalytic agents such as sodium carbonate, but a really high-quality foundry coke has almost the rarity of a precious mineral. What is the property which produces a really hot melting coke? This must be considered as in addition to the very desirable physical properties already discussed, and, of course, the obvious desideratum of purity. It is the property of reactivity interpreted as a capacity of the coke to burn to CO_2 rather than to CO at a high temperature. A new test for reactivity considered from this standpoint was recently developed in our laboratories, the investigator being S. Banerjee. It consists in determining the composition of the gas evolved under standard conditions in a small fuel bed, maintained at a constant measured temperature by means of an external heater, and fed by preheated air at a predetermined temperature. The flow sheet of the apparatus assembled for the reactivity test is shown in Fig. 3, above. A convenient expression for reactivity is the ratio of the weight of the carbon content of the gas at the sampling point, derived from the content of oxides of carbon, per unit volume of ingoing air, to the weight of the maximum carbon content of the gas in the same units which would be attained by complete conversion of carbon dioxide to carbon monoxide. Allowance is duly made for the effect of the volatile matter in the coke, and it may be shown that the relative reactivity is is equal to the ratio, $\frac{CO_2 + CO}{2\,CO_2 + CO}$, where CO_2 and CO are determined from the volume percentage analysis of the dry stack gases.

In the range of temperature 1,200-1,400 deg. C., a strong correlation between relative reactivity and coke-bed temperature was observed, which fitted the equation, for a Langley-Park coke,

$$R = \frac{T_C - 719 \cdot 4}{1000} \quad . \quad . \quad (1)$$

where T_C = temperature in degrees C. and R = reactivity.

The data were alternatively fitted to an Arrhenius equation of the form

$$\log R = -\frac{1810 \cdot 5}{T} + 0 \cdot 9151 \quad . \quad . \quad (2)$$

where T = temperature in degrees K.

The above two formulæ lead to some revealing interpretations if the curves are extrapolated to a value of reactivity = 1, when the reacting gas is completely converted to carbon monoxide. We thus arrive at an index of the maximum practicable temperatures attainable without preheat. The results of reactivity tests on a series of industrial and experimental cokes are shown in Fig. 4, on this page. The plain line shows the values of the temperature at which reactivity reaches unity derived from the Arrhenius equation (2) plotted against reactivity determined at 1,300 deg. C. The points in circles on the right of the line show similar values of maximum attainable temperatures extrapolated from equation (1). The discrepancies are to be expected and the matter has been pursued further. The abbreviations, L.M.M., and L.P., stand for Lower Mountain Mine and Langley Park, and L.T. and H.T. for low-temperature and high-temperature cokes.

In the test of reactivity described, the rate of flow of the air was closely controlled to a standard value of 0·2 cub. ft. per minute at 0 deg. C. and 760 mm. pressure. It is to be expected that the character of the reactions in the fuel bed must be affected by changes of rate of flow. Accordingly, further investigations are being made into the influence of this variable. It is desired, of course, to pursue such inquiries into the range of temperature of such great practical importance, namely, the range 1,600-1,700 deg. C. At these temperatures, experimental difficulties become increased. Fusion of ash introduces interference, and limitations in the materials used for the apparatus offer formidable obstacles. For this purpose, it has been necessary to resort to platinum for the containing vessel and to use the oxy-acetylene flame for obtaining the requisite temperatures. Experiments at lower temperatures by R. Smith suggested tentatively that the influence of the air rate was to lower the reactivity at a particular temperature, the reactivity tending towards a limit with increase of velocity, and the relationship being expressed by a hyperbolic function of the velocity of the gas. The explanation lies probably entirely in the mode of transport of oxygen to the reacting surface, and not necessarily in any specific character of that surface. This is in keeping with the known increase of temperature of combustion with increase in rate of air supply.

The important conclusion of this work is that in the cupola, and possibly also in the blast furnace, rates of melting and temperatures of the metal are influenced materially by coke reactivity, and that increased velocity of blast tends to produce the equivalent of a fall in reactivity for a particular temperature. A significant remark was made to the author one day by Dr. Dunningham, that he and his colleagues believed that, in the cupola and the lime kiln, specific maximum temperatures were attainable by particular cokes, but that they had no means of either confirming the belief or assessing the temperatures. If such a determination can be made practicable it will be of considerable value in the evaluation of coke. It was further evident in our work that there was a specific value to be placed in the parentage of the coal, which must be taken into consideration in further efforts to improve the economic value of metallurgical cokes.

PREHEAT AND BLAST HUMIDITY.

From the above conclusions, it would also appear that the disability of a high reactivity can receive compensation from an increase in any condition that may serve to add preheat or reduce endothermic demand in the metallurgical reactions. The significance of humidity is to cause reduction of carbon, with the evolution of carbon monoxide and hydrogen. The decomposition of 1 lb. of water vapour requires the burning of 0·37 lb. of coke to produce the heat required for the reaction, and 0·06 lb. of coke to heat the water vapour to the reaction temperature. D. E. Krause and H. W. Lownie have shown, in a small experimental cupola, that an increase of moisture from 27 to 219 grains per pound of air gave a loss of 135 deg. F. in tapping temperature, a reduction in carbon from 3·45 to 3·17 per cent., a lower melting rate and an increased loss of silicon and manganese, resulting from more oxidising conditions.

Theoretically, the hot-blast cupola should produce conditions which counteract the adverse effect of inferior fuel, but it obviously introduces complexity where the ideal should be simplicity and ready reproducibility of results. The first application of the hot-blast cupola goes back to the days of the development of the hot-blast stove in blast furnaces and many types have been tried. The claims made as between cold and hot-blast cupolas are very remarkable. At Aachen, efficiencies of 55 to 65 per cent. have been stated by E. Piwowarsky to have been obtained in an experimental cupola. The most hopeful development lies in the use of a separately heated stove. The limit in the reduction of the coke ratio would appear to be at about 8 per cent. with a blast temperature of 600 deg. C.

Among the remaining features of possible future development is the use of oxygen enrichment. Until cheap oxygen appears as a reality, at present a somewhat remote possibility since half the cost lies in the cost of power, it would be too costly to operate continuously. Nevertheless, it has proved to be of service for intermittent use for "trouble shooting" and "boosting" at starting up. While an enrichment of 4 per cent. has been found to double the melting rates, refractory wear could be disastrous. The final most desirable requirement would appear to lie in developments towards coke of the maximum "unreactivity."

HEATING AND FURNACE INVESTIGATIONS.

This discourse would not be complete without a brief account of the impact of certain scientific inquiries in the domain of furnace technology on the practice in the foundry of fuels other than coke. Only a brief insight may be given here of the approach that is being made The sceptical may not recognise that it is possible to calculate the temperature inside a mass of steel, or within a refractory mass such as a furnace wall or a sand mould. Considerable progress has been made in regard to the two first named, and the last has been undertaken as a practical problem capable of solution by this means. An immediate problem is that of the drying of a sand mould, about which much may be learnt by combining the theoretical approach with some practical drying experiments. The nature of the heat-transfer coefficients in a stream of moving gases such as one would find in a foundry drying stove, both in terms of convection transfer and gas radiation, is known with some precision. The problem of the cooling of a mass of solidifying steel has been found capable of solution. There is no reason why the heat transfer through a mass of drying sand should not be as readily obtained, provided the nature of the diffusion of the water vapour can be assessed. This should be subject to elucidation in the experimental approach.

In a combustion chamber operated by a mechanical stoker, observations have been made by E. Hammond on the character of the heat release from coal flames and its transmission to the walls of the chamber, which is instrumented to measure the heating effect. Data may be deduced from these observations to predict what may occur in industrial plant. It has also been shown that coal may be burnt completely with relatively low proportions of excess air provided the air is introduced at a high velocity in a number of fine streams. A further interesting series of investigations into the atmospheres which are needed for the safe heating of the critical steels of the Sheffield trades has just been completed by G. R. Mattocks and is nearing the publication stage. Smoke in coal firing has been shown to be merely the unwelcome and almost inert attendant of the small quantities of unburnt combustible which in the presence of sulphur may play curious tricks in the formation of a troublesome sticky scale and possibly some decarburisation. Small quantities of excess air are of minor importance in comparison with the sulphur content of the steel.

In the field of furnace design, investigations by D. Smith, at the University, on a towns' gas-fired experimental furnace, designed to simulate an industrial continuous heating furnace, have shown that a considerable part of the heat transfer within the chamber occurs by re-radiation from the hot refractory surfaces. The basic data upon which the design of such furnaces should be framed are being worked out. This is practicable because the whole structure of the furnace is virtually a calorimeter.* In such furnaces the character of the mixing and any turbulence which determines the character of the flame is usually introduced by the particular design of the burner used.

The many minor matters that enter into the fuel problems of a foundry are questions of organisation and routine detail, questions as to whether all the lessons abundantly evident in a field full of fruitful example have been gleaned and applied. It may perhaps be said of the repeated exhortation one hears in regard to these matters to-day that never has so much been said by so many, and listened to and acted upon by so few. Perhaps it is an application to social science of an analogy of the Le Chatelier principle in the form that Nature seeks to resist the changes that are imposed upon her. Our purpose has rather been to seek the fundamental issues upon which the eternal verities of good practice are based, and to invoke the spirit of science in a field that is perhaps as full of intricate technical problems as other more glamorous aspects of industrial activity.

* R. J. Sarjant and D. Smith. Inst. Mech. Engrs. Preprint "General Discussion on Heat Transfer," Section IV, Sept., 1951.

WELDED-ALUMINIUM DECKHOUSE FOR LAUNCH.

FIG. 1. MOTOR-LAUNCH "QUEEN ELIZABETH" AT WESTMINSTER.

FIG. 2. TACK WELDING PLATE TO STANCHIONS.

FIG. 3. DOWN-HAND WELDING OF ROOF PLATING.

THE "AIRCOMATIC" PROCESS FOR WELDING ALUMINIUM.

THE pleasure craft Queen Elizabeth has been operating on the middle reaches of the river Thames since 1926, having been constructed for this service by Messrs. Salter Brothers, Folly Bridge, Oxford. Originally, she was a steamer, being powered by a vertical compound engine of 150 h.p., but during extensive alterations just completed, the steam machinery was replaced by a Gardner eight-cylinder Diesel engine developing 152 brake horse-power at 900 r.p.m. and arranged to drive the single screw through 2 to 1 reduction gearing. The alterations were carried out to render the vessel more suitable for use by parties on special outings, her owners, Thames Launches, Limited, having considered the vessel unsuitable for this class of work in her original form. The work was undertaken at the owners' yard on Eel-Pie Island, Twickenham, and the vessel, which is illustrated in Fig. 1, above, has now been converted into what is probably the most luxuriously-furnished pleasure craft on the Thames. Additions made to the vessel include a permanent awning over the fore deck and a deckhouse amidships, both of which are constructed from aluminium alloys, the latter structure being of particular interest in that it is of all-welded construction. The Aircomatic process was used for its fabrication and this is believed to be the first time this process has been employed for such a purpose in the United Kingdom.

The Aircomatic process, which was introduced by the Air Reduction Company Incorporated of America, is, however, not new, having been used commercially in the United States for some two and a half years. The United States Navy have applied it to produce the first all-welded aluminium-alloy torpedo boats in the world. It has also been used extensively for the welding of aluminium structures such as radar tripod masts for destroyers. British designers, however, have been handicapped in their investigations into the potentialities of the new process as the equipment could not be obtained here. Recently, the Ministry of Supply obtained an Aircomatic set and allocated it temporarily to the British Welding Research Association for use in connection with their contract with the Ministry for research on the welding of aluminium alloys. Obviously, it was desirable that these researches should be supplemented at an early stage by tests under practical conditions and accordingly the opportunity was taken to weld the aluminium deckhouse of the Queen Elizabeth. The Aluminium Development Association provided technical advice on design and the British Welding Research Association planned and executed the welding. The British Aluminium Company provided the plates and structural sections and the Aluminium Wire and Cable Company, Limited, supplied the welding wire.

The Aircomatic process employs an arc shielded by an inert gas in the usual manner. The electrode, however, is consumable, being formed by the welding wire. This forms the positive electrode, and as a relatively high current is used the deposition rate is also high. The arc is self-adjusting and the equipment includes a reel and feed motor for supplying the filler wire to the electrode holder. The wire is fed to the holder through a special hollow cable, which also conducts the argon gas to the working area. The wire is fed at a constant rate and the adjustment of the arc is governed automatically by an electrical method which depends on the characteristic of the generator being employed for this purpose. If the welder tends to draw the electrode away from the work, so lengthening the arc, the burn-off rate is reduced and the arc subsequently shortened as the wire is fed to the work; conversely, if the wire is brought too close to the work, the reverse occurs. A reasonable latitude, therefore, is allowed to the operator without any adverse effect on the weld. To start welding, the wire is fed forward manually until it projects approximately ½ in. in front of the nozzle of the holder, or "gun," as it is more commonly termed. The welding circuit is then closed by pressing a trigger on the "gun" and the tip of the wire brought down to the face of the joint until the arc is struck. At this stage, a relay starts the wire feed motor and the wire is brought forward as the burn-off action continues. Pressing of the trigger also causes the argon to be fed through the tube to the welding area.

No flux is used and the problems associated with post-weld corrosion are, therefore, largely eliminated. The high current gives a high rate of deposition while the manner of metal transfer, that is, by projection across the arc gap, permits welding in all positions. As will be evident from Figs. 2 and 3, on this page, it can be used with equal facility for vertical and down-hand welding. These last two attributes render the process suitable on all types of fabrication where lreatively heavy-section aluminium plate is welded *in situ*. With multiple-pass techniques, there is no practical limit to the thickness of plates which may be welded and, in general, comparatively few passes are needed owing to the large amount of filler which can be deposited during each pass. By using smaller diameter electrode wire, thin metal down to a thickness of $\frac{3}{16}$ in. can be welded satisfactorily, it being claimed that the efficiency when so employed is comparable wich that on heavy sections. Owing to the nature of the process, the overall efficiency is high since there are no delays for electrode changing, application of the flux and its subsequent removal, and intermediate cleaning of the material. The process was used considerably during the building of the American vessel United States. About 1,000 tons of aluminium were used in the construction of this liner's superstructure, 400 tons of which were accounted for by the davits, lifeboats, masts and funnels and 600 tons by the bulkheads and casings, all davits, some of the lifeboats and much of the superstructure being welded by the Aircomatic process. Use of the process is not confined to light alloys, however, as it may also be employed for stainless-steel and copper-base alloys. Certain types of welds between dissimilar metals such as copper to steel can also be effected successfully by employing an aluminium-bronze wire as the filling material.

Information obtained from the first use of the equipment in this country will be described in a report being prepared jointly by the British Welding Research Association and the Aluminium Development Association for the Ministry of Supply. It is understood that welding equipment similar to that used on the Queen Elizabeth will be produced in this country by the British Oxygen Company, Limited, who have acquired the Commonwealth rights for sale and manufacture and who will market the equipment under the trade name "Argonaut."

FILM ON MECHANICAL HANDLING.—A film entitled "Conveyors as Your Servants" has been produced for the Mechanical Handling Engineers' Association by John Byrd Film Productions. It is supplementary to a previous film, "Mechanical Handling," and deals with the lighter equipment of this type. The engineering examples include the handling of leaves of wagon springs, cycle components, and motor-car bodies. The running time is 36 minutes and the film will be available to professional and technical organisations, trade associations, technical education institutions, etc., from the Association, 94-98, Petty France, London, S.W.1.

THE ACCURATE SPEED CONTROL OF ELECTRIC MOTORS.

WALTER JONES AND COMPANY (ENGINEERS), LIMITED, LONDON.

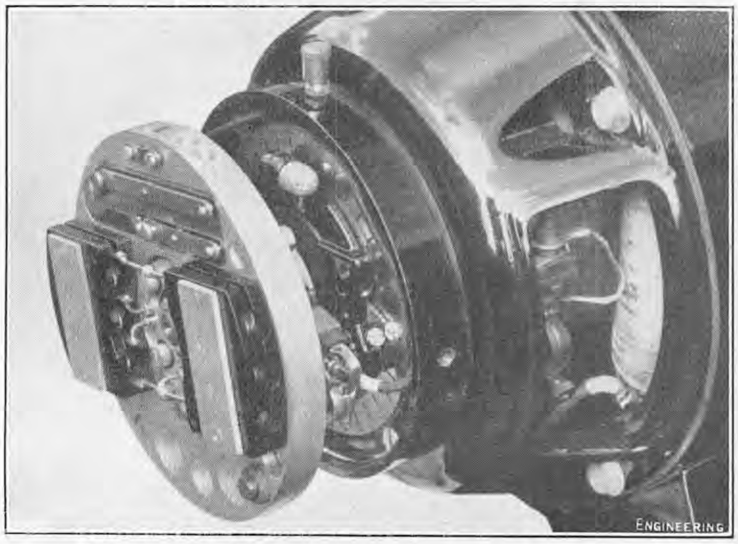


FIG. 1. SPEED CONTROLLER FOR 1-KVA MOTOR.

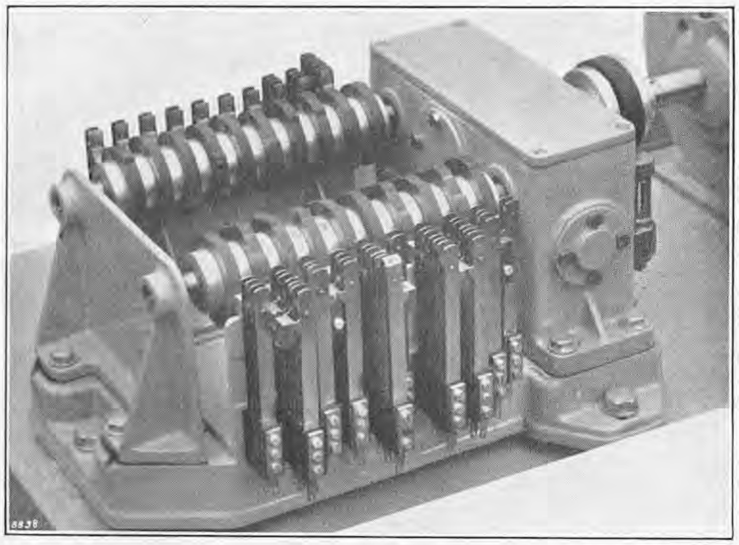


FIG. 2. GEAR-DRIVEN PULSE-TRAIN SENDER.

THE ACCURATE SPEED CONTROL OF ELECTRIC MOTORS.

THE need for accurate and simple frequency control in telegraph transmission has led Messrs. Walter Jones and Company (Engineers), Limited, Charlton Works, Newlands Park, London, S.E.26, to design a centrifugal speed governor for direct-current compound-wound motors. This governor, which will hold the speed constant to within about 0·1 per cent. in spite of considerable changes in load and input voltage, operates in a way analogous to the Tirril voltage regulator; that is, it controls the mean field strength by short-circuiting a resistance in the shunt circuit. This short circuiting takes place for a varying period during each revolution, depending on the degree of correction necessitated by the load and the input voltage. While simple governors of the same general type, which are capable of controlling speed within $\pm 0{\cdot}5$ per cent., are in common use, to ensure correction within $\pm 0{\cdot}1$ per cent. necessitates careful attention being paid to two possible types of error. The first of these is caused by the change in elasticity of the operating spring as the totally-enclosed dust-proof governor warms up, and the second by the transfer of metal from one contact to the other, thus altering the radius and hence the speed of operation. In these instruments the errors have been reduced by the correct choice of spring and contact material, and by reversing the current through the contacts during each revolution by a commutating device.

Motors controlled in this way are used in conjunction with alternators generating at both audible and power frequencies. For instance, the model illustrated in Fig. 1 was installed where the frequency variation of the public supply was considerable and was successful in keeping the frequency of a 1-kVA set to within 0·1 per cent. In another case, the speed of a 0·5-kVA 2,000-cycle motor-alternator weighing only 22 lb. was maintained within $\pm 0{\cdot}1$ per cent. of its specified speed of 10,000 r.p.m.

Speed-governed machines are often used in the communication field in conjunction with gear-driven pulse-train senders, one of which is illustrated in Fig. 2. With these senders, repeating-pulse trains from 100 milliseconds to several minutes may be obtained by the choice of suitable worm or helical gears arranged on a four-shaft system. The contact fingers of these governors have tungsten points and are capable of breaking a current of up to 10 amperes at 230 volts alternating.

FILM ON LUBRICATION.—The Esso Petroleum Co., Ltd., 36, Queen Anne's-gate, London, S.W.1, have recently prepared a 16-mm. film to illustrate the basic principles of lubrication. The film has been made for them by Technical and Scientific Films, Ltd., with the help of Dr. F. P. Bowden, F.R.S., as scientific adviser, and will be used for instructional and training purposes within the Esso Company's organisation. The four sections of the film deal, respectively, with friction, fluid-film lubrication, boundary lubrication and extreme-pressure lubrication, and embody much of the research work carried out in the Laboratory for the Physics and Chemistry of Surfaces at the University of Cambridge. Applications for the loan of the film should be made to the manager, Industrial Sales Department, Esso Petroleum Company.

NOTES ON NEW BOOKS.

Railway Motive Power.

By Harry Webster, B.Sc., M.I.Loco.E., Hutchinson's Scientific and Technical Publications, Stratford-place, London, W.1. [Price 30s. net.]

THIS book is an ambitious effort. The author has set out "to bring between a single pair of covers a description and an outline of the history and development of all the principal forms of railway motive power in use to-day." Unfortunately, it is apparent that in many details either he has not clearly understood the facts or he has not been able to state them accurately. For example, the general reader for whom the book is mainly intended is likely to be misled into thinking that gas turbines depend on spark ignition, and the conception of continuous combustion will probably escape him. Nor will it help his understanding to read, in a brief glossary, that a conjugate valve gear is "the actuation of one valve gear by another through a link mechanism"; or to find, in the main description of the boiler, that the firebox is synonymous with the combustion chamber. Sir William Stanier was never "in office at Crewe," and the engine that now bears his name is not a modified unit but a later development of the Pacific-type engines that he designed. Though it is stated on page 102 that the coal consumed by British Railways in a year is about 40 million tons, on page 35 the author quotes an estimate that in Great Britain the "adoption of the oil-burning gas-turbine electric locomotive for railway operation on a national scale would effect a saving of five million tons of coal a year over present consumption with steam operation"; these two statements are incompatible. The main reason for abandoning streamlining on locomotives—to restore ease of maintenance—is not mentioned, though the change of policy is discussed. Measurements in dynamometer cars include wind speed and direction, but not wind pressure, as stated on page 127. "Cartazzi," where it occurs in the index and the text, is consistently mis-spelt. Errors of omission might be defended on the ground that there is not room for everything in a book that covers so wide a field, but it is regrettable that no mention is made of Churchward's principal and important contribution to locomotive development, though Churchward is referred to in several places on less specific points of detail. These lapses—which were noted without any special effort to find fault—do not encourage confidence in the book as a whole; which is a pity, since the author's plan is praiseworthy and, in general, he shows a sense of proportion in deciding what to include and what to omit.

Manufacturing Processes.

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

THIS book, like the *Engineering Materials Manual* noticed below, is intended as a general guide to a subject that covers a wide field. The author deals with founding, patternmaking, heat-treating, welding, hot forming, cold forming, powder metallurgy, plastics moulding, measuring and gauging, turning, thread-cutting, shaping, planing, drilling, boring, milling, gear-cutting, metal sawing, broaching, and grinding. The treatment of these subjects is suitable for the training of engineers in the fundamentals both of the machines and instruments used and the techniques of the processes. Two new chapters, on cold forming of metals, have been added to the third edition, and several have been rewritten, including those on special casting methods, plastics moulding, and welding and allied processes.

Engineering Materials Manual.

Edited by T. C. DUMOND. Reinhold Publishing Corporation, 330 West Forty-second street, New York 18, U.S.A. [Price 4 dols.]; Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 36s. net.]

HOW to select the best material for a newly-designed part—that is a problem that often taxes the knowledge and sources of information of designers. The easy solution is to use one of the common engineering materials, but that will hardly satisfy anyone who is conscious of the bewildering range of metals and non-metals now available. This book goes a long way towards enabling the designer to survey all the possible choices. It deals with steels, including stainless steels, high-strength low-alloy steels, tool steels and free-cutting steels; cast irons; wrought and cast aluminium alloys; magnesium alloys; nickel alloys; bronzes; beryllium copper; bearing metals; cemented carbides; ceramics; rubber; plastics; hard-facing materials; metal finishes; colouring of metals; porcelain enamels; and industrial adhesives. The book is, of course, based on American standards, but that fact need not detract completely from its value in this country The 28 sections into which it is divided appeared first in the journal *Materials and Methods.* They are illustrated by line drawings, as well as by some photographic illustrations which are not essential to the technical value of the book but improve its appearance. For its size (there are 386 pages) and comprehensiveness it is good value for 36s.

PRODUCTION OF STEEL, IRON AND NON-FERROUS VALVES.—The British Valve Manufacturers' Association, 32. Victoria-street, London, S.W.1, have recently published a booklet, entitled "A Guide to Better Living," presenting in simple language the recommendations of the productivity team representing the British steel, iron and non-ferrous valve industry which visited the United States under the auspices of the Anglo-American Council on Productivity. Copies of the "Guide" may be obtained from the Association at a price of 1s., including postage.

"HINTS TO BUSINESS MEN" BOOKLETS.—Revised editions in the series of booklets on "Hints to Business Men" visiting the Netherlands, Southern and Northern Rhodesia and Nyasaland, Denmark, Mexico, France, Malaya, Saudi Arabia and Yugoslavia have now been published. United Kingdom exporting firms can obtain copies on application to the Board of Trade, Commercial Relations and Exports Department (Industries Branch), Dissemination Section, Horse Guards-avenue, London, S.W.1. (Telephone: TRAfalgar 8855, Ext. 2170.)

BOOKS RECEIVED.

Central Board of Irrigation, India. Annual Report (Technical), 1948. Parts I and II. Offices of the Board, Simla.

Patternmaking. By L. L. Cox, Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 12*s*. 6*d*. net.]

Modern Lighting Technique. By HARRY HEWITT. Edward Arnold and Company, 14, Maddox-street, London, W.1. [Price 21*s*. net.]

A Geology for Engineers. By DR. F. G. H. BLYTH. Edward Arnold and Company, 14, Maddox-street, London, W.1. [Price 25*s*. net.]

Portugal. Laboratório de Engenharia Civil. Publication No. 22. *The Study of Road Subgrades. Progress made since the Congress at the Hague* (1938) *up to the Congress at Lisbon* (1951). General report presented at the IXth International Road Congress, 1951. By E. ARANTES E. OLIVEIRA. [Price 20 escudos.] No. 23. *L'Étude du Sous-Sol des Routes. Progrès accomplis depuis le Congrès de la Haye* (1938) *jusqu'au Congres de Lisbonne* (1951). Rapport Portugais présenté au IXme Congrès International de la Route, 1951. By M. E. ARANTES E. OLIVEIRA. [Price 20 escudos.] No. 24. *Modulação das Construções*. By A. V. GARCIA. Ministério das Obras Publicas, Laboratório de Engenharia Civil, Av. Rovisco Pas 41, Lisbon, Portugal.

Comparison between British and American Standards for the Short-Circuit Rating, Performance, Selection and Testing of Oil Circuit-Breakers. The Association of Short-Circuit Testing Authorities, 36 and 38, Kingsway, London, W.C.2. [Price 10*s*.]

The College of Aeronautics, Cranfield. Report No. 52. *The Distribution of Pressure over the Surface of Wings of Small Aspect Ratio*. By W. S. D. MARSHALL. The Librarian, The College of Aeronautics, Cranfield, Bletchley, Buckinghamshire. [Price 5*s*.]

Administration Report of Aden Port Trust for 1949-1950. The Chairman, Port Trust, Aden.

Units and Standards of Measurement Employed at the National Physical Laboratory. III. *Electricity. Current, Voltage, Resistance, Power, Energy, Inductance, Capacitance, Frequency, etc.* The National Physical Laboratory, Teddington, Middlesex. [Price 9*d*. net, postage 1½*d*.]

A.T.M. Mine Signalling Handbook. Automatic Telephone and Electric Company, Limited, Strowger Works, Liverpool, 7. [Price 5*s*.]

The Performance of Lubricating Oils. By H. H. ZUIDEMA. Reinhold Publishing Corporation, 330, West Forty-Second-street, New York 18, U.S.A. [Price 5 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 40*s*. net.]

Tractors and Their Power Units. By E. L. BARGER and others. 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.]

Nomography and Empirical Equations. By LEE H. JOHNSON. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 3.75 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 30*s*. net.]

Marine Refrigeration. By R. MUNTON. The Institute of Refrigeration, Empire House, St. Martin's-le-Grand, London, E.C.1. [Price 7*s*. 6*d*. post free].

Introductory Soil Mechanics and Foundations. By LIEUTENANT-COLONEL GEORGE B. SOWERS and PROFESSOR GEORGE F. SOWERS. The Macmillan Company, 60-62, Fifth-avenue, New York, U.S.A, [Price 4.75 dols.]; and Macmillan and Company. Limited, St. Martin's,street, London, W.C.2. [Price 32*s*. net.]

Design Policy in Industry. The Council of Industrial Design, Tilbury House, Petty France, London, S.W.1. [Price 3*s*. 6*d*.]

Workshop Practice. By E. PULL. Ninth edition, revised by P. S. HOUGHTON. The Technical Press, Limited, Gloucester-road, Kingston Hill, Surrey. [Price 24*s*. net.]

Electrical Measurements. By DR. FOREST K. HARRIS. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 8 dols]: and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 64*s*. net.]

Foundations of Engineering Science. By LESLIE PILBOROUGH. Blackie and Son, Limited, 16-18, William IV-street, London, W.C.2. [Price 15*s*. net.]

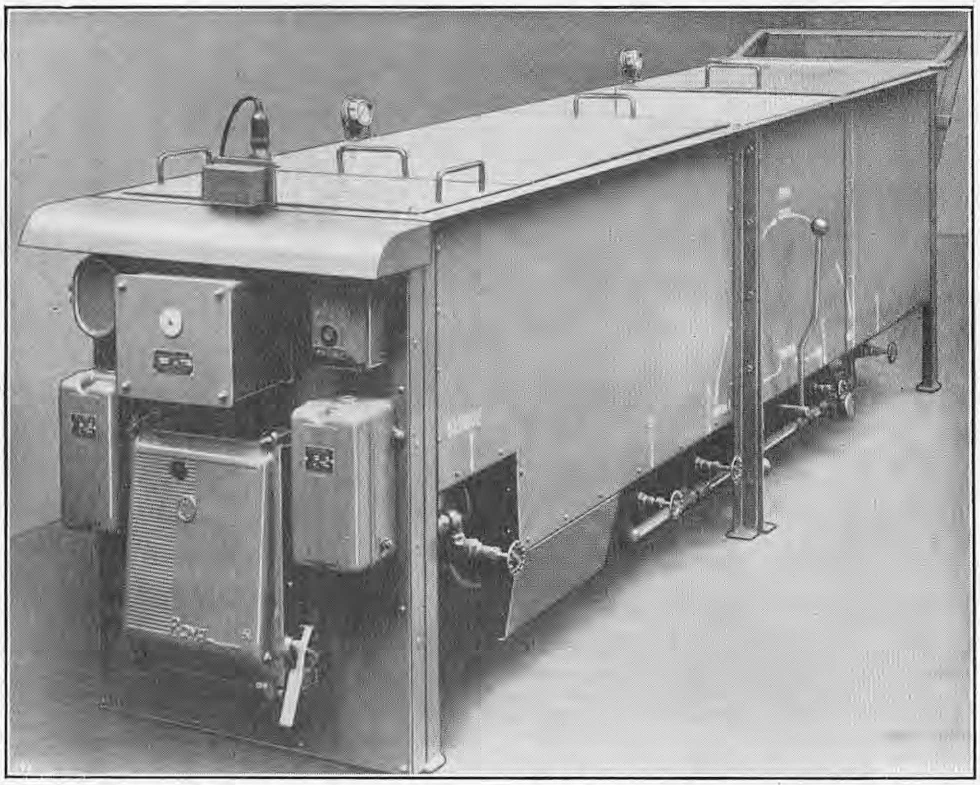
An Explaining and Pronouncing Dictionary of Scientific and Technical Words. By DR. W. E. FLOOD and DR. MICHAEL WEST. Longmans, Green and Company, Limited, 6 and 7, Clifford-street, London, W.1. [Price 12*s*. 6*d*. net.]

Ministry of Labour and National Service. Report of the Joint Standing Committee on Safety in the Use of Power Presses. Fencing of Hydraulic Presses. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s*. net.]

Road Research. Note No. 1. *Recommendations for Tar Surface Dressings*. Second edition. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 9*d*. net.]

ALKALI DEGREASING PLANT.

ORCENE COMPANY, LIMITED, WARWICK.



ALKALI DEGREASING PLANT.

AN alkali degreasing plant with a self-contained oil separator, believed to be the first of its kind, has been introduced recently by the Orcene Company, Limited, Victoria-street, Warwick. The plant, which has a loading of 24 kW, is shown above. It is intended for use by unskilled workers, and is provided with coloured indicator lights which show when the alkali requires regeneration. The plant comprises an alkali tank, a cold-water tank, and a hot-water tank, complete with immersion heaters, and a motor-driven oil separator at the forward end of the plant, together with the necessary electrical switchgear. Alkali degreasing is recommended when a chemically clean surface is required as, for example, for such processes as enamelling or electroplating. By adjusting the strength of the alkali, aluminium surfaces can be etched to provide a key for subsequent finishing processes. The components to be cleaned are immersed in the alkali tank, containing a degreasing solution of suitable strength which has been brought to boiling point. After degreasing, the parts are transferred to an agitated cold-water rinse to wash off the alkali residue. Finally, they are rinsed in hot water which imparts sufficient heat for them to dry off.

The oil separator keeps the surface of the alkali free from oil so that the workpieces are not contaminated as they are withdrawn, and prevents the oil from being absorbed into the alkali solution. It consists of a small tank with an arrangement of weirs, through which the degreasing solution is circulated by a pump. The oil rises to the surface and is run off from time to time; it can be reclaimed for subsequent use.

FILMS ON FORGING, MOULDING, WELDING AND TUBE-MAKING.—Four films on fundamental engineering processes have been produced for Babcock & Wilcox, Ltd., and will be available without charge to schools, colleges, and institutions. They are intended primarily for use in the instruction of students and apprentices, though the directness of the technical expositions and the absence of dramatisation will appeal to engineers. The film on foundry practice (running time 26 minutes) gives most pleasure; it calls to mind that facile craftsmanship of the moulder and patternmaker which every mechanical engineer first admired in his apprentice days. The film on forging (running time 12 minutes) encourages an appreciation of the plasticity of hot steel. "Welding in Boiler Manufacture" (running time 18 minutes) starts with the blacksmith's hammer welding and progresses to modern welding methods, and "Seamless Tube Making" (running time 17 minutes) explains the rolling-mill and Pilger-mill processes. The scripts are quite short and it is hoped to make them available in several foreign languages. They will be distributed through the head office, Farringdon-street, London, E.C.4, and branch offices of Babcock & Wilcox, Ltd.

LAUNCHES AND TRIAL TRIPS.

S.S. "BRAEMAR CASTLE."—Twin-screw passenger and cargo liner, with accommodation for 556 passengers in one class, built and engined by Harland and Wolff, Ltd., Belfast, for the "round Africa" service from London of the Union-Castle Line, London, E.C.3. Third of a series of three similar vessels. Main dimensions: 540 ft. between perpendiculars by 74 ft. by 35 ft. 6 in.; gross tonnage, about 17,000. Two-shaft arrangement of Parsons triple-expansion condensing double-reduction geared turbines and three Babcock and Wilcox oil-fired water-tube boilers. Launch, April 24.

M.S. "GOVERNOR."—Single-screw cargo vessel, built and engined by William Doxford & Sons, Ltd., Sunderland, for the Charente Steam Ship Co., Ltd. (Managers: Thos. and Jas. Harrison, Ltd.), Liverpool. Main dimensions: 460 ft. overall by 59 ft. 6 in. by 28 ft. 8 in.; deadweight capacity, 9,200 tons on a draught of about 26 ft. Four-cylinder opposed-piston oil engine. Service speed, about 13½ knots. Launch, May 8.

LIGHT VESSEL NO. 12.—Built by Philip & Son, Ltd., Dartmouth, for the Corporation of Trinity House, London, E.C.2. Twentieth light vessel built for the Corporation. Main dimensions: 130 ft. by 25 ft. by 15 ft.; gross tonnage, 350. The lantern contains six 500-watt lamps, giving a beam visible for 10 to 12 miles in clear weather. Launch, May 21.

M.S. "CEDRIC."—Twin-screw refrigerated cargo vessel built and engined by Harland & Wolff, Ltd., Belfast, for Shaw Savill and Albion Co., Ltd., London, E.C.3. Main dimensions: 481 ft. between perpendiculars by 69 ft. by 41 ft. 6 in. to shelter deck; gross tonnage, about 10,800. Two single-acting two-stroke opposed-piston Diesel engines. Launch, May 22.

M.S. "NORTH KING."—Single-screw oil tanker, built by the Blythswood Shipbuilding Co., Ltd., Scotstoun, Glasgow, for the Compania Petrolera de Transportes, S.A., Panama. Main dimensions: 530 ft. between perpendiculars by 72 ft. 9 in. by 38 ft. 8 in.; deadweight capacity, 18,500 tons. Rowan-Doxford six-cylinder opposed-piston Diesel engine, developing 7,300 b.h.p., constructed by David Rowan & Co., Ltd., Glasgow. Launch, May 26.

M.S. "ONITSHA."—Single-screw cargo vessel, carrying twelve passengers, built and engined by Harland and Wolff, Ltd., Belfast, for Elder Dempster Lines, Ltd., Liverpool. Main dimensions: 415 ft. by 62 ft. by 33 ft. to shelter deck; gross tonnage, about 5,100. Harland-B. and W. five-cylinder Diesel engine. Trial trip, June 5.

COASTAL MINESWEEPER.—First of a new series, built by J. S. Doig, Ltd., Grimsby, for the Admiralty. Length, 152 ft.; beam, 28 ft. 9 in.; armed with three small guns and carrying equipment for dealing with mines operated magnetically and acoustically. Diesel engine constructed by Mirrlees, Bickerton and Day, Ltd., Stockport. Launch, Jun 9.