THE BRITISH INDUSTRIES FAIR AT BIRMINGHAM—I.

THE British Industries Fair, which opens on Monday, May 5, comes at a time when it is more important than ever before for this country not only to maintain, but to increase its exports. Unfortunately, world prices have continued to move adversely, and this factor, coupled with the urgent need to accelerate rearmament, has imposed unprecedented burdens on almost all industries and made the maintenance of full production an increasingly difficult task. The difficulties are not confined to production, as the embargoes placed by certain countries, hitherto among the best customers, on the importation of a wide range of manufactured articles, have upset well-established selling organisations and led to a search for alternative markets. Increasing competition from Germany and Japan, and the tendency for countries, previously dependent on the United Kingdom for the supply of manufactured articles, to set up their own industries, protected by high tariffs, have added enormously to the difficulties. The high hopes of 1950 that at last the trade gap would be closed have, therefore, vanished, and instead of reaping some small benefits from past endeavours, even greater efforts will now have to be made, costs must be reduced, and new markets found. In this last task, the British Industries Fair can, and does, play a valuable part, as it is a trade exhibition, the various sections of which cover many aspects of British industry. The exhibits are conveniently grouped, so that foreign buyers are able to cover a wide field in the course of a visit to the Fair. Furthermore, the prices, delivery dates, specifications, etc., of the exhibitors can be compared on the spot without recourse to a lengthy correspondence. That the Fair is popular with overseas customers may be gauged from the fact that last year over 19,000 foreign buyers attended, this figure including 1,577 from Australia, 1,309 from India, 1,308 from the Netherlands, and 988 from America.

This year's Fair, the 31st of the series, follows very closely the pattern of its predecessors. As in the past, it has been organised by the Commercial Relations and Exports Department of the Board of Trade, in collaboration with the Birmingham Chamber of Commerce, and in consultation with the various representative industrial organisations. It is being held at three centres, namely, Earl's Court and Olympia in London, and Castle Bromwich, Birmingham. Earl's Court will house the Commonwealth Section and seven main trade sections, 260,000 sq. ft. of floor space being available for the exhibits, while Olympia, at which 300,000 sq. ft. will be available, will contain 14 main trade sections concerned with lighter industrial products. The main interest of engineers, however, will be centred once again on Castle Bromwich, where approximately 1,300 exhibitors, occupying over 500,000 sq. ft. of floor space, will be showing a wide variety of equipment, ranging from hardware and ironmongery to heavy mechanical and electrical engineering equipment. In addition, the usual display of structural and agricultural equipment, mining gear and contractor's plant will be staged on an open-air site beside the exhibition hall.

FIG. 1. "CARLISLE" ROAD GRADER; JOHN BLACKWOOD HODGE & CO., LTD.

ROAD GRADER.

For many years, much of this country's heavier contractor's plant, such as graders, scrapers, etc., was obtained from overseas, notably from the United States. In recent years, however, more of this equipment has been constructed here, some being of British design, while others have been manufactured under licence. It is, perhaps, not inappropriate, therefore, to commence our report of the Fair by describing some of the exhibits in this category. A good example is furnished by the Carlisle Model-200 heavy-duty road grader illustrated in Fig. 1, on this page, which is manufactured by the Distington Engineering Company, Limited, Chapel Bank Works, Workington, Cumberland, a subsidiary of the United Steel Companies, Limited, and will be shown at the Fair by Messrs. John Blackwood Hodge and Company, Limited, 20, Berkeley-square, London, W.1, the distributors. As will be seen from the illustration, the unit is of conventional design. It is powered by a Leyland type-0·350 six-cylinder compression-ignition oil engine having a capacity of 5·75 litres and an output of 75 brake horse-power at 1,600 r.p.m. The transmission incorporates a Leyland clutch and is designed to give eight forward speeds ranging from 2·22 miles an hour in first gear to 19·3 miles an hour in top gear. No differential is fitted, the drive being taken individually to the wheels at each side of the chassis through spur gearing. Channel sections have been used for the construction of the chassis, the main frame being made from two 12-in. by 5-in. by ¾-in. channels welded together to form a box section, with additional ½-in. plates welded to the top and bottom.

Movement of the grading blade is controlled hydraulically, the design being such that the blade, which is 12 ft. wide by 2 ft. deep, can be operated in the vertical position at each side of the machine. A scarifier can be fitted and this, like the blade, is brought into operation by means of a hydraulic cylinder and piston assembly. Heavy-duty 13·00 in. by 24 in. 8-ply pneumatic tyres are fitted to all six wheels, the wheels being of conventional automotive design with 10-stud fixing, and steering is accomplished by a Marles mechanical unit assisted by a Keelavite hydraulic cylinder. To give greater manœuvrability, the front-wheel mountings are designed so that the wheels can be set at an angle, an arrangement that also permits front-wheel skidding to be counteracted, the wheels being canted over so that they oppose the sideways movement. Two braking systems are provided, a Lockheed system, which acts on 16-in. by 3½-in. drums fitted to the rear wheels, and a mechanical system, which acts on the transmission. The overall length of the complete machine is 25 ft. 5 in., the wheelbase 18 ft. 11 in. and the turning-circle diameter 40 ft. When fitted with a scarifier, the total weight is 23,350 lb., of which 7,780 lb. is distributed on the front wheels and 15,570 lb. on the rear wheels.

DUMP TRUCK.

Other exhibits on the stand of Messrs. John Blackwood Hodge and Company, Limited, will include a selection of Euclid rear dump trucks. These machines are made by Euclid (Great Britain), Limited, at their Newhouse Works in Scotland, and, like the grader, are distributed by the Blackwood-Hodge organisation. A typical dump truck is illustrated in Fig. 2, on page 542, where it is shown at work in a quarry. These trucks are powered by a Model-UE 680 six-cylinder Leyland Diesel engine, rated at 154 brake horsepower at 2,000 r.p.m. The transmission group comprises a 15-in. single-plate dry-type clutch, a five-speed gearbox with ratios ranging from 6·54 to 1 in first gear to 0·636 to 1 in top gear, a fully-floating double-reduction rear axle with single-reduction differential, and planetary reduction gearing at each rear wheel. Four-wheel brakes are fitted and these are applied by compressed air, the compressor and associated control gear, etc., being of the Bendix-Westinghouse type. An emergency brake is also provided, acting on the transmission. The frame is exceptionally strong, the side members being formed from I-section beams $12\frac{3}{4}$ in. deep, with 8-in. top flanges and 6-in. bottom flanges.

The body, which has a struck capacity of 9·7 cub. yards and a heaped capacity of 11·4 cub. yards, is built up from channel sections, the "skin" consisting of $1\frac{1}{2}$-in. oak planking sandwiched between $\frac{3}{8}$-in. and $\frac{5}{16}$-in. medium-carbon steel plates. It rests on six rubber shock-absorbers fitted to the upper side of the frame, and pivots on a shaft operating in steel sleeve-type bearings backed by rubber inserts. A three-stage telescopic ram is used for raising and lowering the body, oil under pressure being supplied by a gear-type pump driven from a power take-off on the gearbox, the ram, pump, operating valve and power take-off being designed and made by Euclid, Limited. Raising, lowering and holding the body are controlled by a four-way valve actuated by a lever situated at the left of the driver's seat. As will be seen from the illustration, the driver's cab is protected by a substantial canopy, integral with the forward end of the body. The cab extends the full width of the vehicle and is fitted with safety glass and individual seats for the driver and his mate. The overall dimensions of the truck are: length, 22 ft. $8\frac{5}{8}$ in.; width, 8 ft. $9\frac{1}{4}$ in.; and height, to the top of the exhaust stack, 10 ft. $7\frac{3}{4}$ in. The wheelbase is just over 13 ft., and the unladen weight is 29,400 lb., 11,400 lb. of which is distributed on the front axle.

TRACK-LAYING TRACTOR, WITH ATTACHMENTS.

The outstanding exhibit on the stand of Messrs. Jack Olding and Company, Limited, Hatfield, Hertfordshire, undoubtedly will be the new Vickers VR-180 heavy track-laying tractor, a full description of which was published in our issue for February 29 of this year. This machine, which is fitted with a Rolls-Royce 180-h.p. supercharged six-cylinder Diesel engine, has been developed by Messrs. Vickers-Armstrongs Limited, and is being distributed throughout the world by Messrs. Jack Olding. A selection of earth-moving equipment designed and constructed by Messrs. Vickers-Armstrongs specifically for use with the VR-180 tractor will also be shown, the selection including the bull-dozing attachment illustrated in Fig. 3, on Plate XXI, and the scraper illustrated in Fig. 5, on the same Plate. The bull-dozing attachment consists basically of a centrally-pivoted angling and tilting blade, with triangulated bracing, mounted on a U-frame, which embraces the front of the tractor and is connected to the tractor chassis. It is controlled by cables from a rear-mounted control unit, the cable being led to the forward end of the tractor through an overhead conduit supported by four cantilever box-section legs. The blade has a length of 11 ft. 6 in. and a height of 3 ft. $2\frac{1}{2}$ in., and can be lifted 5 ft. above the ground or lowered 2 ft. below the level of the tracks. The cutting edge is formed from high-carbon steel and is in three sections, a centre section 9 ft. in length and two corner sections each 15 in. long.

The scraper has a struck capacity of 12 cubic yards and a heaped capacity of 15 cubic yards. Like the bull-dozing attachment, it is operated from the rear control unit, the design, in general, following conventional lines. The bowl, which is made from high-tensile steel, has a height of 5 ft. 1 in. and a floor measuring 3 ft. $10\frac{3}{4}$ in. by 8 ft. 8 in., the cutting edge extending the full width of the bowl. Forward ejection is employed, the maximum depth of spread being $12\frac{1}{2}$ in.; there is no limit, however, to the depth of cut. Two 18·00 in. by 25 in. tyres are fitted to the front axle and two

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

FIG. 2. "EUCLID" DUMP TRUCK; JOHN BLACKWOOD HODGE & CO., LTD.

21·00 in. by 25 in. tyres to the rear axle, the front wheels being provided with ball and roller bearings and the rear wheels with tapered-roller bearings. Brakes are fitted to the rear wheels only and are applied by an air-operated servo cylinder operated by the tractor pedal, the air compressor and ancillary equipment being supplied with the scraper for mounting on the tractor. With the exception of the apron lift, which is provided with a $\frac{3}{4}$-in. diameter cable, all cables are $\frac{1}{2}$ in. in diameter, and the sheaves, which are made from case-hardened steel, are fitted with roller bearings. The overall length of the complete machine is 33 ft. $10\frac{3}{4}$ in., the overall width 10 ft. $5\frac{1}{4}$ in., and the height, with the blade resting on the ground, 9 ft. 4 in. The front-wheel track is 6 ft., the rear-wheel track 6 ft. 6 in., and the wheelbase 20 ft. $6\frac{1}{2}$ in.

As already mentioned, both the dozer and scraper are operated by a rear-mounted control unit. This equipment is illustrated in Fig. 4, on Plate XXI, where it is shown installed on the rear of a tractor. It is driven through spur gearing from the rear power take-off and consists basically of two separate winches, each provided with its own clutch and brake. The drum diameters are 9 in. and the length 6 in., and each is capable of accommodating 220 ft. of $\frac{1}{2}$-in. diameter cable. At an engine speed of 1,800 r.p.m., the maximum governed speed, the line speed is 357 ft. per minute with a bare drum and 545 ft. per minute with a full drum. Air-cooled multi-plate clutches are used to transmit the drive to the winch drums and the brakes are of the automatic self-wrapping band type. The laying-on gear consists of vertical swivelling sheaves, each winch being provided with two separate sheaves.

REVERSING AND BRAKING CONTACTORS.

The central feature of the Castle Bromwich stand of the British Thomson-Houston Company, Limited, Rugby, will be a scale reproduction, over 16 ft. high and 14 ft. in diameter, of a 62·4-MVA vertical water-wheel, with its stator, exciter and thrust-bearing frame. Three of these sets have been constructed for the Los Peares power station in North-west Spain. The transformers and switchgear will also be supplied by the same firm. Another model on the stand will be of a 1,000-h.p. Diesel-electric shunting and transfer locomotive, ten of which are on order for the New South Wales Government. An actual control desk with an instrument panel for one of these locomotives is incorporated in a full-size replica of the driver's cabin.

Some interesting equipment, which has been designed for controlling electrically-driven machinery will also be found on the stand. It will include the reversing and braking contactor illustrated in Fig. 6, opposite, which will be connected in the circuit of a 2,370-h.p. 6·6-kV slip-ring motor driving a mine winder. The contactors themselves, which are mounted on a fabricated-steel chassis, are very compact, and have been designed so that they are easy to clean and renew. With the exception of the operating rods, which are made of insulating material with ample creepage surface, porcelain insulation is used throughout. Each pole consists of a copper rod, which forms the terminal and runs through two porcelain insulators which are clamped to the chassis structure. The lower of these insulators supports the moving contact system and one of the arc housings, while the upper carries the fixed contact. The interiors of the arc chutes are wide at the bottom, but taper quickly to a narrow slot, thus ensuring that the arc is cooled. On emerging from the chute the arc is divided by a series of "splitters." The contactor is operated by a steel clapper-type magnet, which is energised by direct-current supplied through a metal rectifier. The magnet system is mounted on the chassis beneath the poles. The magnet itself and the operating lever are fabricated in one piece and are connected to the operating rods, auxiliary switches and mechanical interlock.

The reversing contactors are magnetically operated, mechanical and electrical interlocks being provided to prevent the "forward" contactor closing before the "reverse" contactor is opened. In addition, potential interlocking relays are fitted to prevent the operating magnet of one of the main contactors being energised unless the arc formed across the tips of the other contactor, when opening circuit, has been extinguished. This effect is obtained by connecting a small three-phase potential transformer across the stator winding of the motor that is being controlled and using the secondary circuits of this transformer to energise the normally-closed potential interlocking relays. These relays thereby interrupt the operating coil circuit of each of the high-voltage contactors as long as an arc persists between the main poles. The potential interlocking relays are set so as to remain picked up until the voltage across the main contact tips has dropped to a very low value. The direct-current required for dynamic braking is switched on and off by a triple-pole contactor, two poles of which are connected in parallel to one side of the line. This contactor is also mechanically and electrically interlocked with the power contactors so that only one can be closed at a time. In addition, a relay is provided, the series coil of which is energised by the braking current, thus ensuring that the direct-current supply has been opened before the power contactors can be energised.

(To face page 542.)

EXHIBITS AT THE BRITISH INDUSTRIES FAIR, BIRMINGHAM.

(For Description, see Page 541.)

FIG. 3. VICKERS TRACTOR WITH CABLE-CONTROLLED DOZER; JACK OLDING AND COMPANY, LIMITED.

FIG. 4. CABLE CONTROL UNIT ON TRACTOR; JACK OLDING AND COMPANY, LIMITED.

FIG. 5. VICKERS SCRAPER; JACK OLDING AND COMPANY, LIMITED.

EXHIBITS AT THE BRITISH INDUSTRIES FAIR, BIRMINGHAM.

(*For Description, see Page* 541.)

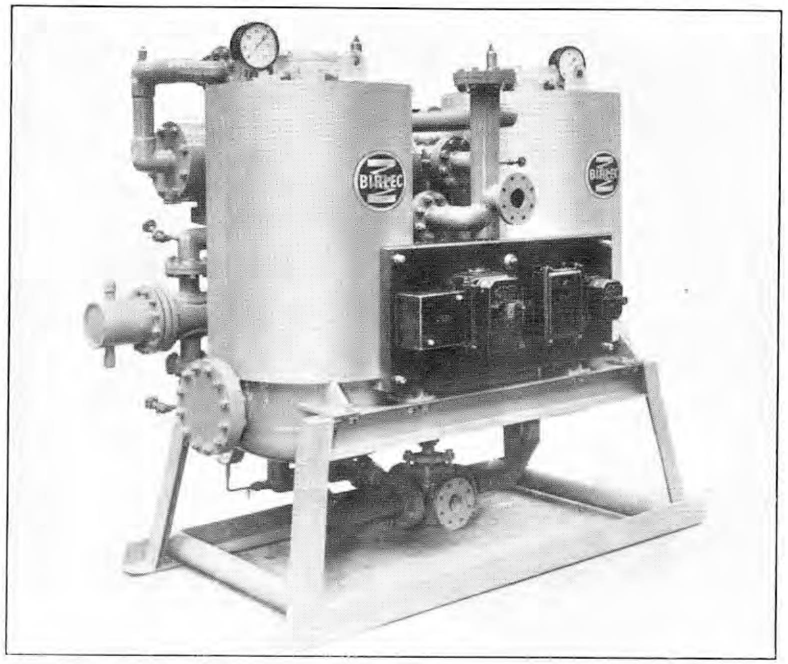


Fig. 11. Compressed-Air Dryer; Birlec, Limited.

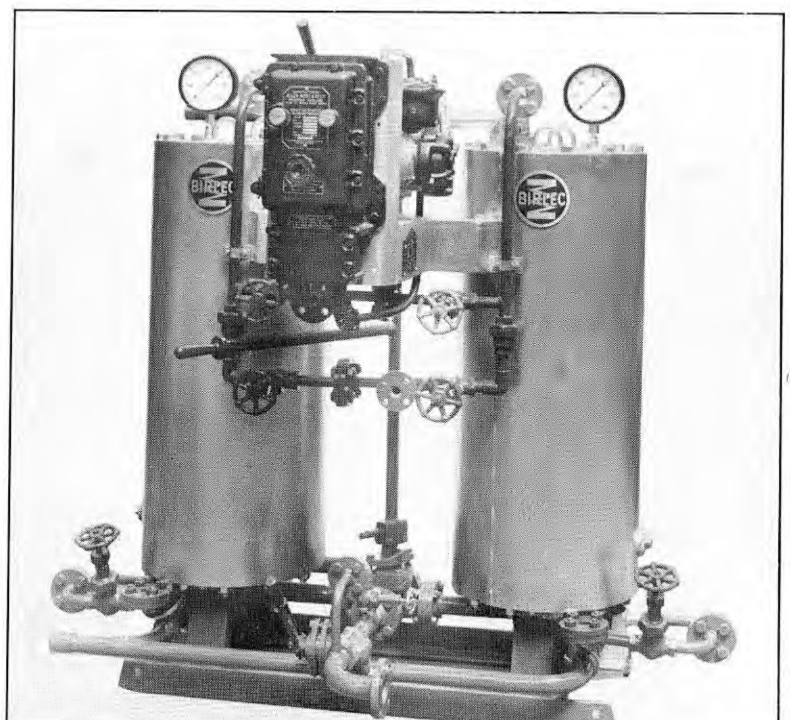


Fig. 12. Dryer for Compressed Industrial Gases; Birlec, Limited.

Fig. 13. Mobile X-Ray Equipment; Newton Victor, Limited.

(*To face page* 543.)

EXHIBITS AT THE BRITISH INDUSTRIES FAIR, BIRMINGHAM.

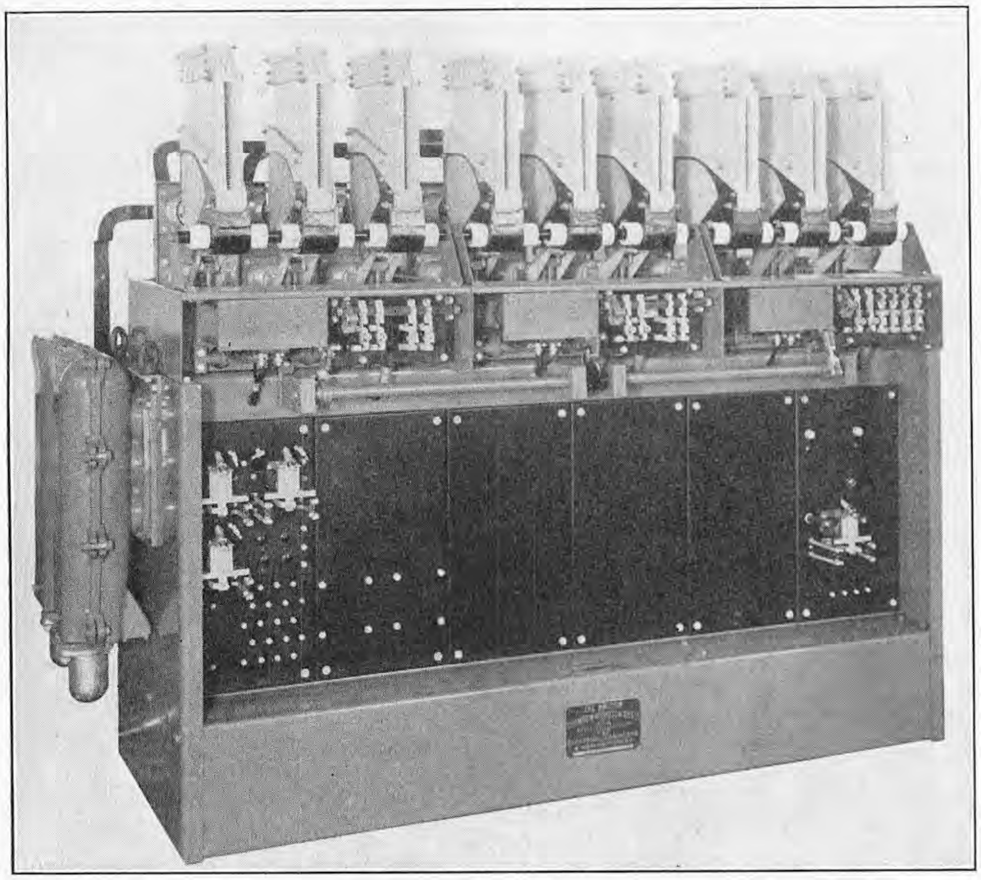


FIG. 6. 2,370-H.P. 6·6-KV REVERSING AND BRAKING CONTACTOR; BRITISH THOMSON-HOUSTON CO., LTD.

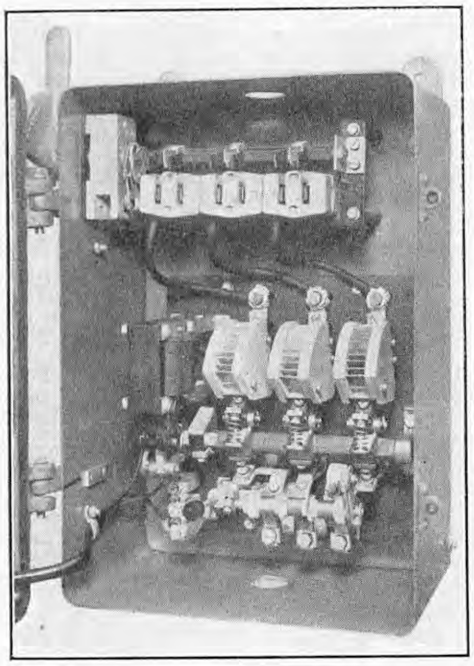


FIG. 7. ALTERNATING-CURRENT CONTACTOR STARTER; BRITISH THOMSON-HOUSTON CO., LTD.

Fig. 7, herewith, shows a starter, with isolator, which has been designed for controlling motors with outputs up to 30 h.p. at 400 volts. It is, therefore, useful in connection with the employment of electric motors of the relatively small sizes which are in demand for general industrial purposes. It incorporates "multi-arc" chutes of a type which has been designed to ensure that the breaking capacity of a contactor fitted with them will be increased owing to the reduction in the quantity of arc gases and vapours emitted. The life of the contacts themselves is also much increased. Another exhibit on the stand of the British Thomson-Houston Company, of which a brief mention may be made, is a three-phase electronic Ignitron control panel which has been designed for use with resistance, spot and seam welding machines. It is illustrated in Fig. 8, herewith. During the exhibition, this panel will be operated on an artificial load so that visitors to the stand will be able to appreciate its performance by observing a cathode-ray oscilloscope.

RELAY CONTACTOR.

Messrs. Londex Limited, 207, Anerley-road, London, S.E.20, will show a new relay contactor, which is illustrated in Fig. 9, on page 544. It is rated at 15 amperes and can be provided with up to five main and two change-over auxiliary contacts. These contacts are of fine silver, tungsten or various alloys, and the coil is designed for use on 600-volt alternating-current or 250-volt direct-current circuits. Where very high speed operation is required, as on spot welders, ball-bearing hinges can be fitted. The firm's well-known multi-contact LF relay is now contained in a pressed-steel case, thus rendering it suitable for use in many industrial situations and facilitating wiring.

POLICE-TYPE WINKER BEACON.

Messrs. Londex, Limited, will also exhibit the "Winker" beacon illustrated in Fig. 10, on page 544. This equipment, which is employed by a number of police forces, for illuminating such

FIG. 8. ELECTRONIC IGNITRON CONTROL PANEL; BRITISH THOMSON-HOUSTON CO., LTD.

positions as unlighted S-bends on country roads, is provided with a cold discharge lamp, which is sufficiently large to give an intense flash. This lamp is supplied through an electro-magnetic impulse generator from a 12-volt battery, the life of which is six weeks if the beacon is run continuously day and night.

DRYER FOR COMPRESSED AIR.

Messrs. Birlec, Limited, Tyburn-road, Erdington, Birmingham, 24, are continuing the policy, which was so successful last year, of confining their exhibits to examples of their Lectrodryers for the dehydration of air (particularly compressed air) and of other process gases and certain organic liquids. Two of the units are of the "dual adsorber" type, that is, they are equipped with two beds of adsorber material, which operate in turn. While one bed is on duty the other can be reactivated, the drying process thus being continuous.

The smaller of these units, illustrated in Fig. 11, on Plate XXII, is capable of drying 200 cub. ft. of air per minute at a pressure of 100 lb. per square inch, from saturation at 70 deg. F. to a dewpoint of 0 deg. F., and is to be used for operating control instruments at an important new oil refinery in Great Britain. The dryer is fully automatic in operation and its mechanism is operated by a time-controlled valve. The drying agent is activated alumina, which is highly resistant to crushing and abrasion and is capable of adsorbing a relatively large weight of water at high efficiency. The material is not moistened or softened when saturated, and is easily restored to full efficiency after saturation. Further advantages are that the alumina is non-corrosive and is inert to nearly all reagents. It is also adsorbent to moisture in some organic liquids as well as in gases. It is undamaged by relatively high temperatures, is not harmed by contact with liquid water and offers low resistance to gas flow.

Reactivation is effected by raising the temperature of the adsorbent by means of a built-in electric heater or steam coil, while air or gas is passed through it to carry off the moisture. A change-over cycle of about 8 hours is usual, the heater being rated to drive off the adsorbed moisture in about half this period, the remainder being allowed for cooling. In the case of the electrically-heated models, thermostats are fitted to prevent overheating. Cooling in the smaller models is by natural radiation, but in the larger models a finned pipe coil is embedded in the alumina and carries cooling water.

DRYER FOR COMPRESSED INDUSTRIAL GASES.

Fig. 12, on Plate XXII, shows a Lectrodryer for drying process gases, which is designed to handle 560 lb. of carbon dioxide per hour at a pressure of 220 lb. per square inch and to dry it from saturation at 95 deg. F. to a dew point of − 40 deg. F. To prevent entry of air into the system, a stream of the gas that is being dried is passed through the bed during reactivating and the moist gas is then cooled, to condense part of its water content, and returned to the gas circuit, thus preventing waste.

Mobile X-Ray Equipment.

Fig. 13, on Plate XXII, is a mobile X-ray unit which is being exhibited by Messrs. Newton Victor, Limited, 15, Cavendish-place, London, W.1. It is self-contained and the X-ray generator, tube unit and control are mounted on a rubber-tyred trolley so that it can be used in any part of a works or construction site where a suitable electricity supply is available. A similar set on the stand will be used for demonstrating fluoroscopic examinations.

The transformer-rectifier unit, which forms part of the equipment, comprises a high-voltage X-ray transformer, valve and tube filament, transformers and two rectifying valves, all of which are oil-immersed in an earthed steel tank. This tank has terminal openings for shock-proof cable bushing adaptors, and a universal static stabiliser is mounted on one of its sides. The control equipment, which, is arranged for wall-mounting, consists of a combined overhead circuit-breaker and line switch, devices for infinitely varying the peak voltage from 30 to 140 kV and for controlling the X-ray tube filament, a pre-reading voltmeter with a range of 0 to 150 volts, and a milliammeter with a range of 0 to 15 milliamperes. There is also a synchronous motor timer, which allows the exposure to be altered from 1 second to 55 minutes in one-second intervals, a timer switch, integrating hour clocks to show both X-ray and filament hours, and an X-ray exposure switch. The equipment is designed for continuous operation from 30 to 140 kV peak and is capable of producing radiographs of steel sections up to 1¼ in. thick. It is particularly suitable for the radiographing of castings and fabrications in light alloys, of thin sheets, rods and tubes of denser material, and of a wide variety of synthetic materials, including plastic and laminated products.

Polyphase Meter-Testing Set.

Messrs. Ferranti, Limited, Hollinwood, Lancashire, will, as usual, exhibit a wide range of their products. These will include a standard 500-kVA three-phase 11,000/433-volt substation transformer, which has been built to the new British Electricity T.1 specification. A 5-kVA single-phase 11,000/250-volt pole-mounting transformer and a 50-kVA three-phase 11,000/433-volt pole-mounting transformer which conform with the same specification will also be shown. In each case the tank side is cut away in section and the interior is illuminated so that the internal construction is visible.

Among the measuring instruments to be shown, mention may be made of the polyphase meter-testing set illustrated in Fig. 14, opposite. It is intended primarily for checking polyphase three- and four-wire meters, but, as the three circuits are operated independently, it can also be used as three single-phase testing sets. It will therefore fulfil all the needs of the smaller testing stations. The desk is constructed, as far as possible, of light-gauge sheet steel and in designing the set great attention has been made to accessibility. The output is 500 volt-amperes per phase and can be continuously varied by auto-transformers in three ranges from 0 to 150, 0 to 300 and 0 to 600 volts. A static phase-shifting transformer with a corresponding rating is provided for power factor adjustment, and the phase angle in each phase can be varied independently through 360 deg. by coarse and fine controls. The dials are marked so that, when the zero power factor has been set for any load, any other power factor may be obtained easily and quickly. Six current ranges are normally provided and these are rated at 100, 50, 25, 10, 5 and 1 amperes, respectively. On each range the current is continuously variable from zero to the maximum by three auto-transformers. In addition, a ganged fine control is provided for load steadying. An output of 500 volt-amperes is available on the 10-ampere and higher tappings, and 250-volt-amperes and 50 volt-amperes on the 5-ampere and 1-ampere tapping, respectively. The current ranges are selected by self-cancelling interlocked push-buttons. The equipment includes three 15-volt-ampere precision current transformers, which are provided with primary ranges corresponding to the current supply tappings, and with 5-ampere secondaries. These transformers can easily be removed for certification. A 4-in. square voltmeter and an ammeter are connected in each phase and are mounted on a panel above the desk, where there are also terminals for sub-standard instruments. These voltmeters can be switched in to read either phase-to-neutral or phase-to-phase values. Power-factor indicators can also be mounted on the panel.

Clip-On Voltmeter-Ammeter.

Another instrument which will be displayed on Messrs. Ferranti's stand is the seven-range clip-on voltmeter-ammeter illustrated in Fig. 15, opposite. This instrument has until recently been for export

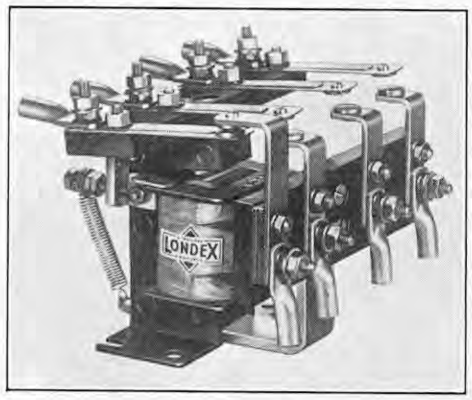


Fig. 9. Relay Contactor; Londex, Ltd.

Fig. 10. Police-Type "Winker" Beacon; Londex, Ltd.

only, but is now available for the home market. It is designed to accommodate conduits up to 2¼ in. n diameter and to measure alternating currents up to a maximum of 1,000 amperes in five ranges, as well as voltages up to 600 volts in two ranges. The ammeter consists of a current transformer and a 2½-in. rectifier-type instrument, which is housed in a black case. Terminals are provided on the front of this case for voltage measurements. The range selector is arranged for thumb operation and the instrument is so balanced that it is easy to operate with one hand. It is suitable for use on 50- to 70-cycle circuits and the ammeter can be used with safety on bare conductors up to 600 volts alternating current.

Non-Magnetic Cast Iron.

As an example of their activities in fields other than electrical measurements, Messrs. Ferranti will demonstrate the properties of NOduMAG. This material is a spheroidal austenitic iron which is virtually non-magnetic and is also soft though tough. The specific resistance is about 95 micro-ohms per cubic centimetre. Compared with grey iron, whether austenitic or pearlitic, NOduMAG is much less brittle, though it has the good founding properties of the former material. The impact strength is 15 ft.-lb. to 20 ft.-lb. on a standard notched Izod test piece and when tested according to British Standard Specification 1349 for grey iron it invariably gives the maximum figure of 120 without fracture. The tensile strength is usually from 20 tons to 24 tons per square inch, and a modulus of rupture of 45 to 50 is obtained in transverse on a 1·2 in. diameter bar on 18 in. centres. Elongations of 5 to 10 per cent. can be obtained and the material bends considerably before fracture.

Crucible Furnace for Non-Ferrous Metals.

The Gas Council display of gas-heated appliances for industry will include a prototype crucible furnace for melting non-ferrous metals, etc., developed by the East Midlands Gas Board. Radiant burners are employed, giving a considerable increase in crucible life over that obtained with the tangential type of burners usually used. The latter comprise single air-blast burners firing tangentially round the base of the crucibles; the hot gases travel upwards in a helical path between the outside of the crucible and the inside of the furnace. The crucible is, therefore, heated by convection from the hot gases, radiation from the furnace walls, and conduction from the base of the crucible, resulting in local overheating at the point of highest flame intensity and uneven heating of the crucible. The plumbago around the base of the crucible tends to scale off, there is a considerable amount of unused heat in the exhaust gases, also a high degree of combustion noise, and relatively high heat losses from the furnace walls.

The new crucible furnace, which is illustrated in Figs. 16, 17 and 18, opposite, has four radiant burners bolted to the cast-iron side plates. Refractories are required only at the base, at the four corners of the furnace, and above the burners. The arrangement of the burners ensures that the crucible is evenly heated on all sides, thus eliminating local hot spots and reducing exfoliation. Each burner comprises four standard radiant blocks, each rated at 60 cub. ft. of gas per hour, the air being at a pressure of 28-in. water gauge, and the gas at the normal mains pressure at the inlet of the special air-gas mixing unit. The maximum gas rate is 960 cub. ft. per hour, with a standby rate of 400 to 500 cub. ft. per hour. The burner faces reach a temperature of 1,400 deg. C., which falls to a red heat when a crucible is placed in the furnace, and rises again as melting progresses.

The burners have withstood completely satisfactorily a severe three-weeks' testing period, melting general non-ferrous scrap. Heat losses through the furnace walls are greatly reduced in the new furnace, since most of the internal wall area consists of burner faces. The combustion noise is also greatly reduced at all gas rates. From a cold start, an initial melt of 90 lb. of brass (60/40 mixture) can be poured in 45 minutes; subsequently, a similar amount can be melted in 30 minutes, using a 120-lb. crucible. A crucible furnace of similar design has been used satisfactorily for powder-metallurgy research work.

Portable Cover Furnace.

Another interesting exhibit on the main stand of the Gas Council will be a portable cover furnace, for the heat-treatment of ferrous or non-ferrous castings and forged-steel rolls up to temperatures of 1,050 deg. C., developed by the Dowson and Mason Gas Plant Company, Limited, Alma Works, Levenshulme, Manchester, 19. Fig. 20, on page 546, shows a cover furnace, similar to that to be shown at the exhibition, capable of accommodating 4 tons of castings. The sand-sealed hood, which weighs less than 5 tons, can be raised and lowered by a 5-ton electrically-operated winch at a hoisting speed of 20 ft. per minute. The speed is automatically reduced by a micro-switch to 30 in. per minute when the hood is near the base, to avoid any risk of damage. A 6-cwt. jib crane is incorporated in the furnace for handling material to and from the furnace base; a limit switch ensures that the

EXHIBITS AT THE BRITISH INDUSTRIES FAIR, BIRMINGHAM.

FIG. 14. POLYPHASE METER-TESTING SET; FERRANTI, LTD.

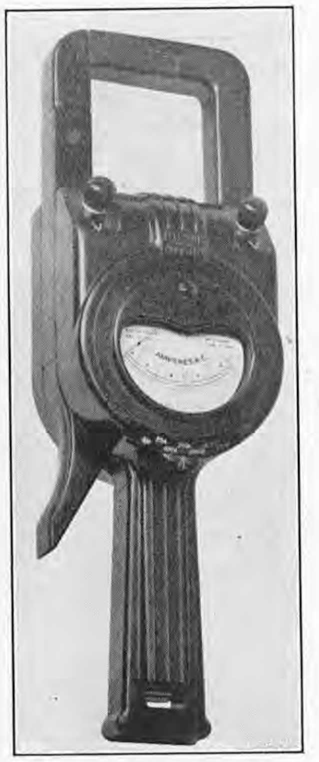


FIG. 15. SEVEN-RANGE CLIP-ON VOLT-AMMETER; FERRANTI, LTD.

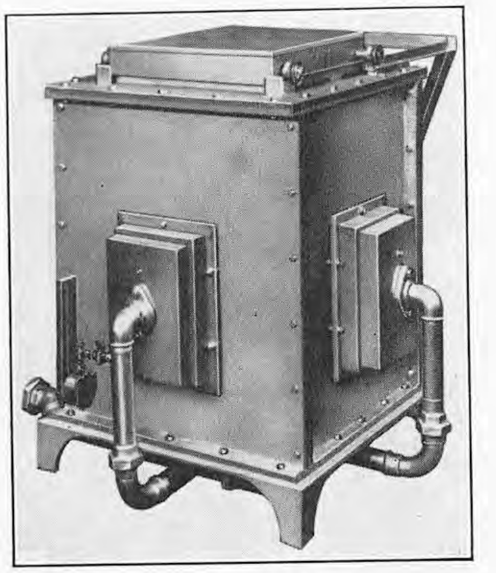


FIG. 16.

hood cannot be lowered unless the jib crane is clear. Although highly efficient, this type of furnace is less costly than the normal furnace with a lifting door equipped with gearing and counterbalance weights. The hearth is 4 ft. wide and 7 ft. 6 in. long. With the hood lowered, the height from the hearth to the underside of the flat roof is 3 ft. 8 in. The burners are arranged to give a high degree of flame radiation; they are installed in both longitudinal sides of the base, and are supplied with town's gas and air at 6 in. water-gauge pressure, through gas and air mains, of welded-duct construction, built into the furnace base. The burnt gases exhaust at hearth level and are led away through flues in the hood. An air-blowing fan and a single-point recording and controlling instrument are included in the installation. According to the Gas Council, "the use of this type of furnace for the heat-treatment of forged-steel rolls has resulted in the production of rolls of a type which have more than challenged the superiority which American rolls formerly had in this field."

FORGE FURNACE.

Other examples of heat-treatment plant on the Gas Council stand will include a Cyclone forge furnace, for temperatures between 800 deg. and 1,250 deg. C., made by the Thermic Equipment and Engineering Company, Limited, Salmon-street, Preston, designed for high-quality forging and stamping work. There is little or no flame impingement on the hearth, and a high degree of temperature uniformity can be attained over the hearth area. A muffle furnace constructed by the Selas Gas and Engineering Company, Limited, Selas Works City-road, Manchester, 15, with a maximum working temperature of 1,250 deg. C., designed for use with low-pressure gas, is also to be shown; such furnaces are used for production heat-treatment work, research and experimental work, and medical purposes.

INFRA-RED DRYING TUNNEL.

The use of radiant heat for drying is also to be illustrated on the Gas Council stand. One example is an infra-red drying tunnel manufactured by Messrs. Thomas de la Rue and Company, Limited, Imperial House, 84-86, Regent-street, London, W.1. It consists of a series of cast-metal panels, each heated directly by 12 gas flames and backed by insulation and housed in a sheet-metal case. Fig. 21,

Fig. 17.

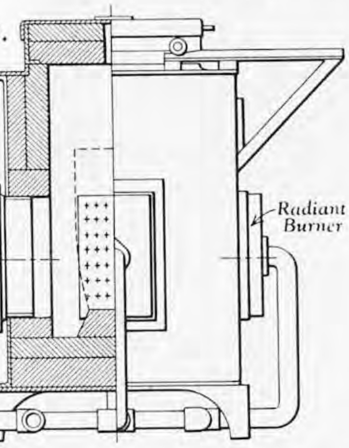
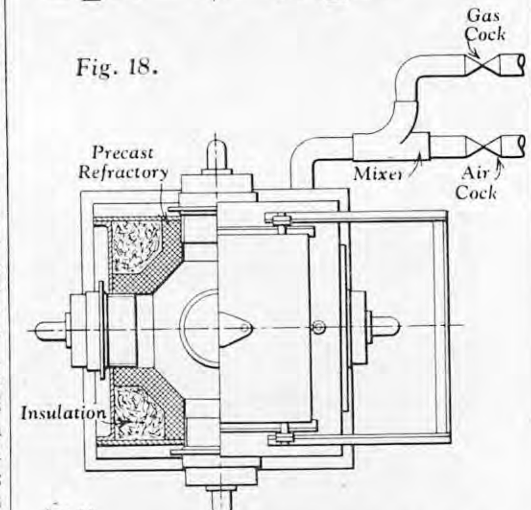


Fig. 18.



FIGS. 16-18. GAS-FIRED CRUCIBLE FURNACE; EAST MIDLANDS GAS BOARD.

on page 546, shows a tunnel of this type consisting of 32 horizontal panels. The unit on view at Castle Bromwich will have four horizontal infra-red panels built over a wide-mesh conveyor belt 11 ft. long by 2 ft. wide; the conveyor is provided with a variable-speed unit giving a ratio of maximum to minimum speed of 4 to 1. It is a typical example of the kind of oven used for stoving batches of small articles, such as cores which have been graphite-blacked, at a temperature of about 300 deg. F.

CORE-DRYING STOVE.

Another core-drying stove on view will be the Acme continuous vertical stove made by the Foundry and Engineering Company, Limited, Sandwell-road, West Bromwich. A similar stove, installed at the Coseley foundry of Messrs. Thomas Green and Company, Limited, Bilston, Staffordshire, is illustrated in Fig. 19, on page 546. It is designed to dry large quantities of small cores. The stove is constructed in double sheet steel, lagged with silicate cotton. The conveyor is carried on steel framing, independent of the body, the lower part of the conveyor usually being arranged to pass underneath the combustion chamber, which is then at a convenient height, with a loading point about 2 ft. or 2 ft. 6 in. above floor level. Within the body of the stove is a furnace lined with refractories and fired by burners with Aeromatic injectors. Part of the secondary air, which is provided by a blowing fan, is discharged into the firebox below the burners to dilute and carry the burnt gases into the stove towards the loading end. Air is also passed into a heater box over the top of the burners and discharged towards the descending cores for a final baking and oxidation of the core binder. The average gas consumption of the fully-loaded stove is about 600 cub. ft. per hour. The stove can dry 15 to 20 cwt. of oil-sand cores in an hour. The continuous vertical system, it is claimed, gives a high thermal efficiency, requires the minimum of floor space, and gives a uniform finish.

FOUNDRY DRYERS.

Other gas-fired foundry dryers on the Gas Council stand will include a drawer-type core-drying furnace made by Messrs. F. J. Ballard and Company, Limited, 26, Dudley-road West, Tividall, Tipton, Staffordshire, and fitted with flame-failure mechanisms and explosion-relief panels conforming with the recommendations of the Factory Department of the Ministry of Labour; a mould dryer, produced by Modern Furnaces and Stoves, Limited, Booth-street, Handsworth, Birmingham, 2, for use where dilution of the hot air with products of combustion is possible; and foundry mould and core drying torches manufactured by the Selas Gas and Engineering Company, Limited, Manchester. Also for foundry use, a crucible furnace for aluminium and bronze die-casting, made by the Morgan Crucible Company, Limited, Battersea Church-road, London, S.W.11, is to be displayed; it will have a capacity of 200 lb., but it is available in sizes up to 400 lb. capacity. A demonstration of glass working will be given by Messrs. G. Springham and Company, Ponders End, Middlesex, using a burner supplied by Messrs. Chance Brothers, Glass and Lighthouse Works, Smethwick, Birmingham, 40;

EXHIBITS AT THE BRITISH INDUSTRIES FAIR, BIRMINGHAM.

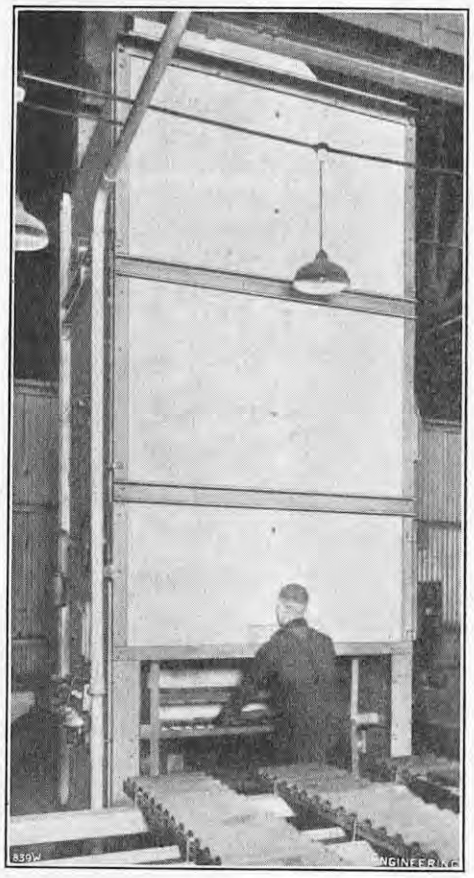


FIG. 19. CONTINUOUS VERTICAL CORE STOVE; FOUNDRY & ENGINEERING CO., LTD.

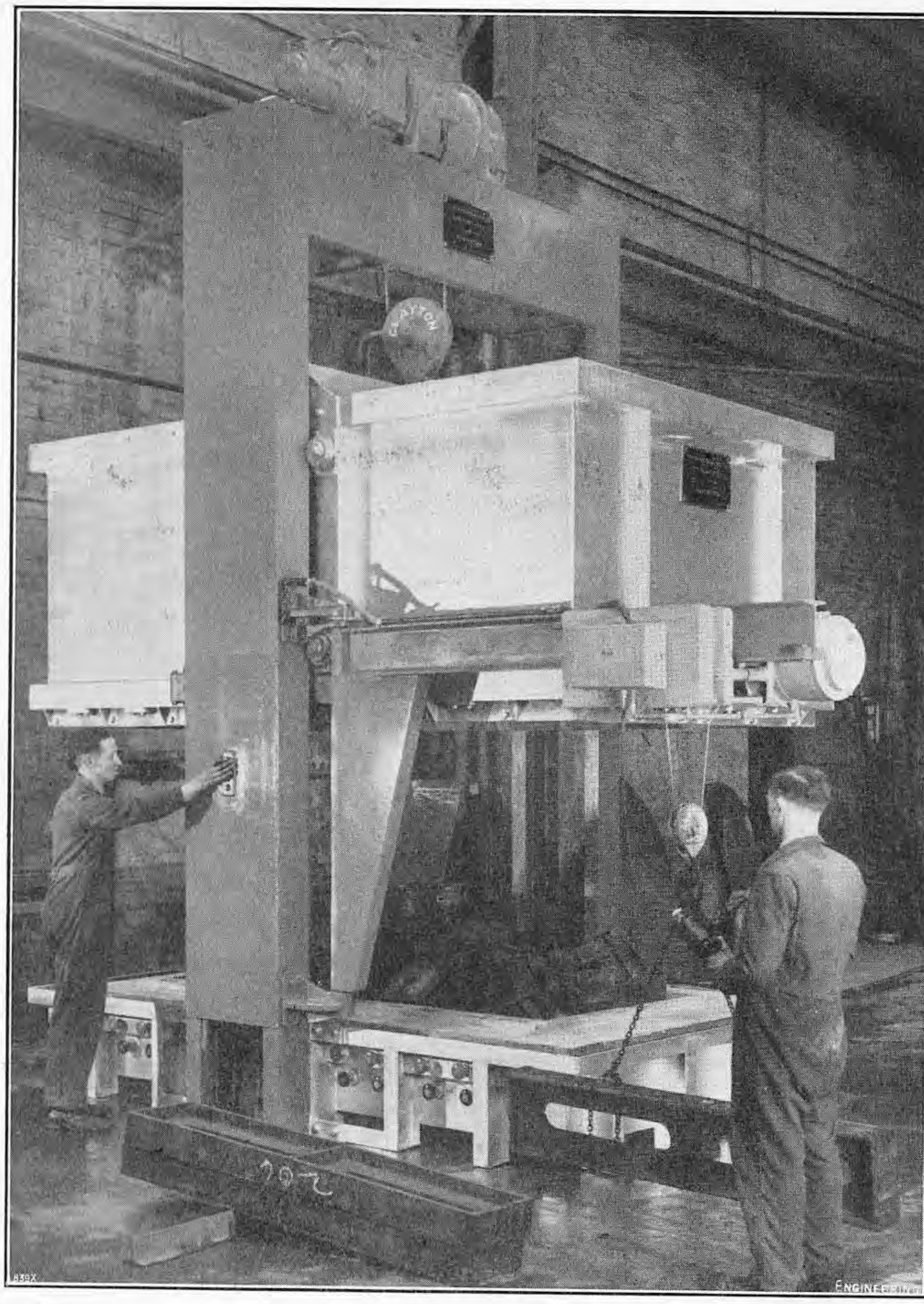


FIG. 20. PORTABLE COVER FURNACE; DOWSON AND MASON GAS PLANT CO., LTD.

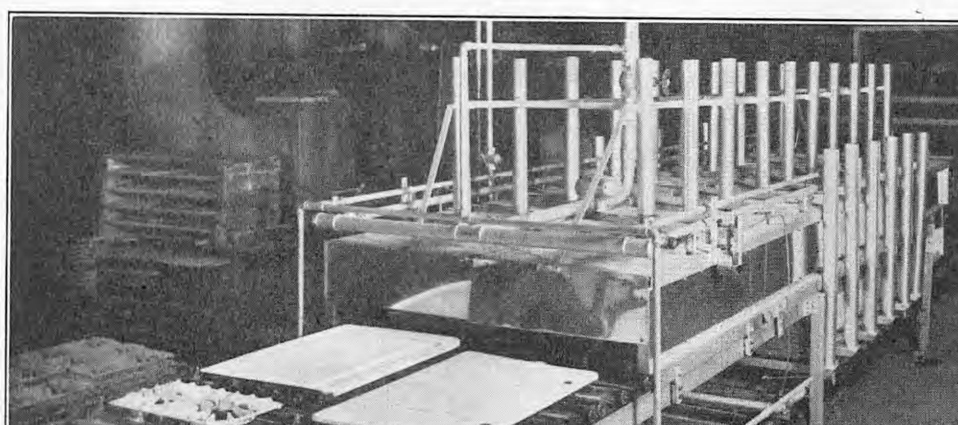


FIG. 21. INFRA-RED DRYING TUNNEL; THOMAS DE LA RUE & CO., LTD.

and a demonstration of steel spraying, to prevent corrosion or for building up worn parts, using a flame fed by oxygen and gas under pressure, will be given by Metallisation Limited, Barclays Bank Chambers, Union-street, Dudley, Staffordshire.

AUTOMATIC GAS-MIXTURE CONTROLLER.

Messrs. Keith Blackman, Limited, Mill Mead-road, Ferry-lane, Tottenham, London, N.17, will exhibit a range of industrial gas equipment, including burners, injectors, automatic shut-off and mixing valves, compressors and thermostats. Their Type 2 automatic mixture controller has been fitted with an air-operated gas cut-off which automatically shuts off the gas supply when the air pressure is too low for satisfactory combustion, thus ensuring quiet lighting and extinguishing in apparatus where frequent starting and shutting off is required, as for example, when under thermostatic control. Figs. 22 and 23 show sections through the mixture controller itself; Fig. 25 shows the layout of the gas cut-off relay valve in relation to the mixture controller; and Fig. 24 is a section through the relay valve.

The purpose of the automatic gas and air mixture controller is to maintain the correct mixture proportion irrespective of changes in the gas or air pressures and in the resistance of the burners and furnace. Normally, the gas supply is maintained at atmospheric pressure. This is accomplished as follows: referring to Fig. 22, the lower side of diaphragm *a* is connected to atmosphere by a small port *b*. The upper side is connected by a passage *c* to the mixing chamber *d*. Thus, if the pressure above the diaphragm *a* exceeds, or is less than, atmospheric, the diaphragm will tend to deflect outwards, or inwards. Its movements are communicated through the rod assembly *e* to a small relay valve *f*. The gas-valve plate *g*, which admits gas to the mixing chamber *h*, is arranged to follow the motion of the relay valve *f* exactly, in the following manner.

The ungoverned gas supply, entering through the gas inlet, passes through three gauze filters into the chamber *h*, on one side of the diaphragm *i*. The gas pressure is communicated to the chamber *k*

EXHIBITS AT THE BRITISH INDUSTRIES FAIR, BIRMINGHAM.

Fig. 22. LONGITUDINAL SECTION THROUGH CONTROLLER.

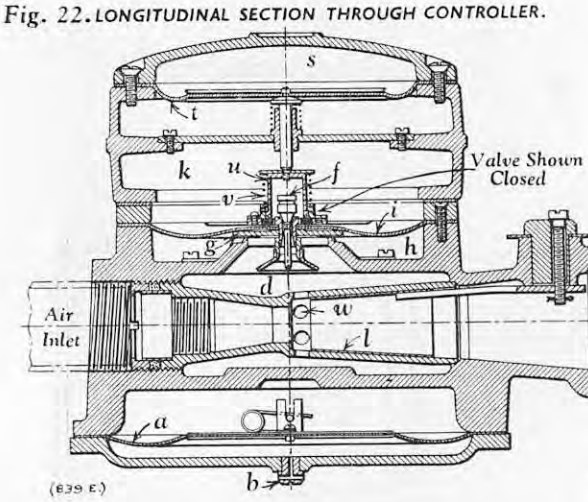


Fig. 23. CROSS SECTION THROUGH CONTROLLER.

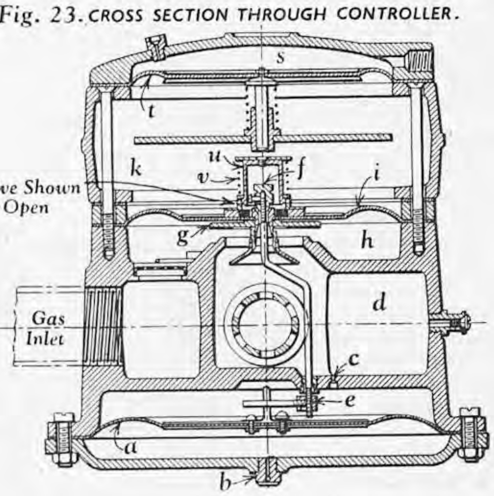


Fig. 24. SECTION THROUGH CUT-OFF.

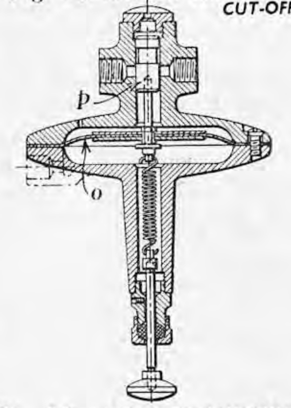
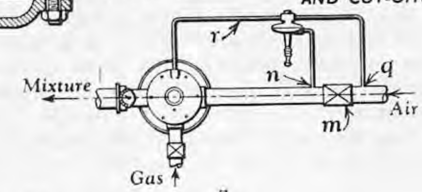


Fig. 25. LAYOUT OF CONTROLLER AND CUT-OFF.



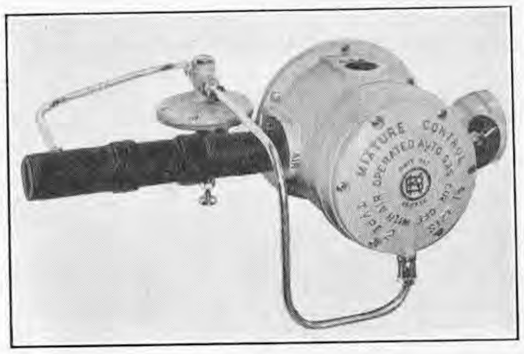


FIG. 26.

FIGS. 22-26. GAS-MIXTURE CONTROLLER; KEITH BLACKMAN, LTD.

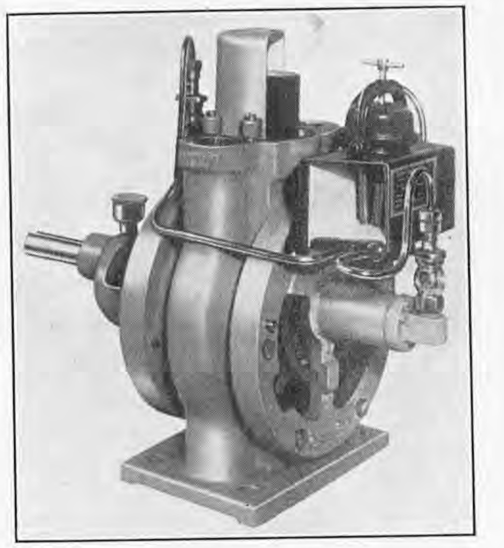


FIG. 27. ROTARY COMPRESSOR; KEITH BLACKMAN, LTD.

Fig. 28.

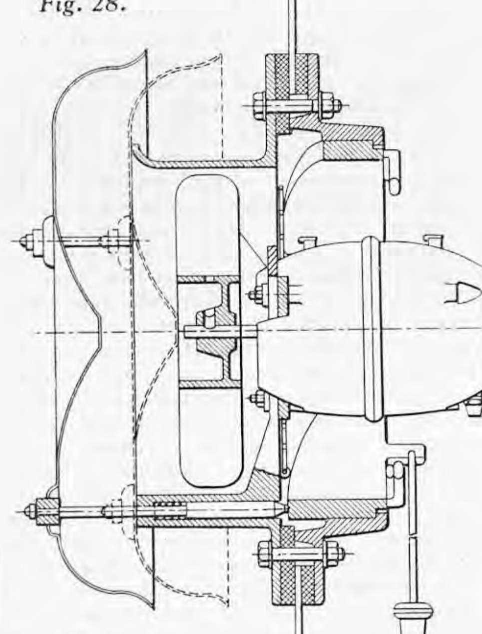


FIG. 28. VENTILATION FAN; KEITH BLACKMAN, LTD.

on the other side of the diaphragm *i* through a small aperture. If the relay valve *f* is lifted off its seat, the gas in chamber *k* escapes into the mixing chamber *d*, and its pressure is thus reduced slightly. The valve plate *g* therefore tends to lift off its seat, as shown in Fig. 23, under the higher pressure in chamber *h*. Thus, gas is admitted to the chamber *d* and is drawn into the injector through the ports *w*. If the pressure above the diaphragm *a* tends to increase and to close the relay valve *f*, the gas pressure in the chamber *k* is re-established and the valve plate *g* tends to move on to its seat. In this way, the gas pressure in the chamber *d* is made to correspond exactly with the atmospheric pressure. The proportion of gas to air can be adjusted by a sliding sleeve *l*, which varies the area of the ports, and is locked when the desired mixture is obtained.

The action of the air-operated gas cut-off may be followed from Fig. 25. When the valve *m* controlling the air supply to the automatic mixture control is being closed, to shut off the burner, the air pressure at *n* is reduced, causing the diaphragm *o*, in Fig. 24, to be lowered under spring pressure and to open the valve *p*. This allows air at full pressure to pass through the passages *q*, *r* (Fig. 25) to the chamber *s* on the mixture controller (Fig. 22), thus shifting the diaphragm *t* to force the valve plate *g* on to its seat. The flow of gas from the chamber *k* through the relay valve *f* is stopped by the valve *u* being forced on to its seat. When the burner is being relighted, the opening of the main air valve causes the diaphragm *t* to move to the open position, as in Fig. 23; the valve *u* is then opened by the spring *v*, and the mixture controller resumes normal operation.

Fig. 27, on this page, shows one of the rotary compressors to be exhibited by Messrs. Keith Blackman for use in industrial gas installations, such as furnace heating, metal melting, etc. The compressor shown, the A 4, has a capacity of 500 cub. ft. per hour at 380 r.p.m., at a pressure of 5 lb. per square inch, and is designed for a belt drive. Other compressors in this range have capacities up to 20,000 cub. ft. per hour. Also on view will be an example of a range of smaller compressors directly coupled to an electric motor.

VENTILATION FAN.

In addition to industrial gas equipment, Messrs. Keith Blackman will show a wide range of fans, blowers and dust-collecting units. Fig. 28, herewith, shows one of their aluminium Extravent EF1 fans, for mounting in windows, etc., fitted with a retractable dome enabling the fan aperture to be sealed against the weather, whether the fan is running or not. The fan is operated by a simple, spring-return pull-cord. It is driven by a totally-enclosed induction motor. The fan is available in 6 in. or 9 in. diameter sizes, with capacities of 10,500 and 18,500 cub. ft. per hour, respectively, and absorbing 33 or 35 watts, according to the size. The fan blades are of aerofoil section.

SEMI-PRODUCER FURNACE.

The Coke Department of the Gas Council, which has carried out considerable development work, in co-operation with the industry, on raising the thermal efficiency of coke-fired installations, will have a stand of its own, on which will be shown a coke-fired gravity-feed furnace for industrial drying and process-heating plant, central-heating and small steam-raising boilers, and various gravity-feed coke burners. Six new technical handbooks on coke-fired appliances will be available on the stand. Figs. 29 and 30, on page 548, show sections through an automatic coke-burning furnace, a sectioned example of which will be displayed, for supplying heat at closely-regulated temperatures up to 1,200 deg. C., for the direct drying of many materials, and for process work such as lime burning, liquid heating in heat exchangers, etc. The furnace, which was patented by the Gas Council and is described as a semi-producer furnace, is built under agreement by the M.E.T. Furnace Construction Company, 162, Trafalgar-road, Greenwich, London, S.E.10.

The semi-producer furnace, available in sizes for burning up to 6 cwt. of coke per hour, comprises a step grate at the front with outlet ports for the hot gases at the back. Coke flows by gravity from a fuel hopper to maintain a constant fire-bed, resulting in a steady heat output and gas temperature. The firebed depth does not exceed 2 ft. 6 in. The gases generated are always burning at the furnace-outlet ports, so that there is no possibility of unburnt inflammable gases escaping from the furnace. The furnace structure consists of an outer wall of common brick, with a firebrick lining, tied together by a structural-steel framework. The step grate is made up of flat steel bars 8 in. by $\frac{3}{4}$ in., with wide spaces between the bars for removing clinker. The bars are cooled by a water drip, the rate of which can be controlled. This reduces heat losses and, by generating water gas, causes an increase in the furnace output. The top of the furnace, constructed as an arch, has a charging door in the side. In practice, the furnace would normally be erected in a pit so that the charging door is at a convenient height for loading. The hopper can be constructed with a capacity to give from 3 hours' to 12 hours' running without refuelling. A vent damper on top of the furnace must be opened, to allow the escape of any gases that may have accumulated in the top of the furnace, before the charging door can be opened. The furnace-outlet ports can be closed by removable dampers. An expansion-type dust-settling chamber can be fitted on heavy-duty induced-draught installations.

Low-Pressure Steam Boiler.

The drawing reproduced in Fig. 31, herewith, illustrates the Bouellat B-type central-heating and small steam-raising boiler developed by Messrs. Bouellat Engineering, Limited, 167-8, Millbank, Westminster, London, S.W.1, in collaboration with the Gas Council Coke Department. The example on view is a low-pressure steam boiler, suitable for a pressure of 25 lb. per square inch, with a maximum output of 3,750,000 B.Th.U. per hour. A large water-cooled combustion chamber enables low-grade fuel to be used. Any type of fuel and method of firing may be employed. Up to 85 per cent. efficiency has been achieved with solid-fuel firing. The water-cooled panels of the combustion chamber are of ⅜-in. boiler-quality plate reinforced by welded stays. The rear panel incorporates the tubeplate, into which the convection tubes are expanded and bell-mouthed after expansion. The convector tubes are 9 s.w.g. thick, cold-drawn.

Gas Appliances.

In addition to the exhibits centred on the Gas Council stand, there will be an extensive display by individual makers of gas appliances, among which may be mentioned the stand of Radiant Heating, Limited, Radiant Works, Barnsbury Park, London, N.1. They will show, in addition to space-heaters, catering equipment and a full range of industrial burners, a gas and air mixing machine in which gas and air can be mixed in widely varying proportions to produce high furnace temperatures. The machine can also be used for proportioning air and butane vapour for distribution as town gas. Two experimental butane-air plants were opened in Wales in January for supplying all gas consumers at Whitland, Carmarthenshire, in place of coal gas. Messrs. George Bray and Company, Limited, Leicester-place, Blackman-lane, Leeds, 2, will show, among a wide range of gas burners the special butane-air burners developed for use, with butane-air mixture at Whitland. Another exhibit by this company is the spray jet for agricultural purposes, a modification of the Bray flat-flame gas burner. Messrs. Sperryn and Company, Moorsom-street Works, Birmingham, 6, will exhibit thermostats, control valves and flame-failure protective devices for industrial gas installations. A new mains-energisation unit has been introduced for use with their multiple-burner flame-failure mechanism which, in its original form, depends on the current generated in a thermocouple for energising an electromagnetic valve which cuts off the gas supply when any one of the burner flames, and its associated pilot burner, are extinguished. The number of burners which can be controlled by the thermocouple is limited by the circuit resistance, and so Sperryn and Company have developed a mains power unit which replaces the thermocouple; it will energise up to 12 safe-control thermally-responsive pilot units. The mains unit, which incorporates a variable resistance, has an output of 3 amperes at 10 volts, direct current, from an alternating supply of 200 to 250 volts. In the event of electrical failure, the gas is cut off.

Electric Cables.

The exhibits of British Insulated Callender's Cables, Limited, Norfolk House, Norfolk-street, London, W.C.2, are arranged in five groups to show the company's activities in the power station; transmission and distribution; industrial and mines; farm and domestic; and transport fields. Special mention may be made of the claw-type cable-cleating system which is being shown. This has been developed to satisfy the need for a universal assembly which can be built up easily on site to suit new arrangements or re-arrangements of cables. The cleats are mounted on suitable back straps, either singly or in groups, for fixing to walls or steel-work. The magnesium-free silicon-aluminium alloy used is highly resistant to corrosion, so that the system can be used in exposed positions. Another accessory is the bolted flame-proof coupler, with which joints in mine or quarry cables can be made above ground and sealed with hot-pouring compound. The range comprises half-couplers, the assemblies, and straight and right-angle adaptors, all certified flameproof by the Ministry of Fuel and Power. Lengths of cable fitted with these half-couplers can be used to extend roadway cables to advance with the coal face or workings. An electric vulcaniser, also shown, consists of two half-cylindrical hinged shells containing heater elements and fitted with dowels to ensure correct alignment. The equipment operates as a pressure mould, which ensures the complete amalgamation of the repair to the cable sheath and enables repairs to be carried out on cables with diameters from ¾ in. to 2 in. A copper-type vulcaniser exhibited is suitable for use on alternating-current circuits and comprises a transformer, controller and thermocouple temperature inductor. No liner, chamber or bath is required. The vulcanising heat is obtained by passing a low current through a copper tape, or braid, wrapped tightly round the repair section.

(To be continued.)

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

Fig. 29.

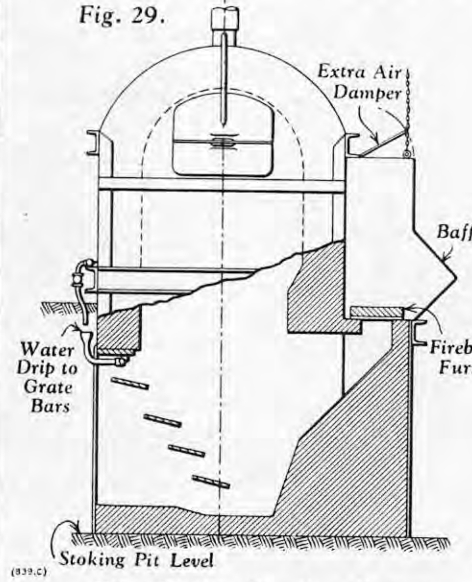
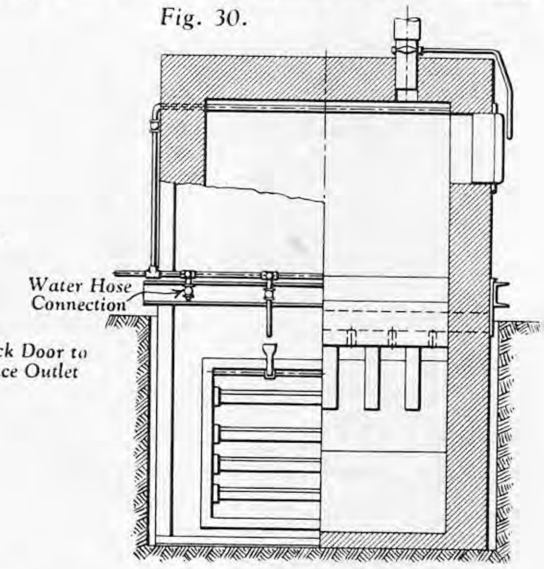


Fig. 30.



Figs. 29 and 30. Semi-Producer Furnace; Gas Council Coke Department.

Fig. 31.

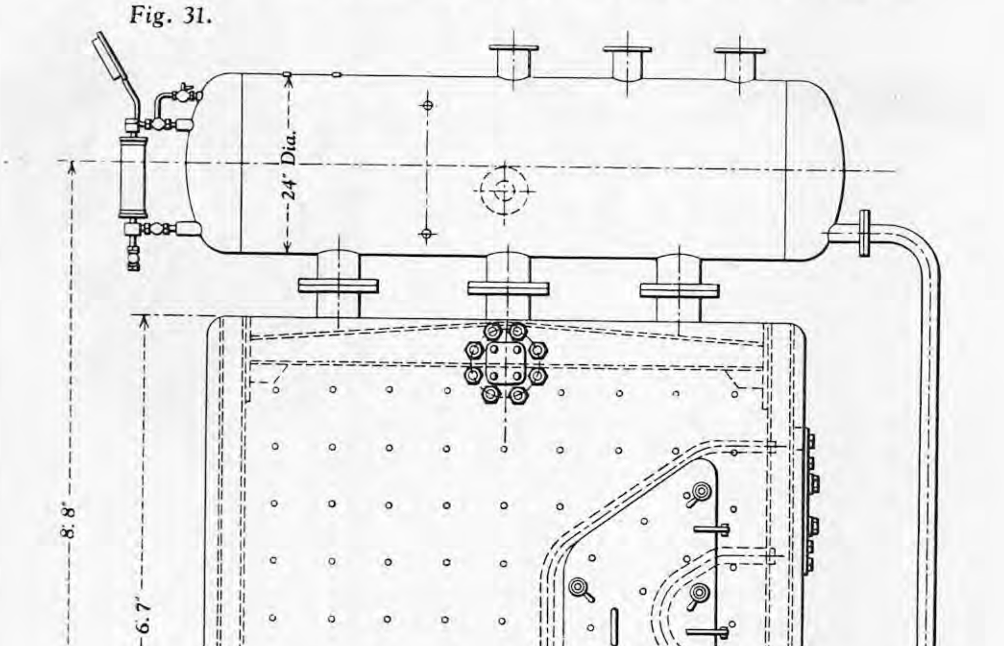


Fig. 31. Low-Pressure Steam Boiler; Bouellat Engineering, Ltd.

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Continued from page* 514.)

THE third paper in the programme of the 1952 Spring Meeting of the Institution of Naval Architects, held in London from April 2 to 4, inclusive, was by Mr. Norman M. Hunter and reviewed "Changes in Ship Construction, 1850 to 1950."

CHANGES IN SHIP CONSTRUCTION.

Although the first iron ship classed by Lloyd's Register was built as long ago as 1837, said Mr. Hunter, the wooden or composite ship retained its popularity for many years. Steel was first tried about 1860, but did not come into general use for shipbuilding until about 35 years later. Good roadways were rare in shipyards, and the usual lifting appliances were wooden pole derricks with wooden jibs. Hoisting was by means of steam winches. The introduction of piecework payment, in the 1870's, greatly improved the quality and speed of output, and in turn influenced a better layout of shipyards. Portable hydraulic riveting machines, introduced by R. Tweddell in 1871, accelerated the work and extended the scope of hydraulic riveting. In the early 1900's, electricity for lighting and power began to displace steam drive and the oil lamp, and soon temporary electric lighting was arranged on building berths. Between 1906 and 1910, oxy-acetylene cutting by hand tools came into use, gradually replacing hand cutting and the drilling out of shaped plate edges, to be hand-finished with chisel and file. Pneumatic power came into use at about the same time, and various small power-driven portable tools became general. By the old methods of hand working, some remarkable speeds of building were accomplished, but there was much waste of labour. Gradually, prefabrication was introduced, and some shipyards installed multiple punching machines for straight runs of work. In 1911, Mr. Hunter mentioned, he visited a Continental shipyard in which every part of the ship was prefabricated before the keel was laid. The one-man punching table further accelerated the work, but eventually punching of plates, etc., tended to give way to drilling. Electric welding came gradually into use after the development of the coated electrode about 1913. Automatic and semi-automatic welding machines followed, and the advantages of "down-hand" welding led to the provision of large sheds near the berths, in which unit structures weighing up to 40 tons could be fabricated. The author expressed a preference for welding by alternating current in the shops; on the building berth, and when fitting ships out afloat, direct current was safer and quite as economical. Smithwork had almost disappeared from the modern shipyard, and the work of the shipwrights had changed greatly in such matters as the laying of wood decks, and the methods of releasing a ship in launching.

DISCUSSION.

Sir Charles S. Lillicrap, who opened the discussion, said that iron, and subsequently steel, replaced wood because of the desire to build larger ships. It was a sobering thought that nothing was known about the art and science which enabled Noah to produce such a mammoth in wood as the Ark. Nothing like it had ever been produced since. Passing to the subject of electric welding and the type of current for welding, he thought that no one would dispute that the enormous output of warships and merchant ships during the war was due entirely to welded construction. They could not have been produced by riveting. Without any doubt whatever, the welding of ships would go ahead. To mention only two reasons: the universal shortage of steel enforced economy in its use, and welding design and practice meant a considerable saving in steel; and, he believed, as time went on, it would become increasingly difficult to get the labour necessary to do the hard work of riveting, however much that might be assisted by machines. The author's mention of the covered electrode brought back memories of the fights of the early days to establish the covered electrode over the cheap bare wire. Later, there was no question of departing from the covered electrode. No one knew more about it than Mr. Hunter, to whom the British shipbuilding industry owed a lot for his steady advocacy of the welded ship, either wholly or in part, ever since that method became a practical proposition. He agreed entirely that a mixture of welding and riveting required careful considerations; it should not be done at all if it could be avoided, and if it could not be avoided, the welding must be done first and the riveting afterwards. He would like to know the author's views on the highly controversial question of the relative costs of welding and riveting. It was very desirable that the kind of current used, alternating or direct, should be stated definitely and categorically. Section 28 of the paper, dealing with the speed of building, cited some remarkable cases. A further example of quick construction was a cruiser built at Devonport Dockyard during the 1914-18 war. The period from the time of laying down until the vessel went to sea was ten months, which was a record for a warship of her size. Even in those days, the electrical installations, etc., were considerable, but to-day, with all the complications of radar, etc., he was afraid that the feat could not be repeated.

Mr. J. McGovern supposed that the "large shipyard" to which the author referred was that of the Furness Shipbuilding Company; he (Mr. McGovern) had been identified with the layout and development of that yard, and was its managing director until a few years ago. As the result of his previous experience, he was convinced that shipbuilding berths were much too close together, and, therefore, in planning the yard, ample space was allowed. Experience had also convinced him that the methods adopted up to that time for fabricating steel plates for the structure of a ship needed modernising. For the steel ship, in those days, there was the shell squad, the bulkhead section, and so on, and people were employed under contract to do the shell plating, at so much a plate, or on any other basis. That seemed to be wrong. Another defect concerned the punched rivet holes. He had been impressed by the inaccuracy of shipyard riveting, compared with bridge building. The bridge-building firms used to punch the plates, but had to drop that because the inspectors would not accept it. He decided to adopt drilling. This gave them a further chance to overcome difficulties with the platers, and it also gave the opportunity to arrange to separate the various parts of the work, preparing the material in stages. In designing a ship, therefore, the plans were worked out for the preparation of the materials. In many cases, there would be, on one ship, 120 multiple shell plates. Having prepared one master template, they had only to put it on top of four blank plates as delivered from the steelworks and drill them together under a battery of twelve radial drills, looked after by one semi-skilled man; and a piece-work rate was made with the drillers which satisfied both parties.

Mr. F. C. Cocks found it hard to believe that the difficulties experienced by the builders of wooden ships were so many or so acute as those which beset shipbuilders at the present time, when materials were scarce, time was so important, and the requirements of shipowners were so various and complex. It was clear, however, that the many mechanical aids to construction described in the paper, while undoubtedly they tended to destroy to a great extent the much-prized craftsmanship of old, had contributed to progress to a degree which would have been impossible without them. Electric welding, while conferring great benefits, could be a source of trouble unless exceptional care was exercised in its application and supervision. It might become foolproof some day, but that day had not yet arrived. The piece-work payment of welders might constitute a danger, since bad workmanship might result from a tendency for the welder to scamp his work in order to increase his output. With riveting, this tendency could always be resisted when signs of defective riveting are discovered by the testers. Defective welding was hard to track down, once it was completed, and piece-work welding should be adopted only under conditions of the strictest control of procedure and under the closest supervision. The introduction of radiographic control of welder and welding was a forward step which had resulted in a conspicuous improvement in workmanship. The adoption of electric welding and the movement towards large-scale prefabrication had led to wholesale reorganisation of shipyards and their layout. This had been extremely difficult where the site was confined, and in many cases had been made possible only by the surrender of one or more of the existing berths. It was discovered, early in the American war-time building programme, that an assembly area for prefabricated units equal to the area of the building berth was insufficient keep pace with the rapid turn-out from the sheds, and additional storage area for those parts had to be found. It would appear that Mr. McGovern had foreseen that condition when he laid out his yard. One improvement which had resulted, in some cases, from the reconstruction of shipyard facilities was the adoption of concreted berths, assembly areas and roadways. The tidiness and cleanliness of concreted areas in the shipyard must make for increased efficiency. The transition from riveted to welded construction had been rapid since the war, and was approaching the point where riveting might disappear, if only because riveting as a trade was disappearing.

He could sympathise with the author if, in his desire that such transition should be complete, he was disappointed because prudence might over-ride expediency to the extent of recommending a riveted stringer angle in an otherwise wholly-welded hull. He agreed, however, that the gunwale was, in some ways, the most vulnerable point in the structure and was extremely susceptible to the effects of indifferent workmanship or defects in design. Many failures had occurred in the welded connection of stringer plate to sheer strake, and in the interests of safety the riveted connection was to be preferred. In his description of the electrical arrangements for welding on the berth, the author had said nothing about the need for efficient earthing. That was essential, especially if automatic welding was extensively employed.

Mr. J. Lenaghan thought that, more than anything else in shipbuilding, labour relations had changed, and might well come within the terms of reference of Mr. Hunter's paper. Planning and progress departments were growing very rapidly, and, as a result, there were changes in personnel. Care was necessary in discussing that question, because in shipbuilding there were some 21 different unions and about 93 different sections. Two examples of rapid shipbuilding came within his own experience. In 1930-31, a 22,000-ton whale-factory ship was put into service ten months after being laid down. The second ship was built by a North-East Coast shipyard, in 1942-43, and went to sea nine months after being laid down. The equipment used was not as modern as that of to-day, and he wondered why it was not possible to do better with modern equipment. He did not think that it was because present-day ships were too complicated.

Captain J. P. Thomson hoped that the author's most interesting paper would have a wide circulation among the youths who were coming along, so that they might see what has been done by the shipbuilding industry. He was interested to hear Mr. McGovern's remarks on drilled plates. He had been concerned with the operation of nine such ships, all of which gave a good account of themselves; seven of them were all-drilled, and two were partly drilled and riveted, and partly welded. One of the drilled ships was torpedoed twice on the way to Australia in 1943. The crew had to abandon her, and she drifted round the Indian Ocean for five years before stranding. In the two vessels which were partly welded and partly riveted, the weight came out at very much less than was estimated, with the result that there was a considerable amount of extra carrying capacity. The welded construction was well liked for oil tankers. The tanks could be kept tighter, and so far there had been no serious failures.

Major J. Caldwell said that it was 14 years since he had anything to do with electrically welded ship construction, but he was still interested in electric welding for repair services. He asked why some electrically welded ships had failed recently; two of them were reputed to have broken their backs. He had been told that, during the war, ten such ships were destroyed. It might be that speed was the reason for the trouble; perhaps the sections employed were too large, resulting in locked-up stresses, all concentrated at one point. In the first world war, he had visited all the shipyards on the east coast in America to instruct them how to apply electric welding to ship construction. The firm which took up welding with the greatest speed was Messrs. Ford, who laid down a special yard for the construction of what they called "Eagles," but they got into trouble because they used excessive current for the work. In 1918, the Admiralty barge 1032 was launched at Richborough, and that was followed in 1920 by the launching of the Fullagar—two British welded ships. Then there were two in Japan, and some barges were built in America; and then Mr. Hunter had built his fleet of electrically welded ships, which were different entirely from any of the other structures. In the early days of electric welding they made innumerable tests, but the most reliable, informative and searching test of welding was that of testing the ships in use.

Mr. Hunter, replying to the discussion, said that the welded ship was no dearer in material than the riveted. It was suggested by Mr. Cocks that the piece-work payment of welders might constitute a danger. He did not think so. Extreme care should be taken in the testing of the work as it progressed, and he always recommended that the seams should be inspected before any welding was done, to ensure that they were correct and suitable for welding. Each run put down was cleaned and inspected, and for specially strained parts X-ray photographs should be taken at odd times. They had really efficient earths, as well as having the 'busbars down each side of the berth.

Joint Session with Institute of Marine Engineers.

At the afternoon session on Thursday, April 3, which was held jointly with the Institute of Marine Engineers, the chair was taken by Dr. S. F. Dorey, F.R.S., who is President of the Institute and also chairman of the Council of the Institution of Naval Architects. The paper presented, on "The Generation of Gas Bubbles at the Shrinkage Boundaries of Built-up Crankshafts for Diesel Engines," was contributed by Mr. S. Amari and Mr. E. Ando, respectively, the Chief of the Ship Bureau and Chief of the Bureau's Machinery Section in the Japanese Ministry of Transportation. In the absence of the authors, who were unable to make the journey from Japan to England, the paper was presented by Mr. H. N. Pemberton, of Lloyd's Register of Shipping, who explained that he had shared with the authors responsibility for the action taken when bubbles of the type described had been detected in Japanese-made crankshafts.

Gas Bubbles at Shrinkage Boundaries.

In August, 1950, the authors stated, when a marine Diesel main engine was being overhauled, minute bubbles were observed to be generating at the shrinkage boundaries of the built-up crankshaft; and, soon afterwards, the same phenomenon was observed elsewhere. It was feared that the existence of these bubbles might indicate a risk that the cranks might slip on the shaft in service, though inquiry showed that, in a similar case some 23 years earlier, the shaft had continued in service without ill effects resulting. A committee was formed by the shipyards and the crankshaft makers concerned, in conjunction with the Japanese Shipbuilders' Association and Lloyd's Register, to investigate the problem, and the conclusions were reached that bubbles unavoidably occurred from the escape of hydrogen from steel; that slip in a built-up crankshaft was caused by oiliness on the shrink-fit surfaces between the crank web and the journal; and that the bubbles originated independently of slip and, therefore, their generation did not jeopardise the use of the crankshaft. In their paper, the authors set out the data used in the researches and outlined the result of the inspections carried out. The question remained, however, why the bubbling occurred only in crankshafts made in Japan, and, apparently, not in those constructed in the United Kingdom and the continent of Europe. The reason was believed to lie in differences of materials and methods of steel manufacture, the procedure of heat treatment, or the climate. It was noted that, in Japan, only a single heat-treatment was carried out, i.e., after finish-forging; whereas in England a further heat-treatment was given after rough-machining, which might have the effect of liberating much of the hydrogen present. They asked, in conclusion, whether any instances had been observed in Europe.

Discussion.

Mr. Glen Thomas, Principal Engineer Surveyor to Lloyd's Register of Shipping at Glasgow, who had been to Japan to obtain information about the crankshafts, opened the discussion. It was thought at first, he said, that the appearance of the bubbles was associated with defective shrinkage; but, after examining the standard of machining of the contact surfaces, carrying out a careful check of the dimensions of the pin diameter and web bore, and witnessing the actual shrinkage operation in Japan, his doubt on that score was quickly removed. The shrinking was carried out with all the skill and care that that important operation demanded. He assured the authors that the phenomenon had definitely been observed not only in Japan, but on the Continent and in the United Kingdom; but he could not say that it was general, as a very large number of crankshafts had been carefully examined, with negative results. Possibly that was not unconnected with the additional heat treatment usual in Britain and in Europe, which was mentioned in the paper. On the Continent, where he had examined a semi-built eight-throw crankshaft which had been shrunk some three or four months previously, bubbles were discovered on a number of the shrinks. The gas was collected and was shown to have a high percentage of hydrogen. In Britain, gas bubbles had been found on a large fully-built crankshaft, intended for a Diesel engine, which had been assembled only a week before the examination. Another shaft, three to four years old, was examined on the Continent and showed no sign of gas bubbles; that seemed to be in keeping with the Japanese assertion that, after about six months, gas bubbles would not be seen anywhere. Lloyd's Register arranged for sample blocks of Japanese steel to be sent to England for further examination and analysis, which was carried out by Messrs. Colvilles at Motherwell and Messrs. Thos. Firth and John Brown at Sheffield. The samples were from different steelworks, one from the south and one from the north of Japan, and whereas the analysis carried out by Messrs. Colvilles did not indicate any abnormal hydrogen content, the results obtained by Messrs. Firth-Brown suggest that the original hydrogen content of the steel was high. It is perhaps significant that the samples dealt with by Messrs. Firth, Brown came from the steelworks at Muroran, which is referred to in the paper in connection with the possible influence of atmospheric humidity.

He was satisfied that, in the cases examined in Japan, in this country and on the Continent, in which the gas bubbles were found at the shrink boundaries, the shrinkage fits were sound and unaffected by the escape of gas, and he felt sure that further information would be forthcoming from some of the metallurgists who had recently investigated the problem. The paper contained some useful information on shrink fits; e.g., Table IX, showing the degree of permanent set in the web after removal of the journal. Temperatures of the web were recorded during the heating process, showing the variations of temperature at different points in the web, and details of those readings, he thought, would be a useful addition. He asked whether the authors were completely satisfied that the shrinkage failure mentioned in the paper as being due to grease applied to the journal before shrinking, was, in fact, due to that cause; and how much and what sort of grease was applied. Some oily matter must always be present on the journal during a normal shrink, despite any last-minute wiping of the surface.

Dr. S. Livingston Smith found the paper particularly interesting, because the failure of built-up crankshafts formed part of the research programme of the British Shipbuilding Research Association. The authors' careful experimental work had established that the bubbling phenomenon bore no relation at all to the slip in the built-up crankshaft. Though very few failures of shrink fits were reported in crankshafts built in this country, the subject was of great interest and importance to engine designers. He thought that the figures given in the paper for the coefficient of friction were probably lower than the actual values, because the normal pressure between the mating surfaces had been calculated by assuming an elastic condition, whereas the values of the permanent set, given in the paper, showed that the plastic strain was quite appreciable. The results of tests carried out for the B.S.R.A. confirmed the authors' conclusions that the surface finish had little effect on the friction, and that the coefficient of friction was greatest when the mating surfaces were clean and dry; but it was found that the application of mineral oil and sperm oil to the pin before assembly gave a coefficient of friction of 0·2 to 0·3, whereas in the shop-dry condition it was 0·3 to 0·4. As it was not possible to achieve chemically dry surfaces in practice, variation of the friction with the surface condition of the faces was absolutely the important thing; and investigation reported in America seem to confirm the authors' conclusion that adsorption of hydrogen on the surfaces had little effect on the friction. From the same piece of work, however, it seemed that the metallic soaps formed by fatty acids were most effective in reducing friction, and it would be of interest if the authors could give details of the greases used in the shrink fits that failed, and of the greasy substance found on the mating surfaces. One of the main characteristics of cutting fluids was low friction under boundary-lubrication conditions. It followed, therefore, that it would be harmful to shrink fits. The breakdown of shrink fits might arise from additives put into lubricating oil to improve boundary-lubricating qualities.

Mr. I. M. Mackenzie said that the fact that hydrogen was evolved from steel at ordinary temperatures, and that the rate of evolution was increased when the metal was cold-worked, had been known to metallurgists for a number of years; but since it was of no practical importance, possibly it had not been publicised in engineering circles. It is not unexpected that hydrogen should be observed to come from a shrink fit, but it would be surprising to find that hydrogen came from a shrink fit in Japan and not from a shrink fit in Britain. He doubted whether there was any great difference in the quantities of hydrogen evolved from shrink fits where the shafts were made of basic open-hearth steel. His own company had carried out many determinations of hydrogen content, both of molten steel and of the finished product. Hydrogen determinations being rather difficult, it was doubtful, without knowing something about the experimental methods employed by the Japanese, whether the results claimed in the two countries were directly comparable; but it was felt that the hydrogen contents which were determined in basic open-hearth steel in this country were comparable with those reported in the paper, and a hydrogen content of 6 c.c. per 100 grammes would not be abnormally high for the interior of a large forging. The size of the forging was a very important factor in determining the length of time over which the hydrogen was evolved. It was known, however, that the hydrogen content of steel made in the acid open-hearth furnace was much lower than that made in the basic furnace. Typical values for acid practice were 3 or 4 c.c. per 100 grammes, whereas for the basic practice they ranged from 5 c.c. per 100 grammes upwards. It might be that some of the crankshafts examined in this country were made from acid steel, since, he understood, it was common for customers to employ acid steel for their large forgings. If this were the case, he thought that, in many instances, it would be found impossible to detect the hydrogen evolved from the shrink fits, because it was not coming off fast enough to be measured. The paper raised several interesting metallurgical points with regard to the effect of humidity on hydrogen content, but he did not think that the variation due to wet weather, between 4 and 6 c.c. per 100 grammes, was significant from the point of view of engineers in the application of the steel. If it were a question of wet weather, makers of crankshafts in Scotland would probably be well aware of the effect.

Mr. W. J. Borrowman expressed appreciation of the thorough way in which the problem had been treated by the authors and the Japanese Committee.

The same problem had arisen in his own works in 1947, concerning a semi-built shaft 490 mm. in diameter, made in Czechoslovakia. Experienced erectors stated that previously they had witnessed signs of bubbling, but that no further attention was given to the cause, as it was thought that this could not affect the safety of a shrink fit. On hearing rumours from Japan, they had investigated the matter more closely and found bubbles at different shrinkage boundaries of a semi-built crankshaft which, about three weeks before, had passed official trials. Another shaft of the same size, which had been in stock for about six months and had not been used in an engine, also showed bubbling, but only to a negligible extent. Those shafts were made in Czechoslovakia. It was known that hydrogen entered steel in the atomic state and diffused out in molecular form, and that, in this form, it could not re-enter the steel, but might escape into cavities and eventually build up very high pressures. The question arose whether such hydrogen, trapped between the shrinkage surfaces, could form a film under high pressure which would act against the radial shrinkage pressure. It must be assumed that, even with the finest machining, metallic contact would never cover 100 per cent. of the shrinkage surface, and that a net of capillary channels must exist round the higher spots, which had been flattened by stresses above the yield point. The fact that bubbles escaped at the shrinkage boundaries caused them to abandon the idea of a gas film or pockets. Supersonic tests were then carried out on shrinkages, whereby a considerable variation in the intensity of the echo was noticed; this was not only between webs, with or without bubbling, but also over the length of single webs and between different webs showing no signs of bubbling. Tests were then made to find out the influence of surface finish and specific pressure, but so far supersonic control had not given the desired practical results. Air pockets in shrink fits might exist, especially if the workmanship was not sufficiently accurate or if the pins had been adjusted by filing; but a loss in contact in local sections was compensated by higher specific pressure in other sections, so that lack of contact in limited areas did not seriously affect the shrinking moment. Such pockets, however, facilitated the infiltration of oil, which, under full working service conditions, had a more dangerous effect on the coefficient of friction than might appear from the authors' tests. Cases were known where oil which had infiltrated during service, together with other unfavourable factors, had led to slipping of cranks on their pins.

He was interested in the measured values of permanent set, which amounted to about 15 per cent. of the shrinking allowance of 1·5 to 1·6 per cent. of the diameter. A certain portion might be attributed to the flattening of the high spots, but it seemed that, with fine finish, a higher allowance would not correspondingly increase the shrinking moment. Sulzer engines with 20 years' service worked successfully with a shrinking allowance of 1·3 to 1·4 per cent.; the largest engines, with ten and more years service, had 1·4 to 1·5 per cent. When calculating the factor of safety, they reckoned on a friction coefficient of only 0·2, knowing that, under normal conditions, they could actually rely on 0·3. Experience showed that, with a fine dry finish and accurate workmanship, their shafts would stand torsional vibration stresses up to $\pm$ 700 kg. per square centimetre. Shrinking with oily or greasy surfaces could not give the same results and he wondered on what theories or assumptions such a procedure was based, and how it happened that the failures were attributed to hydrogen diffusion. That misleading statement, however, had the advantage that a closer investigation was made of the problems involved, which confirmed the results gained by earlier research work and by long practical experience. It also led to the conclusion that hydrogen diffusion could not seriously affect the reliability of a built-up crankshaft, built in accordance with the standard practice.

Professor A. W. Scott said that, having been associated with the work which Dr. Livingston Smith described, he could endorse some of the points made. As to the nature of the film separating the surfaces, at the Technical College in Glasgow a lot of work had been done on force-fitting of railway wheels and axles; there, the effect of the nature of the lubricant was remarkable. With tallow—and he suspected that the Japanese engineers used something akin to tallow, referring to it as grease—the strength was only a fraction of the strength obtained when using a spindle oil. He did not think it was a matter of the thickness of the film, but it depended entirely on the nature of the substance separating the metals. The result of the radial pressure between the two surfaces in contact did not agree with the theory put forward in the paper—if, in fact, the fit allowance was above a certain value. Many factors came into that difference, and the authors mentioned one of them; they put it down entirely to shrinkage. They said that "Partial plastic deformation has occurred close to the bore of the web. It is assumed that the deformation can be ascribed to the distortion caused by thermal stresses during the heating of the web. . . ." Professor Scott was sure that, though that must have some effect, it was nothing like the whole story; and if it was possible to obtain the figures of the temperature cycle through which the web passed, prior to and during shrinking, it would be of great help in solving the problem. The figures in the table, showing the diameters of journal and web-bore before shrinking and after dismantling, gave a clear indication that the centre part of the web had been more over-stressed than the end part; in other words, the assumption of uniform radial pressure on a shrink fit did not hold. One possible explanation was that, when a fit contracted, it not only contracted radially, but also axially, and there would be a much higher radial pressure at the centre than at the end.

The chairman, Dr. Dorey, explained how it was that suspicion arose concerning the possibility of slip when a gas was evolved at the shrink boundaries. When the first engine was on trial, the webs moved on the journal. Another engine was tried, and there again the web shifted. That was the crux of the whole matter; it was one of the most important pointers to the method of shrinking. It had been brought to the notice of Lloyd's Register that the webs were heated, put into place and then rapidly cooled. They knew from experience that, if cold air was directed to a heated web, the web would contract where it was cooled, which was on the outside surface, and air was entrapped between the pin and the journal. Cases were found where the shrink was only effective at the outside edges, and no sign of grip was shown in the body of the pin. In dealing with shrinking, there was the important matter of whether a clean surface could be ensured; and, if there was not a clean surface, whether it was possible to have a lubricant there which would not make very much difference. There was a method of shrinking whereby a ring was extended over a pin by means of oil, and closed down; there were grooves at the interface to let the oil out. It had occurred to him at one stage that, perhaps, all propellers should be fitted to tail shafts by that method. In a fatigue-testing macnine at Lloyd's Register, some tests were being made on 3 in. specimens to see whether comparable results could be obtained, and the specimens were gripped by that method. It was working under all conditions of stress, as high as they could be taken. The tests described in the paper, and most of the tests of which results were available, were static tests, i.e., the torque applied was not of an alternating character, such as occurred in practice. He thought that shipbuilding research would be looking for tests in which alternations of torque could be applied, and comparisons made with the static tests. The paper stated that the gas was given out not only at the interface, but also at other parts of the web, where the metal would be stressed; though not quite so much was evolved there as at the interface. The amount of gas evolved would depend on, perhaps, three factors: first, on whether the material was acid or basic steel; secondly, on the type of stress which was likely to evolve the gas; and thirdly, the condition of the metal at the time of pouring might have some effect on the amount of gas. Prolonged boiling might mean a greater absorption of hydrogen. Dr. Dorey concluded by thanking the authors for having prepared the paper, and Mr. Pemberton for having presented it.

(To be continued.)

THE KELVIN LECTURE OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

THE forty-third Kelvin Lecture was delivered at the Institution of Electrical Engineers on Thursday, April 24, by Sir Charles Goodeve, O.B.E., D.Sc., F.R.S., who took "Iron Atoms in the Service of the Electrical Engineer" as his subject. Before the lecture, certificates of honorary membership were presented by the President (Sir John Hacking) to Sir Arthur Fleming and Sir Edward Appleton. In acknowledging the honour Sir Arthur Fleming recalled that he had been associated with the Institution for over half a century, during which time he had been brought into contact with many other members of the profession. From them he had learnt many things which had added to his knowledge. Sir Edward Appleton said that it was with great pride he joined an Institution which had encouraged so liberally the pure as well as the applied aspects of electrical science.

In opening his lecture Sir Charles Goodeve pointed out that iron, or its offspring steel, had very wide applications in electrical engineering. Depending on its composition and heat treatment it might be soft and ductile or hard and strong, corrosion-resistant with good mechanical properties at high temperatures and magnetic or non-magnetic. It could provide the hardened steel ball on which the modern television mast was pivoted and the high yield point steel, which enabled the wind resistance of the mast structure to be reduced to a minimum.

The iron atom, which dominated the metallurgical world to such an extent that all other metals were called non-ferrous, and had served mankind for many thousands of years, had until recently well hidden its scientific secrets. It was now, however, known that its neutral atom had 26 electrons and its nucleus 26 positive charges. The nucleus itself was made up of 26 protons and generally 30 neutrons, though in the isotopes of iron the number might be a few more or less. When any element was formed from protons and neutrons there was a loss of mass which was equivalent to the binding energy of the nucleus. For its weight the iron atom had the largest mass loss of almost any element. This meant that it was one of the most stable of the elements, a fact which perhaps accounted for its prevalence.

Iron owed its chemical and many of its metallurgical properties to a nicely balanced affinity for oxygen and carbon, as well as for certain other elements. In fact, were it not for its affinity with carbon much of the versatility of steel would be lost. So far as physical properties were concerned, there were gaps in our knowledge of the causes of the ductility and strength of steel, but these were rapidly being filled so that the way was being pointed to further technical advances. The yield point of pure iron could be raised from about 5 to 6 tons per square inch to 15 tons per square inch by adding 0·2 per cent. of carbon and producing ordinary constructional steel; and to about 20 tons per square inch by the further addition of about 1½ per cent. of manganese. Steels with yield points of up to 30 tons per square inch could be commercially produced by the addition of small amounts of chromium, nickel and molybdenum to manganese steel, while a recent development was a steel containing about 0·003 per cent. of boron and about 0·5 per cent. molybdenum. This had a yield point of 32 tons per square inch without any falling off in ductility and toughness.

Our knowledge of creep phenomena, continued the lecturer, was still rather obscure; and the development of creep-resisting steels had been achieved mainly as a result of empirical experiments. It should be pointed out that, apart from increases in the creep resistance of steels, which were obtained by the addition of alloying elements, many improvements in creep strength had been obtained from a more detailed understanding and closer control of steel making, mechanical working and heat treatment processes. Alloy steels of high creep resistance had now been adopted as standard for steam pipes and superheater tubes using temperatures up to 900 deg. and 1,000 deg. F., respectively. A steam temperature of about 1,050 deg. F. was to be employed on two stations of the British Electricity Authority and this would necessitate the use of special austenitic steels of much greater alloy content, in order to provide strength and ensure against corrosion.

Summing up, Sir Charles said that the iron atom owed its special position in the metallurgical world to its prevalence, to the delicate balance common throughout its character and to its "friends." The first was probably associated with the inherent stability of its nucleus. The second gave it chemical properties of great value and crystal dimensions which explained its good working properties as a metal and its magnetism. Its friends—other atoms near its own size and carbon—aided it in reaching great heights of technical achievement and, in particular, covered up its faults.

CONSTRUCTION OF THE KENT OIL REFINERY.

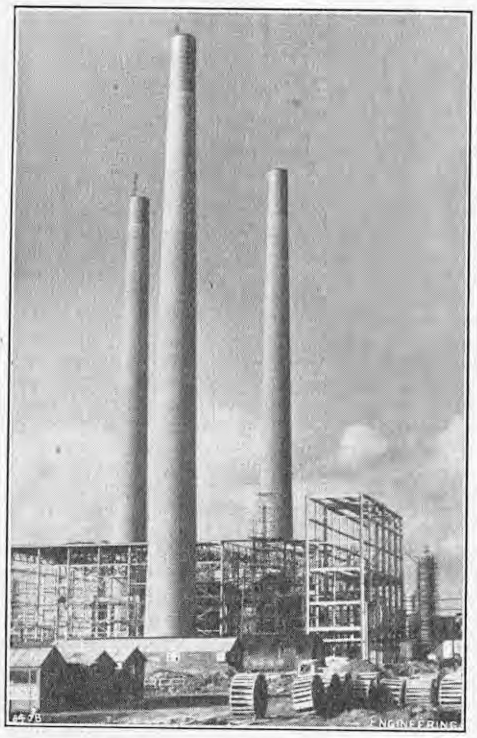
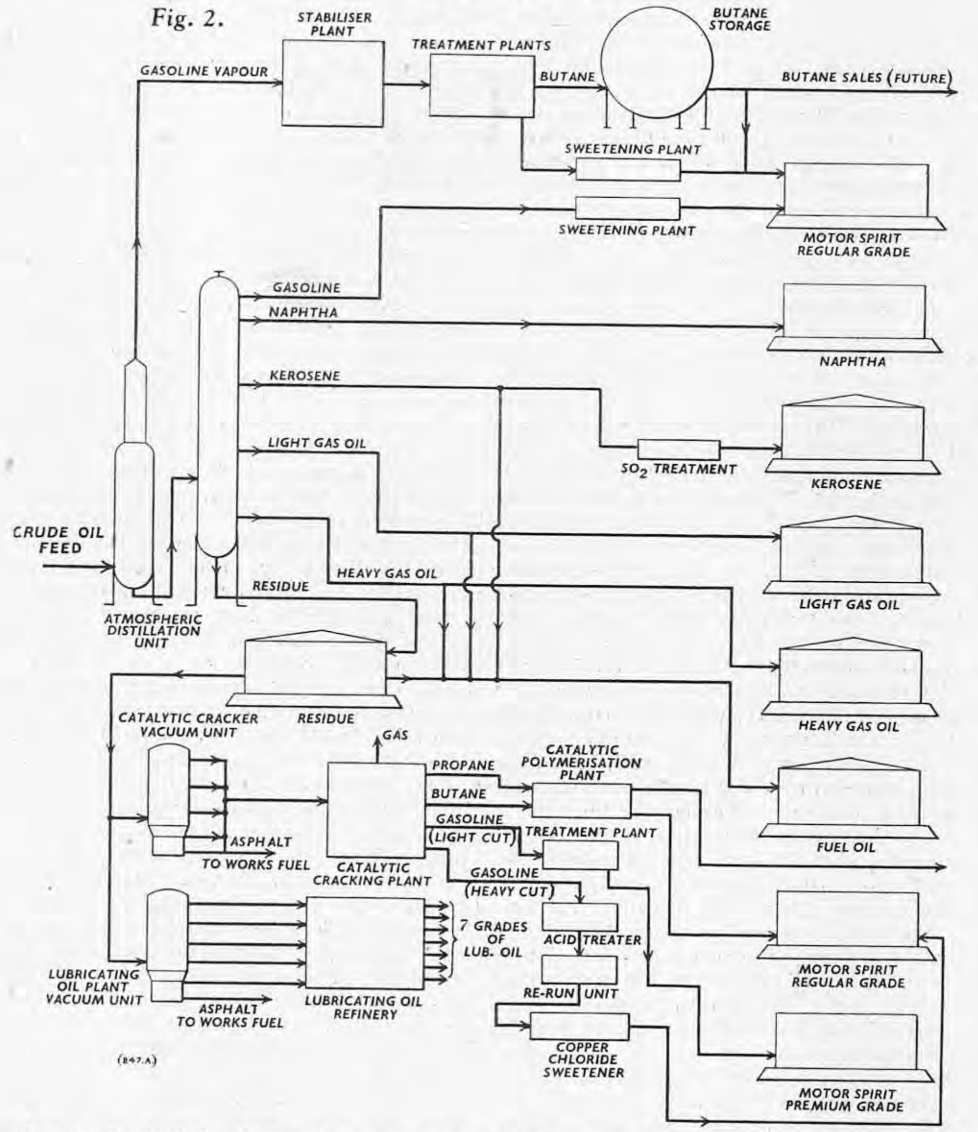


FIG. 1. REFINERY POWER STATION UNDER CONSTRUCTION.

Fig. 2.



KENT OIL REFINERY OF THE ANGLO-IRANIAN OIL COMPANY.

THE Anglo-Iranian Oil Company expect the first part of their new Kent oil refinery to go into production about July this year. The refinery is situated on the Isle of Grain—the isolated tip of the peninsula between the Thames and Medway estuaries—and is about 40 miles from London. In a brief visit, such as Press representatives paid this week, it is only possible to gain a general picture of this vast undertaking. About 5,000 men are engaged on the construction of the refinery, which will be one of the largest, if not the largest, in Europe, and the work involved includes civil, mechanical, electrical and chemical engineering of considerable interest. Though there are some American firms working on the refinery, by far the greater part of the design and construction is being carried out by British firms, the oil company themselves undertaking the overall design. The managing agents for the oil company are Messrs. E. B. Badger and Sons (G.B.), Limited, Aldwych, London, W.C.2. The civil-engineering consultants are Messrs. Rendel, Palmer and Tritton, 125, Victoria-street, London, S.W.1, and the consultants for the power and steam services are Messrs. Ewbank and Partners, Limited, 15, Grosvenor-place, London, S.W.1. The civil engineering contractors are Sir Robert McAlpine and Sons, 60, Park-lane, London, W.1; and Messrs. George Wimpey and Company, Limited, London, W.6. The mechanical engineering contractors include Messrs. Costain-John Brown, Limited, 73, South Audley-street, London, W.1; Messrs. Matthew Hall and Company, Limited, Dorset-square, London, W.1; and the Motherwell Bridge and Engineering Company, Limited, Motherwell, Lanarkshire. Messrs. E. B. Badger and Sons Company, Boston, U.S.A., are responsible for the design and procurement of the distillation and vacuum units; the M. W. Kellogg Company, New Jersey, U.S.A., for the catalytic cracker and de-asphalting unit; the Lummus Company, New York, for the extraction unit and the clay contact unit; and the Foster-Wheeler Corporation for the M.E.K. de-waxing unit.

The Anglo-Iranian Oil Company have registered a new subsidiary company, Kent Oil Refinery, Limited, to undertake the operation of the new refinery. Four million tons per annum of Middle East crude oil will be processed, and the principal products will be motor spirit (965,000 tons a year), premium grade kerosene (110,000 tons), tractor vaporising oil (29,000 tons), gas oil (490,000 tons), fuel oils (1,862,000 tons) and lubricants (140,000 tons). Work began in mid-1950 and will be completed in three stages. Stage 1 comprises the crude-oil distillation plant and auxiliary plants for the sweetening and blending of the chief products. These plants are due to be commissioned about July. Stage 2, due for completion in mid-1953, embraces the catalytic cracking plant, for converting the heavier types of semi-refined oils into high-grade motor spirit. A lubricating-oil refinery will follow as stage 3. Plants for the manufacture of other products requiring special processes may be installed at a later stage.

A flow diagram of the refinery is reproduced in Fig. 2, above, and Figs. 1, on this page, and 3 and 4, on page 556, show parts of the plant under construction. The distillation unit (Fig. 3) through which all the crude oil passes, will be the largest single unit of its type in Europe, having a capacity of 80,000 barrels a day, or 4,000,000 tons a year. The crude oil is piped through the stills, which heat it to about 750 deg. F. In the fractionating column the hot oil vapour rises and is taken off in " cuts " at various levels by trays on which it condenses. Fig. 2 shows the various products at this stage. Residue from the distillation unit is processed in a vacuum unit, from which certain cuts are fed into the catalytic cracker; the latter will have a capacity of 10,000 barrels a day, or 500,000 tons a year. A catalyst is used to break down oil fractions such as distillate oils in vapour form, to produce, in this case, high-grade motor spirit and butane. The lubricating-oil plant, when completed, will produce up to 140,000 tons a year. The oils will be manufactured from part of the residue from the distillation unit after further distillation in a vacuum unit.

The refinery will require about 4,000,000 gallons of cooling water an hour from the Medway estuary. A new sea wall has been constructed, enclosing a small bight on the foreshore in order to form a reservoir, and a concrete channel will conduct water nearly three-quarters of a mile to the fore-bay of a main cooling-water pump house. The reservoir will be filled by tidal action through balanced flap valves and will contain enough water between tides to keep the refinery running. When the water demand increases, the tidal supply will be augmented by three low-lift pumps, each with a capacity of 2,000,000 gallons an hour. Four steam-turbine pumps, each with a capacity of 1,500,000 gallons an hour, are being installed in the pump house. The refinery's requirements for process steam will be 430,000 lb. per hour, and for electricity 14,500 kW. Five boilers, each evaporating 150,000 lb. of steam an hour, will be installed, together with four turbo-alternators with a total capacity of 16,000 kW. The alternators will operate in parallel with an 11-kV grid supply. To provide sufficient feed water for the boilers, 12 high-pressure steam generators will be installed, to evaporate fresh water obtained from local supplies. Water-treatment plants, of both the lime-soda and base-exchange types, will be provided.

Four deep-water jetties, and another jetty for loading lubricating oils, are being built. The deep-water jetties will be capable of receiving the largest tankers (32,000 tons) afloat, and each will be capable of handling 2,000,000 tons of oil a year. The jetties are of reinforced-concrete construction, resting on steel box piles and provided with prestressed-concrete deck slabs.

ANNUAL REPORT OF THE INSTITUTION OF ELECTRICAL ENGINEERS.—It is announced that copies of the annual report of the Institution of Electrical Engineers for the session 1951-52 and of the accounts for the year ended December 31, 1951, which will be presented at the annual general meeting on Thursday, May 15, can be obtained by members on application to the secretary.

EXTENSION OF POWER STATIONS.—The British Electricity Authority have received the consent of the Minister of Fuel and Power to the establishment of a new section of the Hams Hall power station, near Birmingham, to be known as the Hams Hall "C" station. The present "A" and "B" power stations have an installed capacity of 249,450 kW and 321,000 kW, respectively. The new section will have an installed capacity of 360,000 kW, made up of six 60,000-kW turbo-generators each served by a boiler unit with an evaporative capacity of 550,000 lb. of steam an hour. Three cooling towers, each having a capacity of six million gallons of water an hour, will serve the new section. Consent of the Minister has also been given to extensions of the Ocker Hill power station at Tipton, Staffordshire, and Northampton power station. The extension at Ocker Hill will consist of two 30,000-kW turbo-generator sets and three boiler units each of an evaporative capacity of 180,000 lb. of steam an hour. A further 30,000-kW set and two boiler units, each of an evaporative capacity of 150,000 lb. of steam an hour, will be installed at Northampton.

MODEL OF BASCULE BRIDGE AT THE ROYAL SCOTTISH MUSEUM.

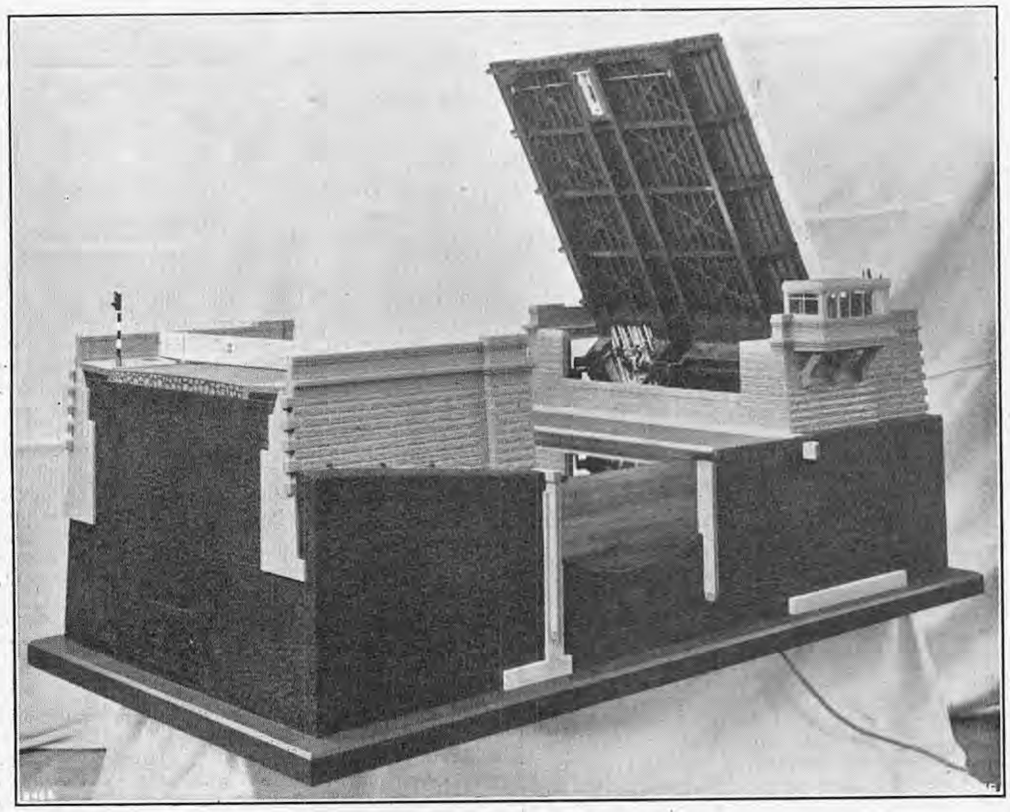


FIG. 1. MODEL WITH BASCULE RAISED.

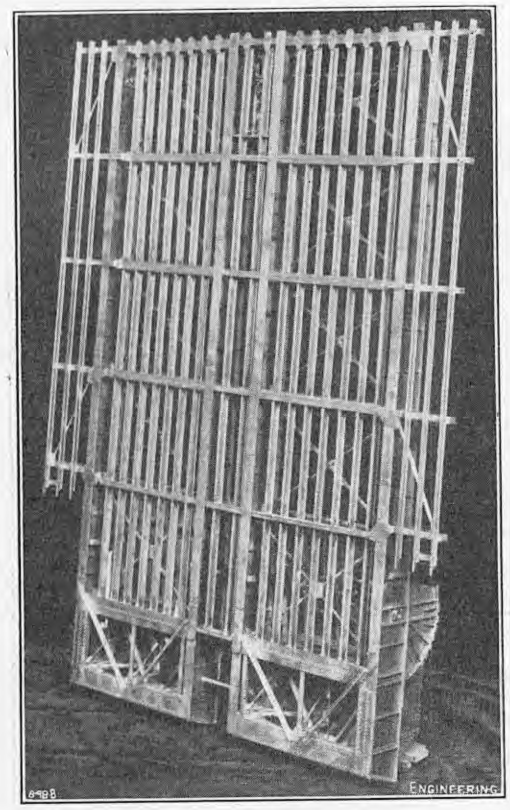


FIG. 2. FRAMEWORK FOR BASCULE.

MODEL OF A BASCULE BRIDGE.

WE illustrate in Figs. 1 and 2, herewith, a model of a bascule bridge which has just been added to the collection of working mechanical models in the Hall of Power at the Royal Scottish Museum, Edinburgh. When, some years ago, a model of an opening bridge was contemplated, Sir William Arrol and Company, Limited, who were consulted, recommended a single-leaf bascule bridge, 55 ft. span, which they had recently completed at Temple, on the outskirts of Glasgow, as suitable for reproduction. It is one of a number of bascule bridges carrying the main thoroughfares from Glasgow over the Forth and Clyde Canal. The gift by Messrs. Arrol of a full set of working drawings enabled an immediate start to be made in the Museum workshops. The scale is ⅜ in. to 1 ft.

The Temple Bridge is of the Scherzer rolling-lift type, in which all mechanism is located below the roadway level. The single-leaf bascule has four quadrants which rest on short tracks fixed to the foundations of the south abutment. The electrically-driven gearing is mounted within the span, pinions on the axis of rotation engaging with horizontal racks fixed to the foundations. In operation, the pinions carry the axis of rotation along the rack, rolling the bascule towards the raised or lowered positions according to the direction of rotation. The balance boxes sink into a pit in the foundations. The model is 4 ft. 6 in. in length and, despite the rather small scale, no detail of any significance has been neglected. Every rivet is shown and, even in the finer details of the hand-operated emergency gears and the surface patterns of manhole covers and road edge-plates, care has been taken to preserve faithful reproduction. Certain parts are sectioned to show the details of driving gears, bascule rolling gear, gate-operating mechanisms, deck construction, nose-locking gear, foundations and sheet piling of the canal, etc.

Some interesting problems arose in the arrangement of the driving mechanism for the model. A combination of mechanical linkages and electric controls was required which would be entirely hidden from sight within the base and would automatically carry out all the necessary operations with precision and in correct sequence. These operations, to be initiated by the pressing of a button, were the sounding of a warning bell, with illumination of miniature traffic signals and navigation lights, and the closing of the traffic gates over the roadway, followed by the raising of the bascule. Then, on re-pressing the button, each operation was required to be repeated in the reverse order, with the exception of the warning bell. Geared electric motors operate the gates and bascule through separate cranks and connecting rods, so avoiding the necessity of reversing for the second half of the cycle of operations.

THE BRITISH CONTRIBUTION TO TELEVISION.

A CONVENTION on "The British Contribution to Television," which had been organised by the Radio Section of the Institution of Electrical Engineers, opened in London on Monday, April 28, and closes to-morrow. A number of useful papers have been read at the technical sessions and visits have been paid to the works of manufacturers of television equipment and to the transmitting stations of the British Broadcasting Corporation.

The President of the Institution of Electrical Engineers (Sir John Hacking) was in the chair at the first meeting on Monday, April 28, when the convention was formally opened by the Lord President of the Council (the Rt. Hon. Lord Woolton). In the course of his remarks Lord Woolton said that, of the many advances which scientific research had contributed to civilisation in recent years, television was the one which had most rapidly attracted the general public. When the stations now under construction were in operation, television would be available to 78 per cent. of the population of the United Kingdom and he was in no doubt that we were at the beginning of an era when its use would be greatly extended, not only for domestic, but for commercial and industrial purposes. It was gratifying that the radio industry in this country had taken full advantage of the opportunities provided by the television broadcasting service. Cathode-ray tubes and other components were being produced on a scale which would have been considered impracticable only a few years ago. This was of more than domestic significance, as the experience thus gained, and its high reputation for quality and reliability, would place British industry in a good position to compete in the world market.

In an address on "Television Development," Sir Noel Ashbridge said it was greatly to be regretted that little progress had been made towards internationally agreed standards. In the so-called "western world" there were so far four different specifications for monochrome broadcasting television; and it was now doubtful whether any widely common standards were possible. The almost certain introduction of colour during the next few years would make the problem even more complex. The high cost of television programmes (which would tend to be higher still when colour was in use) made the case for standardisation important. Many countries might wish to exploit television as a nation-wide service, but would be unable to provide a sufficient number of programmes without making interchange arrangements with other countries.

Reviewing the prospects of colour television, Sir Noel said it was difficult to envisage exactly what would be involved, until some system had been finally selected and considerable experience of day-to-day operation gained. It was certain, however, that the costs of programme production and technical operation would be higher. The use of colour might not be justified for some programmes and it might be a good thing to use lighter and simpler apparatus when transmitting in monochrome. On the other hand, there was no reason why colour television should not give truer reproduction than colour films in the past. Among the less important improvements, many of which were almost certain to materialise, mention might be made of better and more consistent camera tubes, larger and better pictures, and a reduction in the cost of receivers. The possibility of much higher definition should not be ruled out and, scientifically, there was no doubt that good stereoscopic television could be produced, with or without colour. It was, however, doubtful for economic reasons whether such a system would be in regular operation for many years.

At a meeting on Monday afternoon, a paper on "History of Television" was presented by Mr. G. R. M. Garratt and Mr. A. H. Mumford, in which a broad review was given of the various methods whereby visual phenomena could be transmitted and received at a distance. Television, they said, might be dated from the discovery by Becquerel, in 1839, that when two electrodes were immersed in a suitable electrolyte and illuminated by a beam an electromotive force was generated between them. The next stage in development was the discovery by Willoughby Smith, in 1873, of the effect of light on the resistance of selenium, while the need for a process of scanning was recognised by Senlacq five years later. Early in the present century, interest in the possibility of distant electric vision was revived by the gradual development of photo-electric elements and the cathode-ray tube. In 1908, Campbell Swinton outlined a scheme very similar to modern systems, but this had to await the production of appropriate apparatus before it became practicable.

After the development of thermionic amplifiers, fresh interest was stimulated in the possibilities of television by the efforts of Mihaly in Budapest, Jenkins in America and Baird in England. By the early 1930's the basic ideas underlying much modern practice were well developed. By 1934, Baird Television, Limited, had evolved an entirely mechanical system giving a definition of 240 lines with 25 pictures per second, sequentially scanned. A little later, Electric and Musical Industries, Limited, were demonstrating a camera of the Smitsŏn type giving a definition of 405 lines with 25 pictures per second. The Alexandra Palace station of the British Broadcasting Corporation was opened in November, 1936, using these two systems alternately until February, 1937, when the Marconi-E.M.I. system was finally adopted.

(*To be continued.*)

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

SAILINGS BETWEEN CLYDE AND NORTH AMERICA.—The Scottish Council (Development and Industry) are to ask the Clyde Navigation Trust to help them in investigating complaints that sailings between the Clyde and North America have become so "infrequent, irregular, and slow" as to prejudice Scotland's export trade. Dr. Christopher Macrae, secretary of the Council, said that, in some instances, buyers in the United States are insisting that goods which they order must be sent by what they term the "fast-sailing" ports in the south, instead of the "slow-sailing" port of Glasgow.

GLASGOW-WEST PACIFIC SHIPPING SERVICE.—Furness Withy & Co., Ltd. announced on April 24 that a direct shipping service is to be resumed between West Pacific ports and Scotland. The service, discontinued during the war, will re-open when the Brazilian Prince leaves Glasgow on June 9. Subsequent sailings will be in intervals of about three to four weeks.

NATIONAL FUEL POLICY.—The need for a national fuel policy was a recurrent topic on April 19, at the spring meeting of the Scottish Association of Gas Managers at Rhu, near Helensburgh. Appealing for collaboration among the fuel and power industries, Sir Andrew Clow, chairman of the Scottish Gas Board, criticised the view that prosperity depended mainly on competition, declaring that the idea was out of date for industries like gas and electricity. Mr. G. E. Currier, senior vice-president of the Institution of Gas Engineers, said that if the electricity people had their way they would swallow up all the expected increase in coal production up to 1960. In modern gasworks the thermal recovery from coal could be raised from 75 to 85 per cent., which was the best way of meeting the coal shortage.

RE-ARMAMENT ORDERS.—Pressure on Scottish steelmakers for delivery on account of re-armament orders has been more marked in recent weeks. The greatest urgency seems to be in respect of tanks, mines, depth charges, and steel helmets, but the "Super Priority" symbol is also being attached to orders for shell steel and for material for naval work under construction in the shipyards.

LEITH IMPORT TRADE.—Imports at Leith totalled 77,776 tons during March, which compared with 90,106 tons in the corresponding month of last year. Total imports for the first three months of 1952, however, were 254,944 tons, against 235,181 in the first quarter of 1951.

BUILDING OF REFUSE DESTRUCTOR DELAYED AT GREENOCK.—Greenock Corporation have been informed by the Department of Health for Scotland that there is no possibility of allowing work to start this year on the erection of a new refuse destructor, at an estimated cost of 135,000*l*.

CLEVELAND AND THE NORTHERN COUNTIES.

TEES-SIDE WATER SUPPLY SCHEMES.—From the Stockton works of the South Durham Steel & Iron Co., Ltd., the first load of steel piping was dispatched last week for the construction of a main to keep Tees-side adequately supplied with filtered water. The total consignment is for 700 tons of piping for a 4,000-yard main between Lartington and Barnard Castle, which, when completed, will supply an extra 1,000,000 gallons of water a day for consumption in the Tees-side area. The work of laying the 30-in. diameter pipes is expected to be completed in about 14 weeks. Another scheme of the Tees Valley Water Board is the conversion of a cooling pond into a filter at Broken Scar, near Darlington. As recorded in these notes, the Minister of Housing and Local Government approved the supply of the steel for the schemes last month, after a meeting with officials of the Tees Valley Water Board in London.

TYNE SHIPBUILDING.—The shipbuilding output from the Tyne yards continues to lag behind the 1951 total. There was only one launch on the river in April, namely, a vessel from the South Shields yard of John Readhead & Sons, Ltd., and, in May, the only Tyne launch will be the 11,850-gross tons tanker Caltex Liverpool, from the Hebburn yard of R. & W. Hawthorn, Leslie & Co., Ltd. The vessel is for Overseas Tankships (U.K.), Ltd., and is due to enter the water on May 22. This will bring the Tyne's output for the first five months of the year to seven vessels, aggregating 58,000 gross tons. The figures for the corresponding period of 1951 were 12 vessels, comprising nearly 100,000 gross tons. It is likely that June also will be a poor launching month, but an improvement is expected in the second half of the year.

COAL SCRAPER AND CUTTER PLOUGH.—It is understood that the Durham Coal Board have ordered about 27 coal ploughs for use in Durham collieries. In a 12½-in. seam at Blaydon, a scraper plough is being used successfully, and there are hopes that many seams which, in the past, have been too thin to be worked economically will now be worked at a profit. A similar machine is being used in the Brockwell Seam at the Morrison Busty Pit, Annfield Plain, and it yields an output of 3½ tons per shift. At the same colliery, a German-type plough, introduced in 1947, has improved production by one-third compared with normal methods. It is proposed to use scraper ploughs in the thinnest seams and cutter ploughs in seams more than 2 ft. 6 in. thick.

DERWENTHAUGH COAL STAITHES.—The National Coal Board are to begin work on the reconstruction of the Derwenthaugh coal staithes, near Newcastle-on-Tyne, which were extensively damaged by fire nearly a year ago. About 100 yards of a wooden structure carrying the railway were destroyed by the fire. It is expected that the reconstruction work will be completed by the end of this year.

THE NORTH EASTERN ELECTRICITY BOARD.—The quarterly report of the North Eastern Electricity Board, submitted to the North Eastern Consultative Council at Newcastle-on-Tyne, states that 80 new substations have been brought into operation in the area and that 95 farms have been connected. Villages supplied with energy include one in the Tyne area, two in the Tees area, six in the York area, and four in the Harrogate district. During the quarter, the Board have approved estimates amounting to 705,170*l*., covering schemes for 98 housing and 30 rural electricity supplies. The present capital allocation for 1952-53 will allow stage 2 of the rural development scheme to be completed and supplies to be provided for nine additional villages. Moreover, a start will be possible on the supplying of villages under stage 3 of the scheme. These include 28 villages in the Tyne area, two in the Wear area, three on Tees-side, 10 in the York area, and 14 in the Harrogate district. During the past quarter, the Board have afforded high-voltage supplies to 18 industrial and commercial consumers.

LANCASHIRE AND SOUTH YORKSHIRE.

NEW WORKS IN SOUTH AFRICA.—A wholly-owned subsidiary of the English Steel Corporation, Ltd., is completing the erection of a new works at Germiston, near Johannesburg, for the assembly and finishing of railway wheels and axles, to be dispatched from this country in a rough state. The Manchester subsidiary of the Corporation will supply some of the products, and others will be sent from works in Sheffield and Rotherham. Mr. F. Pickworth, managing director of the English Steel Corporation, who returned recently to Sheffield from a business tour of South Africa, is optimistic about the business prospects there, as the dollar crisis is causing buyers in South Africa to look to this country for steel products formerly bought from the United States.

MODERNISATION OF TYRE MILL.—In addition to the modern railway-wheel mill at the works of Steel, Peech and Tozer, described in ENGINEERING on page 515, *ante*, the modernisation of the tyre mill is to be undertaken. A good deal of the plant and machinery has arrived at the works, including plant received as reparations from Germany.

HOLIDAYS WITH PAY.—The Cutlery Wages Council have confirmed their earlier decision to grant employees in the cutlery industry an additional week's holiday with pay, thus making a fortnight, in addition to the normal Bank Holidays. The proposal will now go forward to the Minister of Labour for signature and the issue of an Order. There was objection to the proposal on the ground that Sheffield cutlery firms were suffering from the effects of the Australian import restrictions. More than 7,500 cutlery employees and over 600 firms are affected in Sheffield.

THE MIDLANDS.

CANAL MAINTENANCE.—During the Easter holidays, cleaning and repairing of the canal at Farmer's Bridge locks, Birmingham, has been carried out. Farmer's Bridge locks, 13 in number, form the connection between the Birmingham canals passing through the Black Country to Wolverhampton, and the Grand Union line which leads to London. Traffic between London and Birmingham, Wolverhampton and the north-west passes through these locks, and there is also a fair amount of local traffic. The repairs included replacement of three lock gates, which are of the usual Midland "narrow gauge canal" type.

THE SHROPSHIRE LANDSLIP.—The conference held at Broseley on April 23 to discuss the landslip at Jackfield, Shropshire, decided to ask the Department of Scientific and Industrial Research to examine the site and report on possible remedial measures. The geological formation of the district is complicated, and there are at present several views current, both as to the cause of the landslip and the possible remedies.

TECHNICAL COLLEGE EXTENSIONS.—Wolverhampton Education Committee are considering a recommendation to approve a tender for 52,463*l*. for the third stage of the extensions to Wolverhampton and Staffordshire technical college.

UNIVERSITIES AND INDUSTRY.—The part played by universities in training men for posts in industry was discussed at a conference in Birmingham on April 21. The conference was called jointly by the University of Birmingham, the Federation of British Industries, and the Birmingham Chamber of Commerce. The industrialist's point of view was expressed by Sir Arthur Smout, J.P., a director of Imperial Chemical Industries, Ltd., who considered that university courses were too concentrated, and gave students no time to think. He asked the universities to concentrate on building character and initiative, adding that, if these qualities were developed, industry could be relied upon to complete the training of young men to suit its own needs without difficulty. The conference also discussed post-graduate courses, and it was pointed out that industrialists had said that they could not release executives to take part in these courses for a full year. Mr. Sidney Vernon, LL.M., the Pro-Chancellor of Birmingham University, said that, in view of the points brought out at the meeting, it might be necessary to modify the courses. He appealed for greater support to be given to them, otherwise they might have to be discontinued.

MINISTRY OF SUPPLY FACTORY.—It was announced in Birmingham on April 22, by Mr. F. C. Limbrey, a deputy regional controller for the Ministry of Supply, that a new factory for finishing blades for gas turbines is to be erected in the Midlands. The factory will be built by the Ministry of Supply, and operated by Blade Research and Development, Ltd. An area of about 100,000 sq. ft. will be occupied, and building is to start at once. The exact location of the factory was not stated. The announcement was made to allay the fears expressed by some manufacturers that part of their premises was to be requisitioned for blade-finishing.

SOUTH-WEST ENGLAND AND SOUTH WALES.

UNEMPLOYMENT AT ROGERSTONE WORKS.—Anxiety felt by workpeople at the Northern Aluminium Company's factory at Rogerstone, near Newport, has been voiced by Monmouthshire Members of Parliament. In reply to Mr. D. Granville West, M.P., who asked for additional allocations to avoid redundancy at the mills, the Minister of Supply has stated that the company's supply of aluminium could only be increased by reducing the allocations to other fabricators, and this would unbalance the industry. The Minister pointed out that the new mill was so efficient that it required only one man for every five needed to run older mills. Since the new mill began working, the labour force at Rogerstone had been reduced from 4,500 to 3,900, but the plant was still overstaffed because the company's policy was to avoid dismissals as far as possible. The Minister gave an assurance that, if more aluminium became available, the claims of Rogerstone and other plants in development areas would receive special consideration.

REDUCED COAL PRODUCTION AT LYDBROOK.—On account of diminishing coal reserves it is no longer possible to work two coal-winding shifts at Arthur and Edward Colliery, Lydbrook, in the Forest of Dean. All the coal produced is now being wound on the morning shift, which means that the services of between 60 and 70 men, mainly haulage employees and those engaged on surface work, are no longer required.

COAST-DEFENCE SCHEME, LLANDUDNO.—Llandudno's 123,000*l*. coast-defence scheme is now virtually completed. The final centre section of the 2,885-ft. stepped wall has been finished and only work on clearing the site and re-surfacing the paved area remains to be done. Despite difficulties in obtaining steel, the work will be completed to schedule, two years after it was begun.

RIVER USK CROSSINGS.—The Newport Town Council have been asked by the Newport and Monmouthshire Chamber of Commerce to give serious consideration to the construction of a second crossing of the River Usk at Newport. At a meeting with representatives of the Ministry of Transport, 15 months ago, the same project was discussed and one member reported that he was told that a second crossing would not be considered until 1966.

NOTICES OF MEETINGS.

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

INSTITUTE OF ECONOMIC ENGINEERING.—*Glasgow Branch:* Saturday, May 3, 10.30 a.m., The Christian Institute, 70, Bothwell-street, Glasgow. Open-Discussion Meeting. *London Branch:* Thursday, May 8, 7 p.m., The George Hotel, Church-lane, Kingsbury, N.W.9. "Material Handing as a Factor of Efficiency," by Mr. J. R. Smart. *Manchester Branch:* Friday, May 9, 7 p.m. The Engineers' Club, Albert-square, Manchester. "Production Control as a Management Tool," by Mr. W. J. Worsdale.

SOCIETY OF ENGINEERS.—Monday, May 5, 5.30 p.m., Geological Society's Apartments, Burlington House, Piccadilly, W.1. "From Sink to Sea," by Mr. B. F. P. Babcock.

INSTITUTION OF ELECTRICAL ENGINEERS.—*South Midland Centre:* Monday, May 5, 6 p.m., James Watt Memorial Institute, Great Charles-street, Birmingham, 3. "Railway Electrification in Great Britain," by Mr. C. M. Cock. *Measurements Section:* Tuesday, May 6, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. "The Electricity Division of the National Physical Laboratory," by Mr. R. S. J. Spilsbury. *North-Western Centre:* Tuesday, May 6, 6.15 p.m., Engineers' Club, Manchester. Annual General Meeting. "The Design of High-speed Salient-Pole Alternating-Current Generators for Water-Power Plants," by Mr. E. M. Johnson and Mr. C. P. Holder. *North Midland Centre:* Tuesday, May 6, 6.30 p.m., Offices of the British Electricity Authority, 1, Whitehall-road, Leeds, 1. Annual General Meeting. *Southern Centre:* Wednesday, May 7, 6.30 p.m., Royal Beach Hotel, Portsmouth. "Technical Colleges and Education for the Electrical Industry," by Dr. H. L. Haslegrave. *North Midland Students' Section:* Saturday, May 10, 2.30 p.m., Offices of the British Electricity Authority, 1, Whitehall-road, Leeds, 1. Annual General Meeting. *Radio Section:* Wednesday, May 14, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. "A Phototelegraphy Transmitter-Receiver Utilising Sub-Carrier Frequency Modulation" by Mr. R. O. Carter and Mr. L. K. Wheeler.

INSTITUTE OF FUEL.—*Midland Students' Section:* Monday, May 5, 7.30 p.m., The University, Edmund-street, Birmingham. Annual General Meeting and Film Display.

CHEMICAL ENGINEERING GROUP.—Tuesday, May 6, 5.30 p.m., Chemical Society's Apartments, Burlington House, Piccadilly, W.1. "Chemical Engineering and Atomic Energy," by Mr. C. M. Nicholls and Mr. A. S. White.

INSTITUTION OF CIVIL ENGINEERS.—*Structural and Building Engineering Division:* Tuesday, May 6, 5.30 p.m., Great George-street, Westminster, S.W.1. "The Historical Development of Structural Theory," by Mr. S. B. Hamilton. *Midlands Association:* Thursday, May 8, 6 p.m., James Watt Memorial Institute, Great Charles-street, Birmingham. Annual General Meeting.

INSTITUTION OF SANITARY ENGINEERS.—Tuesday, May 6, 6 p.m., Caxton Hall, Victoria-street, Westminster, S.W.1. "Sanitation in Multi-Storey Buildings. Part II. Waste Plumbing and Drainage," by Mr. H. E. Gooding.

INSTITUTION OF MECHANICAL ENGINEERS.—*London Graduates' Section:* Tuesday, May 6, 6.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Industrial Health Engineering," by Mr. R. J. Sherwood.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Wales and Monmouthshire Branch:* Tuesday, May 6, 6.30 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Annual General Meeting.

INSTITUTION OF WORKS MANAGERS.—*Wolverhampton Branch:* Tuesday, May 6, 7 p.m., The Star and Garter Royal Hotel, Wolverhampton. "Management and Productivity," by Mr. J. Ayres.

INCORPORATED PLANT ENGINEERS.—*London Branch:* Tuesday, May 6, 7 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. "The Manufacture of Nylon Stockings," by Mr. H. J. Hall. *East Lancashire Branch:* Tuesday, May 6, 7.15 p.m., Engineers' Club, Albert-square, Manchester. Open Meeting. *Newcastle-on-Tyne Branch:* Thursday, May 8, 7.30 p.m., Roadway House, Oxford-street, Newcastle-upon-Tyne. "The Use of Low-Grade Fuel in Shell-Type Boilers," by Dr. E. G. Ritchie. *Dundee Branch:* Monday, May 12, 7.30 p.m., Mathers Hotel, Dundee. Films on "Electric Ship-Propulsion Equipment" and "Safety First."

BRITISH INSTITUTION OF RADIO ENGINEERS.—*London Section:* Wednesday, May 7, 6.30 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "An Aerial Analogue Computer," by Dr. W. Saraga, Mr. D. T. Hadley and Mr. F. Moss. *North-Eastern Section:* Wednesday, May 14, 6 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. Annual General Meeting and Film Evening.

JUNIOR INSTITUTION OF ENGINEERS.—*Midland Section:* Wednesday, May 7, 7 p.m., James Watt Memorial Institute, Great Charles-street, Birmingham, 3. "Sintered Oil Retaining Bushes and Bearings," by Mr. A. E. Mapstone.

INSTITUTION OF ENGINEERING DRAUGHTSMEN AND DESIGNERS.—*Birmingham Branch:* Wednesday, May 7, 7 p.m., Queen's Hotel, Birmingham. "The Design of High Frequency Electrical Heating Furnaces," by Mr. E. May.

INSTITUTION OF PRODUCTION ENGINEERS.—*Nottingham Section:* Wednesday, May 7, 7 p.m., Victoria Station Hotel, Milton-street, Nottingham. "Social Science as Applied to Industry," by Mr. F. A. Wells. *Norwich Section:* Wednesday, May 7, 7.30 p.m., Norwich City College, St. George's-street, Norwich. "Advance of Industrial Heat Treatment," by Mr. J. McHenry. *Birmingham Graduate Section:* Tuesday, May 13, 7 p.m., James Watt Memorial Institute, Great Charles-street, Birmingham, 3. "Design and Wrapping and Cardboard Box-Making Machinery," by Mr. John W. Smith. *London Graduate Section:* Wednesday, May 14, 7.15 p.m., 36, Portman-square, W.1. "A Comparison of Product Finishes with Some Reference to Costs," by Mr. B. Workman and Mr. C. D. S. Bridgett.

ROYAL SOCIETY.—Thursday, May 8, 4.30 p.m., Burlington House, Piccadilly, W.1. "The Research Laboratories of Ilford Limited," by Mr. G. B. Harrison.

ENGINEERS' GUILD.—Thursday, May 8, 6 p.m., Caxton Hall, Victoria-street, Westminster, S.W.1. "The Development of an Engineer," by Mr. H. J. B. Harding.

ILLUMINATING ENGINEERING SOCIETY.—*Leicester Centre:* Thursday, May 8, 6.30 p.m., Offices of the East Midlands Electricity Board, Charles-street, Leicester. Annual General Meeting.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*South Wales Group:* Friday, May 9, 7 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Chassis Frame Construction and Repair," by Mr. C. F. Cunningham.

INSTITUTE OF PACKAGING.—*Northern Area:* Monday, May 12, 6.30 p.m., Old Nag's Head Hotel, Manchester. "Multiwall Paper Sacks," by M. G. M. Hobday.

CHADWICK TRUST.—Tuesday, May 13, 2.30 p.m., Royal Society of Tropical Medicine and Hygiene, Manson House, 26, Portland-place, W.1. "Food and Health," by Dr. E. L. Sturdee.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, May 13, 5.30 p.m., 85, The Minories, E.C.3. "Steam Pipe Materials for Advanced Steam Conditions," by Mr. D. W. Crancher.

INSTITUTE OF PETROLEUM.—Wednesday, May 14, 5.30 p.m., Manson House, 26, Portland-place, W.1. "The Distribution of Oil Reserves in the World," by Dr. G. M. Lees, F.R.S., and Mr. D. C. Ion.

ROYAL STATISTICAL SOCIETY.—*Study Group:* Wednesday, May 14, 6 p.m., The E.L.M.A. Lighting Service Bureau, 2, Savoy-hill, Strand, W.C.2. Discussion on "Prediction of Economic Indices." *Research Section:* Wednesday, May 21, 5.15 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "Some Statistical Aspects of Anthropometry," by Mr. M. J. R. Healy.

SOCIETY OF CHEMICAL INDUSTRY.—*Corrosion Group:* Wednesday, May 14, 6.30 p.m., Chemical Society's Apartments, Burlington House, Piccadilly, W.1. "The Prevention of Corrosion in Packaging," by Mr. E. G. Stroud and Mr. W. H. J. Vernon. *Road and Building Materials Group:* Thursday, May 15, 6 p.m., Institution of Structural Engineers, 11, Upper Belgrave-street, S.W.1. Annual General Meeting and Address by the chairman of the Group, Mr. J. C. Warr.

LECTURES ON HYDRO-ELECTRIC POWER DEVELOPMENT.—A course of four public lectures on "The Civil and Mechanical Engineering Aspects of Hydro-Electric Power Development" will be delivered at 4 p.m. on Mondays, May 5, 12, 19 and 26, in Room 17 of the City and Guilds College, London, S.W.7, by Dr. P. W. Seewer, consultant and late chief engineer of the English Electric Co. Ltd. The lectures are in connection with the post-graduate course in hydro-electric power engineering held in the Department of Civil Engineering of the Imperial College of Science and Technology, London.

MOTOR-VEHICLE EXPORTS.—The exports of cars and commercial vehicles for the month of March were higher than those for March, 1951. A total of 33,500 cars, valued at 12*l.* million, and 13,270 commercial vehicles, valued at 7·5*l.* million, were sent overseas. Corresponding figures for March, 1951, were 27,590 cars and 10,040 commercial vehicles. The exports of cars and commercial vehicles in the first quarter of 1952 were the highest ever in value for the first quarter of any year. In March, 10,100 agricultural tractors were exported, compared with 8,320 a year ago.

PERSONAL.

VISCOUNT WEIR OF EASTWOOD, P.C., G.C.B., D.L., chairman of G. and J. Weir Ltd., Glasgow, has been elected honorary President of the British Employers' Confederation. MR. A. G. STEWART, chairman and managing director of Stewarts and Lloyds Ltd., Glasgow, has been elected President.

MR. G. H. DOWTY, F.R.Ae.S., chairman and managing director of Dowty Equipment Ltd., and a vice-president of the Royal Aeronautical Society, 4, Hamilton-place, London, W.1, has been elected President of the Society for the year 1952-53. He will take office at the Annual General Meeting to be held on May 7.

MR. H. S. GIBSON, C.B.E., M.A., M.I.Mech.E., F.Inst.Pet., managing director of the Iraq Petroleum Co. Ltd., has been elected President of the Institute of Petroleum, 26, Portland-place, London, W.1, for the session 1952-53. Three new vice-presidents of the Institute are: MR. H. HYAMS, F.Inst.Pet., MR. H. E. F. PRACY, B.A., M.I.Chem.E., F.Inst.Pet., and MR. R. B. SOUTHALL, F.Inst.Pet.

MR. ANDREW HOPPER has been appointed managing director of the Parsons Marine Steam Turbine Co. Ltd., in succession to the late MR. W. H. PILMOUR.

Following a recent reorganisation of the technical department of Handley Page Ltd., Cricklewood, London, N.W.2, the following appointments have been made: MR. C. F. JOY, A.F.R.Ae.S., deputy chief designer; MR. G. H. LEE, A.R.C.Sc., B.Sc., D.I.C., F.R.Ae.S., assistant chief designer—aerodynamics; MR. R. H. SANDIFER, F.R.Ae.S., assistant chief designer—structures; MR. C. O. VERNON, A.F.R.Ae.S., chief aerodynamicist; MR. F. TYSON, B.A., A.F.R.Ae.S., chief stressman; and MR. K. C. PRATT, A.M.I.Mech.E., A.F.R.Ae.S., development and test engineer.

MR. M. J. NOONE, until now chief engineer, Whessoe Ltd., Darlington, has been appointed to the new post of manager of operations. He will be responsible for all activities leading to the successful carrying through of contracts and for guiding and co-ordinating the work of the departments principally concerned.

MR. N. G. LANCASTER, M.B.E., an assistant managing director of Tube Investments Ltd., The Adelphi, London, W.C.2, has been appointed executive deputy chairman of the Group's aluminium subsidiary companies: TI Aluminium Ltd., Reynolds Light Alloys Ltd., Reynolds Rolling Mills Ltd., and the South Wales Aluminium Co. Ltd. MR. W. H. BOWMAN and MR. J. H. CATLING, joint managing directors of Reynolds Rolling Mills Ltd., Reynolds Light Alloys Ltd., and the South Wales Aluminium Co. Ltd., have been appointed joint managing directors of TI Aluminium Ltd.

MR. C. WRIGHT has been appointed works manager of Francis W. Birkett and Sons Ltd., Cleckheaton, Yorkshire. MR. J. H. T. BROWNE is now the firm's representative covering the Yorkshire-West Riding area.

MR. FRANK BURGESS, hitherto technical director, has been appointed managing director of Whites-Nunan Ltd., Church-street, Pendleton, Manchester, 6, in succession to the late MR. REGINALD PARKES.

MR. J. G. EMINTON, formerly of the London head office of Keith Blackman Ltd., Mill Mead-road, Tottenham, N.17, has been transferred to Bristol to achieve closer contact with the firm's clients in the West Country. His address is 13, West Dene, Westbury-on-Trym, Bristol. (Telephone: Stoke Bishop 82519.)

MR. C. W. GLANISTER has been appointed the Brush ABOE resident representative in Nigeria, the British Cameroons, the Gold Coast, Sierra Leone and Gambia, and his address will be c/o P.O. Box 159, Lagos, Nigeria, British West Africa.

MR. J. MANN, C.B.E., J.P., a representative of Scottish local authorities, has been made a member of the Central Transport Consultative Committee for Great Britain.

MR. J. H. WIERSUM, A.M.I.E.E., has been appointed manager of the office of Metropolitan-Vickers Electrical Export Co., Ltd., at The Hague, Holland, in succession to MR. H. F. BIBBY.

The Lancashire Dynamo organisation have established a new company specialising in the manufacture of switchgear, to be known as LANCASHIRE DYNAMO SWITCHGEAR LTD., Bristol-road, Bridgwater, Somerset. Production has already been established.

COX AND DANKS, LTD., Scapa House, Park Royal-road, London, N.W.10, have moved their South Wales offices to Portfield House, Adelaide-street, Cardiff. (Telephone: Cardiff 21441.)

BARBET LTD., 175, Piccadilly, London, W.1, have concluded an agreement for technical liaison with R. S. ARIES AND ASSOCIATES, consulting engineers, 400, Madison-avenue, New York, U.S.A.

The offices of the periodical *Revue de Métallurgie* have been removed to 25, Rue de Clichy, Paris (9e). The telephone number, namely, TRInité 18-11, is unaltered.

CONSTRUCTION OF THE KENT OIL REFINERY.

(For Description, see Page 552.)

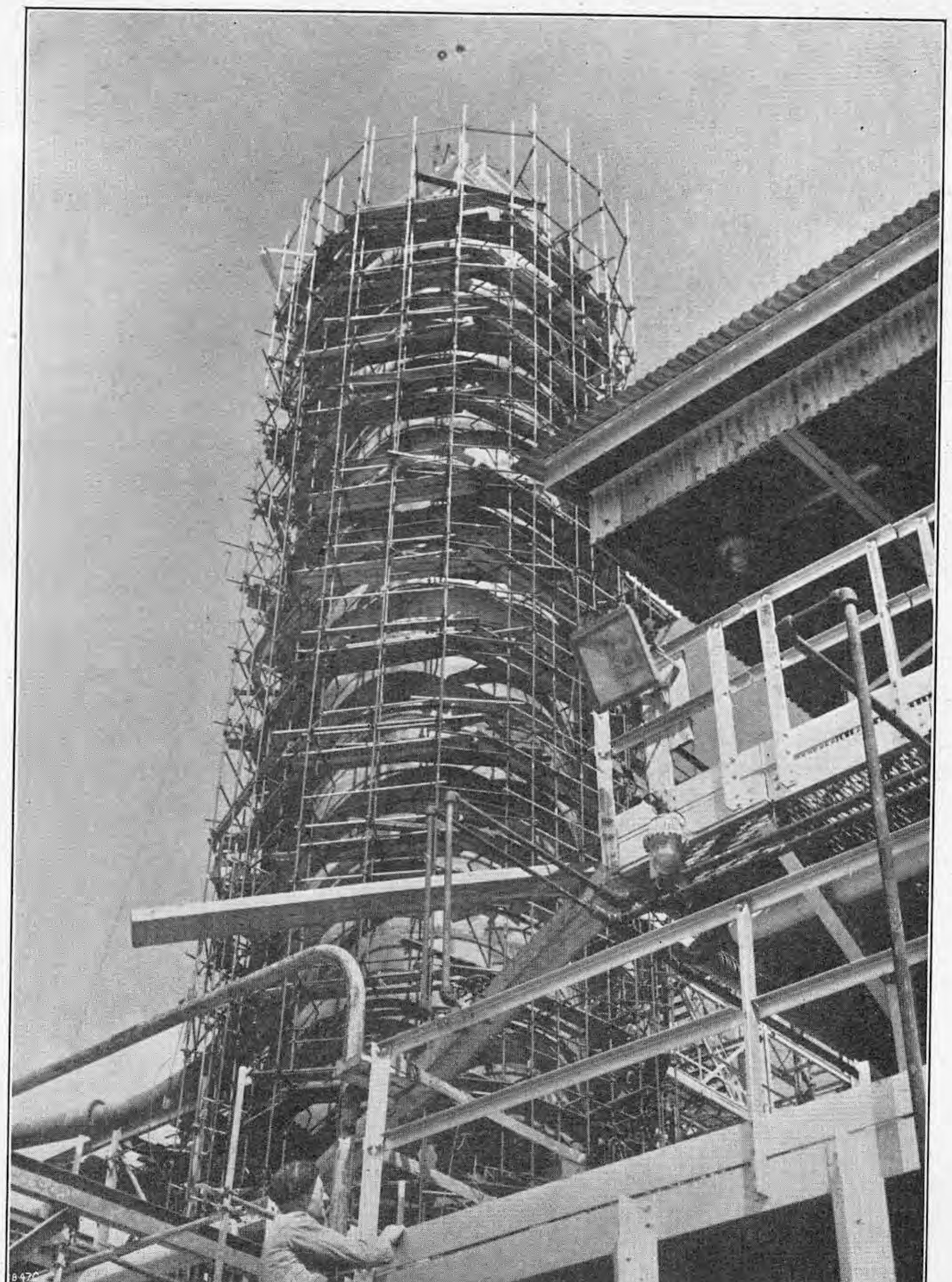


Fig. 3. Distillation Unit.

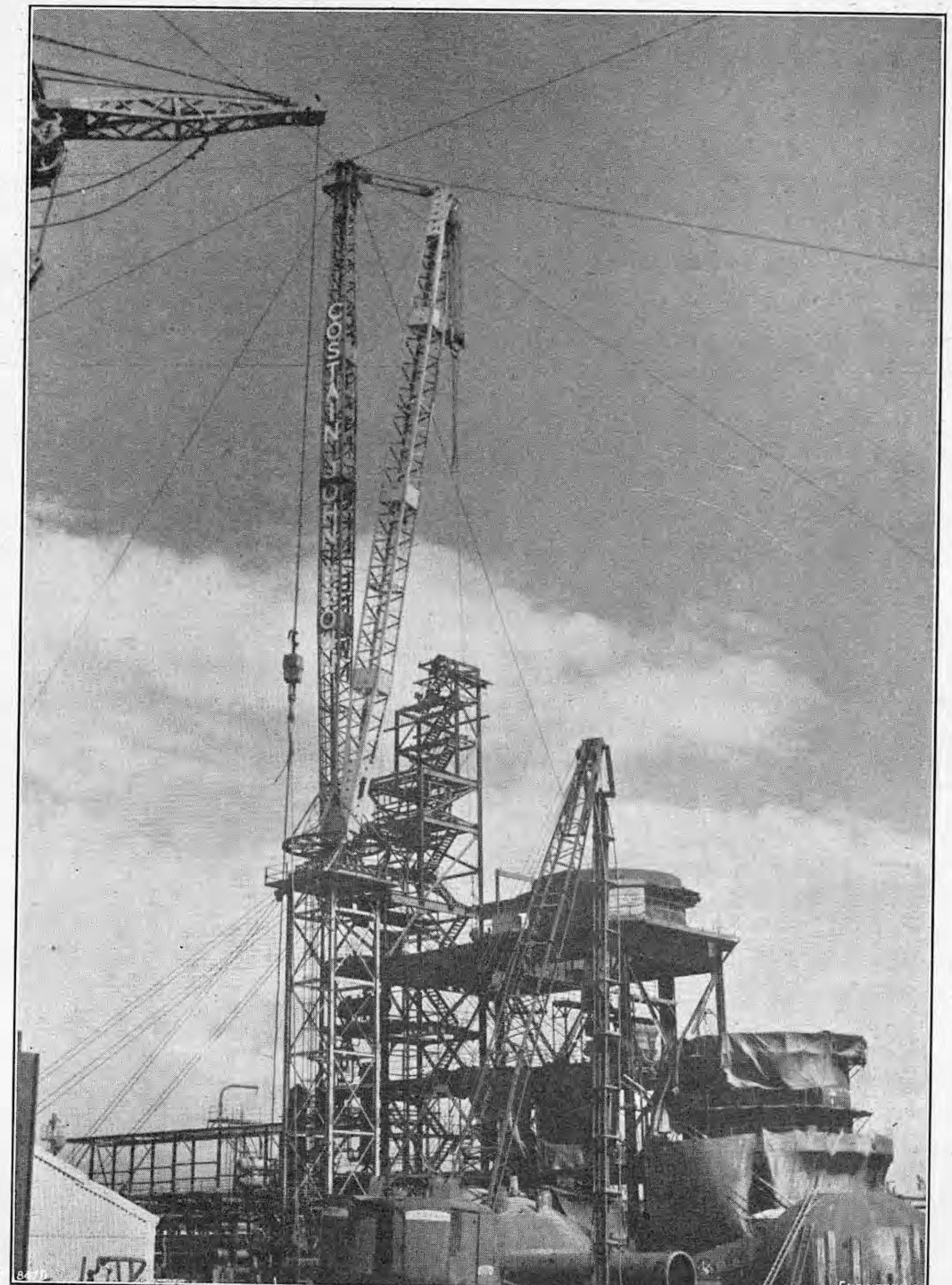


Fig. 4. Catalytic Cracking Plant.

ENGINEERING

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

Registered at the General Post Office as a Newspaper.

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Telegraphic Address:

ENGINEERING, LESQUARE, LONDON.

Telephone Numbers:

TEMPLE BAR 3663 and 3664.

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

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

CONTENTS.

ENGINEERING

FRIDAY, MAY 2, 1952.

VOL. 173. No. 4501.

THE B.I.F. AND THE NATIONAL ECONOMY.

THE British Industries Fair, which opens on May 5 in Castle Bromwich and London, has been an annual national event for so many years that it is in some danger of being taken for granted as an annual event and not much more; a convenient and perfectly sound reason for foreign nationals to conjure British currency out of reluctant Treasuries for a visit to these shores, with or without the possibility of picking up a few lucrative agencies—for it must be remembered that British citizens are not the only ones who find it hard to obtain official permission to spend their own money in other lands—but, in other respects, just another Fair, comparable with those in most of the countries of Europe. To a considerable extent, it must be admitted, the average British citizen has not yet learned to take the B.I.F. very seriously, if he does not happen to be one of those who, for a fortnight or so every year, find themselves committed to attendance thereat; probably because the organisers have never laid themselves out to attract the British sightseer, but have rather tended to place obstacles in the way of those who might wish to visit it, by limiting the possible hours of his attendance to times when, if he has to work elsewhere for his living, he is unable to take advantage of such opportunities as there are. Yet the Fair has been steadily acquiring an increasing significance in the life of the ordinary man, whether he realises that fact or not, and deserves to be more widely recognised for what it really is, and is meant to be, namely, a powerful factor in the seemingly unending struggle to balance the national trading account.

In that endeavour, the engineering sections of the Fair are potentially of an importance even greater than their relative size would appear to indicate. If proof of that statement be needed, it is to be found in full measure in the *Economic Survey of* 1952;* there are few of its 40 pages of text on which the economic significance of the engineering industry and of Britain's engineering manufactures is not emphasised by implication or direct assertion. Whether the chapter headings refer to the general economic situation, exports, re-armament, production, fuel and power, the metal-using industries in general, agriculture, or almost anything else covered by the *Survey*, engineering comes somewhere into the picture, until the conclusion is reached, on page 46, that "exports and re-armament both call for greater production in the engineering industries and in the basic industries which support them."

Mere production, however, is not enough. The engineering industry must sell the goods that it produces, and must sell most of them abroad. This country could probably absorb the entire output of the engineering and allied industries for some years, in overtaking arrears of equipment and maintenance, and in bringing the national power consumption per head more nearly into line with that in the United States, which has benefited so greatly as a nation by the general willingness to employ machines in preference to manual labour wherever possible. As a long-term policy, an intensified programme of national re-equipment may appear attractive, but the urgent need is the short-term one of buying the food and the raw materials that the nation needs next week or next month, and, as the *Economic Survey* points out, "the United Kingdom cannot dictate to other countries the terms on which it trades with them"—not now, at all events, whatever the position may have been in the past. It is highly unfortunate that so many of the countries with which British exporters are concerned are themselves suffering from a financial stringency that compels them to restrict their purchases to the more essential commodities, and, even so, to buy in the cheapest market, irrespective of sentimental or other uneconomic considerations. The manufacture of engineering products, even of the lighter variety, requires considerable initial capital outlay as well as technical skill, and almost everywhere the supplies of both capital and skill are inadequate to meet the demands. Britain has already much of the necessary capital in the form of equipment that is ready for use, and has accumulated a reserve of skill that few countries can equal; hence derives the inescapable conclusion that (to quote the *Survey* again) the essential requirement is "a large expansion in the volume of engineering exports," because few of the other exports are equally essential in the eyes of the potential purchasers or can produce a comparable change in the economic situation with equal speed or an equal expenditure of money and effort in production.

To develop that export trade is a primary function of the British Industries Fair. It is true that some very important sections of the British engineering industry are represented in it only incidentally or not at all, because they organise their own exhibitions at other times and places; but the Fair does provide a display that covers a very wide field, and the quality of the goods exhibited should have the effect of impressing upon the discriminating visitor some realisation of the ability of the industry to provide not only the articles on view, but anything else of which he may stand in need. Numerous and varied as the actual exhibits are, they are no more than samples of what the industry can and does produce, and the potential value of the Fair is not to be gauged solely by the volume of business done in one short fortnight.

* Cmd. 8509. H.M. Stationary Office, York House, Kingsway, London, W.C.2. [Price 1*s.* 3*d.* net.]

LIMITS AND FITS.

The news that a committee of the British Standards Institution have based an entirely new standard for limits and fits on the metric system may cause some surprise. Draft copies have been widely circulated for comment, but unless some formidable objection is raised—and it is difficult to imagine one—it is probable that towards the end of the year the new system will replace that of the existing B.S. 164, "Limits and Fits for Engineering." The change-over is not expected to cause any great difficulty since, owing to the wide selection of fits provided, almost exact equivalents are available in the new series. The advantages of making the change, however, are indisputable. It will enable many organisations to adhere to standard limits and fits where, up till now, they have worked to their own system owing to the inadequacy of the existing B.S. 164.

In 1937, on the recommendation of the Institution of Production Engineers, a committee was appointed to consider the revision of the first (1924) edition of B.S. 164. The war held up this work, though a revised and simplified edition, retaining the essential tables, was published in 1941. After the war a complete revision was mooted, and a new committee formulated proposals for a system which, though giving a wider choice of fits than the existing standard, was nevertheless based on similar principles. The new edition was nearing publication when developments in inter-Services standardisation made it appear desirable to review the whole question. As a result of discussions between Service representatives of the United Kingdom, Canada and the United States at Ottawa in November, 1950, the committee agreed to investigate the possibility of obtaining a universal inch system of limits and fits. The result was a new series of tables based on the International Standards Association's (I.S.A., now the International Standards Organisation—I.S.O.), and it is this system, with the metric tolerance values converted into inches, that is given in the new draft standard. Its principles are summarised on page 561.

The chief feature of the draft revision is its comprehensiveness. It should meet a much greater proportion of the requirements of industry, simply because it gives a greater choice of limits and fits. The system, as a result, is correspondingly more complex, but basically it is simple and once the design office of each organisation has decided on the selection most appropriate to its needs, subsequent design and production will be facilitated. The I.S.A. system was first issued in its present form in 1935, after all the existing systems had been examined, and since that year it has been widely accepted. It is almost universal on the Continent and is already in use by a small number of organisations in this country which use the metric system. The fact that it has been converted from metric to Imperial measure does not, apparently, lead to any serious anomalies or restrictions, and its adoption in this country would give grounds for hope that international agreement on the subject of limits and fits can eventually be reached. It would be a noteworthy fusion of the two systems of measure—metric and Imperial—which in all other ways refuse to compromise, and it would enable experience of limits and fits to be exchanged between different countries. On the Continent it is already possible for engineers to discuss limits and fits by means of symbols, without having the tables in their hands, and thus to exchange information of the type that such and such limits and fits have been found by experience to give satisfactory service for a particular component or assembly. In the event of British industry accepting the proposed new standard, information on accumulated experience of this kind will then be available.

The I.S.A. system was designed so that, within its limits of application, it is sufficiently comprehensive to cater for the normal requirements of all types of engineering, from precision gauge manufacture to coarse-quality work where it is almost unnecessary to specify tolerances. It is sufficiently flexible for it to provide for any extraordinary requirements which may arise from time to time, and its construction is such that it can be logically extended above the present upper limit (about 20 in.) to provide for the needs of heavy engineering, and below the lower limit (0·04 in.) for very light engineering such as watch and clock manufacture. The system permits the use of a unilateral or bilateral hole or shaft basis, though the committee recommend, as in B.S. 164, the unilateral hole system. The manufacturing tolerances provided are proportional to the cube root of the diameter (or other measure) of the workpiece, except that a term + 0·001 D is included "out of consideration of the uncertainties of measuring with increase in diameter (these being mainly due to differences in temperature and deformation of gauges and working pieces). In practice, this is only noticeable in diameters above about 80 mm."

The principal object of the committee (the chairman of which is Mr. J. E. Baty) when deciding on the method of conversion from metric to inch values was to produce a set of limits which differed as little as possible from the exact equivalents of the I.S.A. metric values, but which would not be rendered unrealistic by being specified to an unnecessarily high degree of accuracy. It was therefore agreed, first, that the tolerance values should be obtained by direct conversion of the metric values into inches and not by using the I.S.A. tolerance formula, and, secondly, that no tolerance value should be specified to a higher degree of accuracy than the nearest 0·00005 in., and this only in the very fine qualities. The only exception to this is in two extremely fine tolerance qualities which are intended mainly for gauges. As a result, the inch and metric limits and tolerances are, for all practical purposes, interchangeable, and any fit specified by symbol only will represent the same limits of size whether inch or metric measure is used. The metric values of the diameter size ranges were converted into inches and rounded to the nearest 0·001 in. in the upwards direction. The purpose of rounding upwards was to ensure that a component with a "toleranced" metric dimension would have the same tolerance applied to it whether it is made according to metric measure or whether the dimension is converted into inches and toleranced according to the inch tables. Though the resulting size-range boundary values are not round numbers, this is an advantage, since commonly-used design sizes do not fall at the extremes of a size range.

The new standard rightly stresses the importance of preferred sizes. Some examples of preferred sizes are given in the article on page 561, and it is pointed out there that, in the inch units, designers have a first and second choice; in the metric system as many as five choices are given, but the fourth and fifth are to be avoided as far as possible. That principle, at least, is the ideal, and the advantages to be gained from trying to live up to it need no emphasising; they are probably quite as significant as those initially due to the standardisation of limits and fits.

Though the proposed standard is founded on well-established Continental practice, there is ample opportunity for constructive criticism, and it is to be hoped that all sections of industry concerned will make a point of submitting their observations to the British Standards Institution (from whom draft copies are available) so that the standard, when authorised, will meet all requirements. It is particularly important that firms which, in the past, have used their own systems of limits and fits, should now examine the draft standard to see whether they can, in due course, adopt it.

NOTES.

The Iron and Steel Institute.

The 83rd annual general meeting of the Iron and Steel Institute was held in London on Wednesday and Thursday of this week, April 30 and May 1. At the outset of the proceedings, the retiring President, Mr. R. Mather, occupied the chair. After the presentation of the report of Council and statement of accounts for 1951, the Bessemer Medal for 1952 was presented to Mr. H. H. Burton, C.B.E., of the English Steel Corporation, Limited, for his services to the steel industry and to metallurgy, with particular reference to the development of alloy steels and heavy forgings. The Sir Robert Hadfield Medal was presented to Dr. L. Reeve, of the Appleby-Frodingham Steel Company, in recognition of his contributions to the science and practice of metallurgy, and, in particular, his researches on the weldability of low-alloy steels. The Williams Prize was presented jointly to Mr. J. A. Bond, of the Appleby-Frodingham Steel Company, and Mr. T. Sanderson, of the Workington Iron and Steel Company, for their paper, "Full-Scale Blast-Furnace Trials." The President also presented a cheque to Mr. A. R. Elsdon on behalf of the Council and members of the Institute and stated that Mr. Elsdon had been nominated to be an honorary member of the Institute in recognition of his services as librarian, extending over nearly 48 years. The Council was also proposing to arrange for a portrait of Mr. Elsdon to be painted and hung in the library. At the conclusion of the business of the meeting, Mr. Mather inducted the new President, Captain H. Leighton Davies, C.B.E., into the chair, and, in doing so, recalled his great services to the iron and steel industry and to the Institute, and his many contributions to public life in South Wales. After a vote of thanks to the retiring President, proposed by Captain Leighton Davies and seconded by Dr. J. W. Jenkin, had been received with acclamation, the new President delivered his presidential address, which began with the development of the tin-plate industry from its beginning and concluded with a description of the cold reduction plant at Trostre. The remainder of the morning was devoted to the delivery of the sixth Hatfield Memorial Lecture, on "The Flow of Metals," by Professor E. N. da C. Andrade, D.Sc., F.R.S. The afternoon of that day, Wednesday, April 30, and the whole of the following day, were given over to the reading and discussion of papers. With these we intend to deal in our next and subsequent issues.

The Centenary of Samuel Osborn and Company, Limited.

On April 1, 1852, Samuel Osborn set up in business at 180, Broad-lane, Sheffield, as a manufacturer of files. He was only 26 years of age, but he had acquired a useful knowledge of small tools with two Sheffield firms and possessed, moreover, a sound business sense, great confidence in himself and an equal capacity for hard work. On April 25, 1952, at the Royal Victoria Hotel, Sheffield, his successors and a party of nearly 400 guests celebrated the centenary of the business that he founded, which has been known all over the world for fully three-quarters of a century for steel—especially Mushet self-hardening steel and the numerous developments of it, but also castings, forgings, wire, sheet, strip, etc., of special qualities and specifications for particular duties. The guests were received by Mr. Frank A. Hurst, the chairman and managing director of the company, who also presided at the banquet. It was a matter for general regret that Sir Samuel Osborn, J.P., the second son of the founder, and chairman of the board from 1936 to 1948, who is now 87 years of age, was unable to be present; but arrangements had been made to relay the speeches to him at his home in Grindleford. The toast of "Samuel Osborn and Company" was proposed by the Rt. Rev. the Lord Bishop of Oxford (Dr. K. E. Kirk), whose father, the late Mr. Frank H. Kirk, was secretary of the company, and a director, from 1905 until his death in 1916. The Bishop of Oxford was able, therefore, to recall many personal anecdotes of the founder and his associates in the business, in which he was supported by the Rev. George Osborn, M.A., another of the family. Mr. Hurst, who responded, disclosed that Sir Samuel Osborn had marked the centenary by making over "a large block of ordinary shares in the company to be held upon trust for the welfare and benefit of the employees and former employees of the firm and its subsidiaries." Mr. A. S. Pye-Smith, who has been a director for the past 47 years, then called upon Mr. Percival Phillips (secretary, 1937-47) to open a box which, as a young order clerk, he had helped to seal on the occasion of the firm's jubilee in 1902. The souvenirs contained in it—contemporary newspapers and other documents, etc.—were removed (to a running commentary by Mr. Phillips) and were replaced by others, including *Pioneers for a Century*, the centenary history compiled by Mr. T. A. Seed. The box was then re-sealed, with the aid of Mr. W. R. Snow, chairman of Samuel Osborn (South Africa), Limited. It is to remain sealed until the year 2002. Included in the new contents was a gold nugget, with suitable inscription, presented by the South African company.

ROYAL AERONAUTICAL SOCIETY AWARDS.

The Council of the Royal Aeronautical Society have announced the following awards: the Society's Gold Medal, the highest honour that the Society can confer, to Professor T. von Kármán, Hon. F.R.Ae.S., for work in aerodynamic theory; the Silver Medal to Dr. H. Sutton, F.R.Ae.S., for work over many years on metallurgy in aircraft design; the Bronze Medal to Mr. H. Povey, A.F.R.Ae.S., for work on the production of the Comet; the British Gold Medal, awarded for practical achievement leading to advances in aeronautics, to Mr. G. R. Edwards, F.R.Ae.S., for work in aircraft design; and the British Silver Medal, for practical achievement leading to advances in aeronautics, to Dr. D. M. Smith, M.I.Mech.E., F.R.Ae.S., for contributions to the development of British gas turbines. The Wakefield Gold Medal, awarded to the designer or inventor of apparatus to promote safety in flying, was awarded to Mr. J. Martin, O.B.E., F.R.Ae.S., for work on ejector seats; the George Taylor (of Australia) Gold Medal, for the most valuable paper presented to the Society during the previous session, to Mr. W. Tye, O.B.E., F.R.Ae.S., for a paper on "Modern Trends in Civil Airworthiness Requirements"; the Simms Gold Medal, given for the most valuable paper presented to the Society on any subject allied to aeronautics, to Mr. H. H. Gardner, F.R.Ae.S., for a paper on "Structural Problems in Advanced Aircraft"; the Herbert Akroyd Stuart Memorial Prize, for the most valuable paper presented to the Society on applied thermodynamics, to Dr. J. Seddon, A.F.R.Ae.S., for a paper on "Air Intakes for Gas Turbines"; and the Edward Busk Memorial Prize, for the most valuable paper presented to the Society on applied aerodynamics, to Mr. H. Davies, F.R.Ae.S., for a paper on "Some Aspects of Flight Research." The medals and prizes will be presented at the 40th Wilbur Wright Memorial Lecture, to be given on Thursday, May 29, at the Institution of Civil Engineers.

THE INSTITUTE OF FUEL.

The newly-elected President, Dr. G. E. Foxwell, took the chair at the annual luncheon of the Institute of Fuel, which was held at the Connaught Rooms, London, W.C.2, on Thursday, April 24. In proposing the toast of "The Guests," he recalled that, at the outbreak of war in 1939, when the Institute was 12 years old, the membership was about 1,000, whereas it was now four times that total and included representatives of all the fuel-producing and fuel-consuming industries. Too much attention, he considered, was being devoted to the rival claims of coal, gas, electricity and other interests when what was really required was vigorous action to formulate and apply a national fuel policy. He regretted that, among the members of the Ridley Committee, which the Government had set up to deal with that question, there appeared to be no recognised fuel technologist. Sir John Hacking, deputy chairman of the British Electricity Authority and President of the Institution of Electrical Engineers, who responded, said that, to deal with the present fuel and power position, there were only three courses open, namely, to produce more coal, to develop other sources of energy as quickly as possible, and to use the available energy more efficiently. The Severn barrage scheme was being re-examined and was probably economically sound. At least 20 to 30 years—possibly considerably more—must elapse before atomic energy could supplement coal to any appreciable extent.

BRITISH ELECTRICAL INDUSTRY AND COLONIAL DEVELOPMENT.

A procedure which has certain points in its favour was adopted at the annual luncheon of the British Electrical and Allied Manufacturers' Association, held at the Connaught Rooms, London, W.C.2, on Thursday, April 24. As the Secretary of State for the Colonies (the Rt. Hon. O. Lyttelton) had an engagement in the early afternoon, the speeches were delivered before instead of, as is customary, after the meal. In proposing the toast of "The British Electrical and Allied Manufacturers' Association," Mr. Lyttelton said that he was deeply touched to receive an invitation from those who had not only seen him, but had heard him speak. He knew a good deal about them and, as a potential customer for some 100 MW of plant, he warned them that he should examine their tenders with all the attention of a poacher turned gamekeeper. Before coming to his present office he had not grasped the full extent of the possibilities of colonial development; and in no field of this development was there a greater prospect of good than in the harnessing of power. Apart from the great Volta River scheme, there were in East Africa the Owen Falls scheme and other projects in West Africa, Nigeria, and on the Zambesi. Further schemes were under consideration in Malaya, Cyprus, Malta and in the West Indies. These were really fascinating projects which ought to fire the imagination of all present. The President (Sir George Nelson) replied.

INSTITUTION OF CHEMICAL ENGINEERS.

When proposing the toast of the Institution of Chemical Engineers at the annual dinner of the Institution, held at the May Fair Hotel, London, on April 25, Lord Woolton, C.H., Lord President of the Council, claimed that the Salters Company, founded in 1320 and of which he was Master, were the first chemical engineers in this country. We in Great Britain, he continued, had remained in the forefront in the realm of fundamental science, but, as had been the case with synthetic dyes, penicillin, and a number of organic fibres, we had allowed our discoveries to be developed in other countries. It was of very great importance that industrialists should have scientists on their works staffs and that they should make use of the scientific knowledge, now so freely available, to improve their products. The President, Sir Harold Hartley, K.C.V.O., C.B.E., M.C., D.C.L., F.R.S., in his response to the toast, said that the Institution welcomed Lord Woolton in his capacity of Chancellor of the University of Manchester, where arrangements had just been made to appoint a professor of chemical engineering. Later in his remarks, Sir Harold mentioned that he had recently attended the inaugural meeting of the South African branch, the first overseas branch of the Institution. In South Africa, he added, the demand for chemical engineers vastly exceeded the supply, but in point of fact, this was also true of Great Britain and many other countries. Following his speech, Sir Harold presented the Osborne Reynolds Medal to Dr. F. A. Freeth, O.B.E., F.R.S. The toast to the guests was proposed by Mr. F. Fraser Ross, chairman of the graduates and students' section of the Institution, who stated that during the session September, 1951, to May, 1952, the section, numbering 1,200 members, would have held 50 meetings. He thanked the Council not only for giving the section a large measure of autonomy, thus enabling them to run their own affairs, but also for maintaining a high standard for entry into the membership of the Institution. In his response to this toast, Dr. John Rogers, O.B.E., said that Canada was dependent on chemical engineers for much development work and that suitably qualified men from the United Kingdom were always welcome in the Dominion. At the conclusion of the evening, Sir Harold Hartley inducted his successor, Mr. Stanley Robson, M.Sc., D.I.C., F.R.I.C.

LETTERS TO THE EDITOR.

PROTECTION OF FLAME-ZONE WALLS.

TO THE EDITOR OF ENGINEERING.

SIR,—In many modern combustion processes, it is necessary to form a flame within the confines of a cylindrical or other structure. It is sometimes necessary to use special materials or special methods of cooling, as for example, in rocket motors, gas-turbine combustion chambers, etc. The flame tube may be metallic, provided a source of cooling fluid for the outside of the tube exists. Alternatively, refractory materials may be used to line the flame tube, and in this case a higher surface temperature may be permitted; consequently, the degree of cooling is very much reduced.

For gas-turbine combustion chambers a so-called "louvred" design is described in the patent literature. The cylindrical portion of the flame zone is composed of a series of frusta of cones, each frustum being set apart from its neighbour by a small distance. Between the gaps, cooling air flows in a laminar stream, cooling the cone material across its depth. Akin to the louvred principle of cooling is the porous refractory, the pores of the refractory admitting a cooling fluid into the combustion space. Porous refractories, however, suffer from a tendency to clog with solid impurities, either from the combustion gases or from the cooling medium. An alternative is to take a conventional close-structure material and to perforate the material with small holes regularly placed, the axes of the cylindrical holes being in the radial direction, i.e., inwards towards the flame. Along these holes the cooling medium may be pumped.

To give an example of what is possible, a refractory material perforated with $\frac{1}{32}$-in. diameter holes has been examined, the holes lying in equilateral triangular pitch of 14 holes per inch. Estimates made for a gas-turbine combustion chamber suggest that, for moderate sizes of chamber, the inside wall temperature can be limited to 1,200 deg. C. At a depth of $\frac{1}{4}$ in. this would be reduced to about 400 deg. C. by the cooling effect of the diluent air. Such a structure might have several distinct advantages over the others mentioned above.

Yours faithfully,
I. G. BOWEN.

The Shell Petroleum Company, Limited,
St. Helen's Court,
Great St. Helen's, London, E.C.3.
April 23, 1952.

HYDRAULIC LOCK.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. J. E. Stringer's article in your issue of April 25, on page 509, *ante*, contains ample evidence of "muck-lock," but there is no evidence of true hydraulic lock, i.e., no evidence that the spindle became free again after pressure was released, such as was produced by Dr. Sweeney in his experiments. Therefore, it is difficult to see how this can be regarded as "another explanation" of hydraulic lock. However, apart from a misleading title, Mr. Stringer's research will be of considerable interest to hydraulic engineers, who are mainly concerned with preventing lock of any kind. It does suggest that "muck-lock" may be ten times more severe than hydraulic lock.

In these experiments, the $\frac{5}{8}$-in. spindle had a radial clearance of 0·0005 in. or a potential diametral clearance of 0·001 in., which is comparatively large and would permit sizeable particles of dirt to become lodged in the clearance. With such conditions, dirt becomes the major factor producing lock and, even if hydraulic lock co-exists with it, it will be difficult to distinguish. Further research on these lines with the radial clearance reduced to 0·00005 in. might prove very useful and informative.

Yours faithfully,
for Towler Brothers (Patents), Limited,
F. H. TOWLER,
Director.

Electraulic Works,
Rodley, near Leeds.
April 28, 1952.

LEONARDO DA VINCI, THE ENGINEER (1452-1519).

By K. R. GILBERT, M.A., D.I.C.

IN the Leonardo da Vinci Quincentenary Exhibition at Burlington House, London, there are 106 drawings illustrating Leonardo's work in the field of natural science and technology. They represent, however, only a small fraction of the material available; there are extant some 5,000 pages of notes written over a period of 30 years. To turn through the pages of the *Codice Atlantico*, which contains some 1,700 drawings, is a fascinating experience and one is astonished by the wide range of Leonardo's interests and by the great variety of ingenious machines and devices which he has depicted. In the notebooks there are machines for excavating and dredging canals, bridges, mathematical and surveying instruments, war machines of all sorts, textile machinery, furnaces, machine-tools, cranes and jacks, various kinds of gears, divers, studies of the flow of water, pumps, flying machines, printing presses and town-planning schemes: a list which is by no means exhaustive. Moreover, engineering topics are often treated on the same page as notes on painting, anatomy and botany and drafts of letters, prophecies, and lists of things required for his household.

Although we think of Leonardo principally as an artist whose genius extended into other spheres, his primary occupation after he migrated to Milan in 1481 was engineering in the broadest sense. The small number of pictures that he painted after this date does not account for his time and we must go to the notebooks to see how he spent it. He was apprenticed to Verrocchio, painter, sculptor and goldsmith—an accomplished master of many crafts, and must have learned there the workshop techniques of the day. He doubtless knew in Florence such men as Toscanelli, the physicist, and L. B. Alberti, the artist, architect and scientist. The well-known letter to Lodovico Sforza, the Duke of Milan, written at the age of 29, and contained in the *Codice Atlantico*, in which Leonardo offered his services and stated his abilities, reveals, nevertheless, a surprising acquaintance with military engineering. That his claims were no idle boast is shown not only by his notebooks, but by the willingness, which he expressed in his letter, to demonstrate anything which did not appear to be feasible. This letter has been quoted many times and it is perhaps sufficient to say that, after nine paragraphs in which he described in some detail his qualifications as a military engineer, Leonardo stated that he could give perfect satisfaction as an architect and "in guiding water from one place to another," and then added, almost as an afterthought, "I can carry out sculpture in marble, bronze, or clay, and also I can do in painting whatever may be done, as well as any other, be he who he may."

In 1498, the Duke appointed Leonardo city engineer of Milan, when one of his duties was to join the Grande and Martesana Canals. In this connection he rebuilt the San Marco lock (Fig. 1, Plate XXIII), and there is good ground for believing that he invented the mitred lock-gate.* Before his time, the lock-gate was a panel supported in grooves, which was raised vertically in the manner of a portcullis. When the gate was raised, there was only a restricted headroom for shipping. The sluice, by which water is admitted before opening the main gates, was also probably invented by Leonardo. By hinging it near the middle he could restrain it by quite a small force. In the drawing there is a plan of the lock, a cross-section showing the side walls and floor, and a plan of the sluice with the water shown streaming through. Leonardo's work as general engineer in Milan ranged from the design of equipment for the Duchess's bathroom to a scheme to relieve overcrowding in Milan by the creation of satellite towns. His model cities were to have streets on two levels, the lower system to be used for commercial traffic.

Later, in 1502, Leonardo found employment as chief engineer in the service of Cesare Borgia, who commissioned "Our highly esteemed court architect Leonardo da Vinci . . . to inspect the fortresses and strongholds of our states and to make such alterations and improvements as he may think needful. . . . We desire that every engineer may be prepared to further any undertaking which he (Leonardo) may find necessary."

On his return to Florence, Leonardo was engaged in a scheme to canalise the Arno, designing many cranes, and excavating and dredging equipment. Fig. 2, on Plate XXIII, shows a double crane for removing material when digging a canal. The bucket is raised by the descent of a platform under the weight of an ox, which is then driven up the ramp to repeat the journey. Leonardo even calculated the saving in distance walked by the ox by using the spiral ramp, which is drawn below. The crew of each crane consisted of eight men: four to load the bucket, two on the bank to unload it, and two in charge of the ox.

LEONARDO DA VINCI: SELF-PORTRAIT (*c.* 1510) IN THE ROYAL LIBRARY, TURIN.

To form a just estimate of Leonardo's technological achievement it is necessary to consider the tradition of technology which existed in his day. It is recorded in the writings of such men as Konrad Kyeser and Giovanni Fontana. The first printed book on a technical subject was Roberto Valturio's *De Re Militari*, which appeared in 1472 and which Leonardo knew, since it occurs in what is probably a list of the books in his possession. Fig. 11, on page 561, showing a car propelled by "windmills," is reproduced from this book and is a typical example of a Fifteenth Century technical illustration. The technical level of the time may be gauged from the fact that, as late as 1555, it was thought worth while to republish Valturio's book.

The method of boring out logs by hand to make pipes and pump-barrels, as illustrated by Agricola in 1556, had, by 1661, been improved by the application of power to the drill, as shown in Böckler's book* (Fig. 10, Plate XXIV); but the log was still held in place by wedges. In Leonardo's remarkable boring machine (Fig. 8, Plate XXVI) the log is fixed in position by the use of two connected self-centring chucks. An outer cylinder, to which the handles are attached, has toothed rims which engage with threaded cog-wheels. When these wheels are rotated, they cause the jaws simultaneously to open or close. In this invention Leonardo was hundreds of years ahead of his time.

Some of Leonardo's sketches, such as those of flour mills and "waywisers," record existing devices and are to be met with in earlier manuscripts. Leonardo was very interested in diving equipment and drew many divers, most of them with an air-tube to the surface as in the sketches of earlier writers. Fig. 3, Plate XXIV, however, shows two divers in self-contained diving suits. The same page contains notes relating to a submarine attack, and drawings of a tool with which a plank can be forced from the bottom of an enemy ship. Leonardo had qualms about the use of such devices, for he wrote "How and why I do not describe my method of remaining under water for as long as I can remain without food, and this I do not publish or divulge on account of the evil nature of men, who would practise assassinations at the bottom of the seas by breaking the ships in their lowest parts and sinking them together with the crews who are in them."

The printing press was already known in Leonardo's time, but he tried to improve it by adding an automatic feed. He improved the ballista in details and envisaged the construction of one of immense size. It used to be thought that he added the flyer to the spinning wheel, which, by winding the thread, as it is spun, on to a bobbin, makes spinning a continuous process. This important invention can hardly be due to Leonardo, since it is to be found in the *Hausbuch* of Waldburg, a German manuscript of 1480. His machine does, however, provide a means of distributing the yarn along the bobbin, a function which does not reappear in spinning machinery until Arkwright's second machine of 1775. This example shows the danger of inferring the invention of a machine by Leonardo from its portrayal in his notebooks. It may accordingly be prudent to say of his treadle lathe no more than that it is the earliest known representation of a lathe in which the work is rotated continuously.

While it is clear that, in many cases, Leonardo merely improved existing machines, his notes, taken as a whole, give an overwhelming impression of inventive genius. It is probably safe to concede originality to those devices which, like the parachute and helicopter, were greatly in advance of their time.

One of Leonardo's most brilliant inventions is the screw-cutting machine (Fig. 4, Plate XXIV). In his use of lead-screws and change-wheels he anticipated the work of Henry Maudslay. It is interesting to observe that here, as in several of his drawings of machinery, Leonardo departed from correct perspective in order to show more of the machine than can be seen from one point of view. In this he was following the unintentional practice of earlier illustrators. (See Fig. 11, on page 561.)

* *Engineers and Engineering in the Renaissance*, by W. B. Parsons (1939).

* *Theatrum Machinarum Novum*, by G. A. Böckler (1661).

ENGINEERING DESIGNS OF LEONARDO DA VINCI.

(*For Description, see Page 560.*)

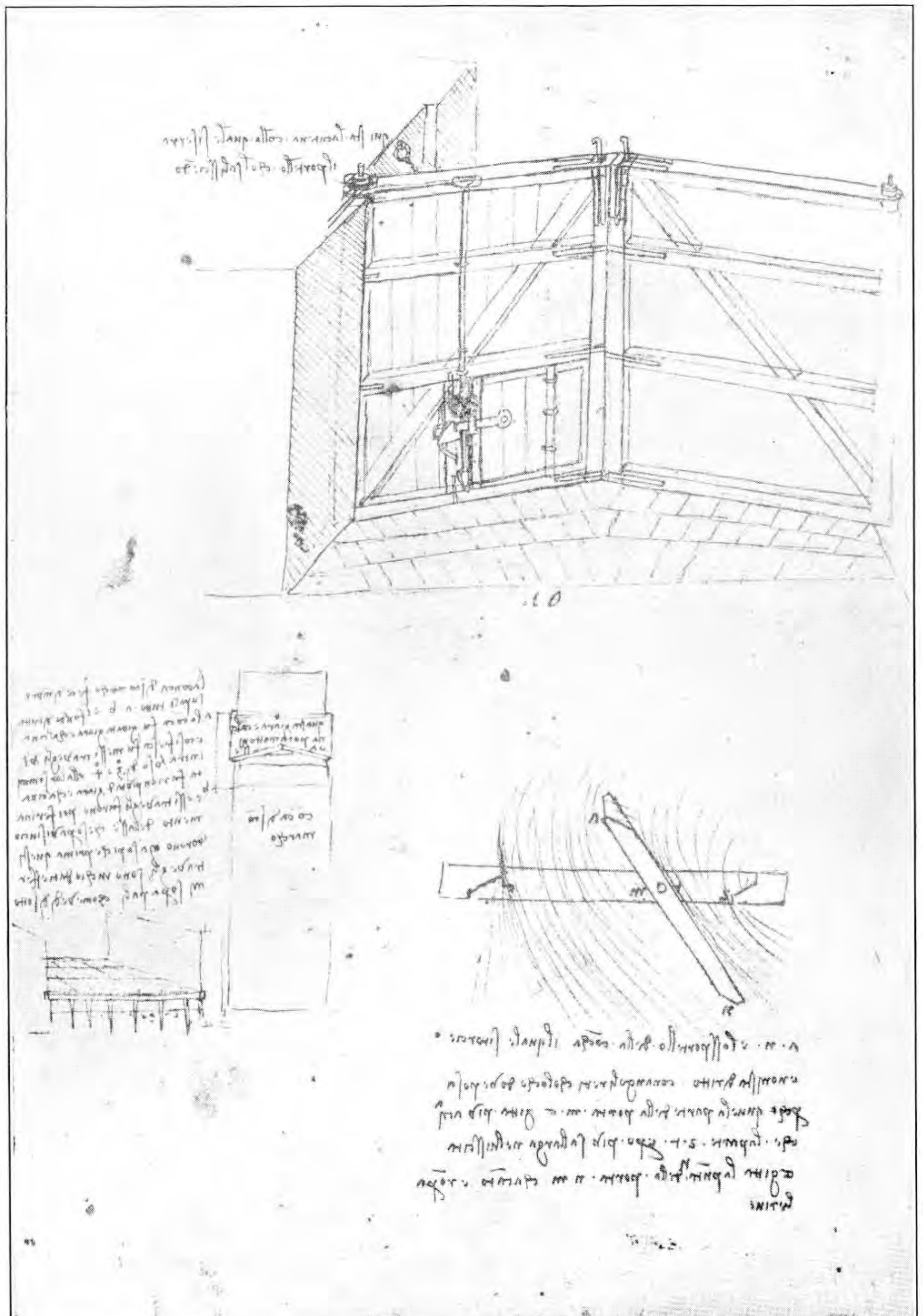


FIG. 1. MITRED LOCK-GATES.

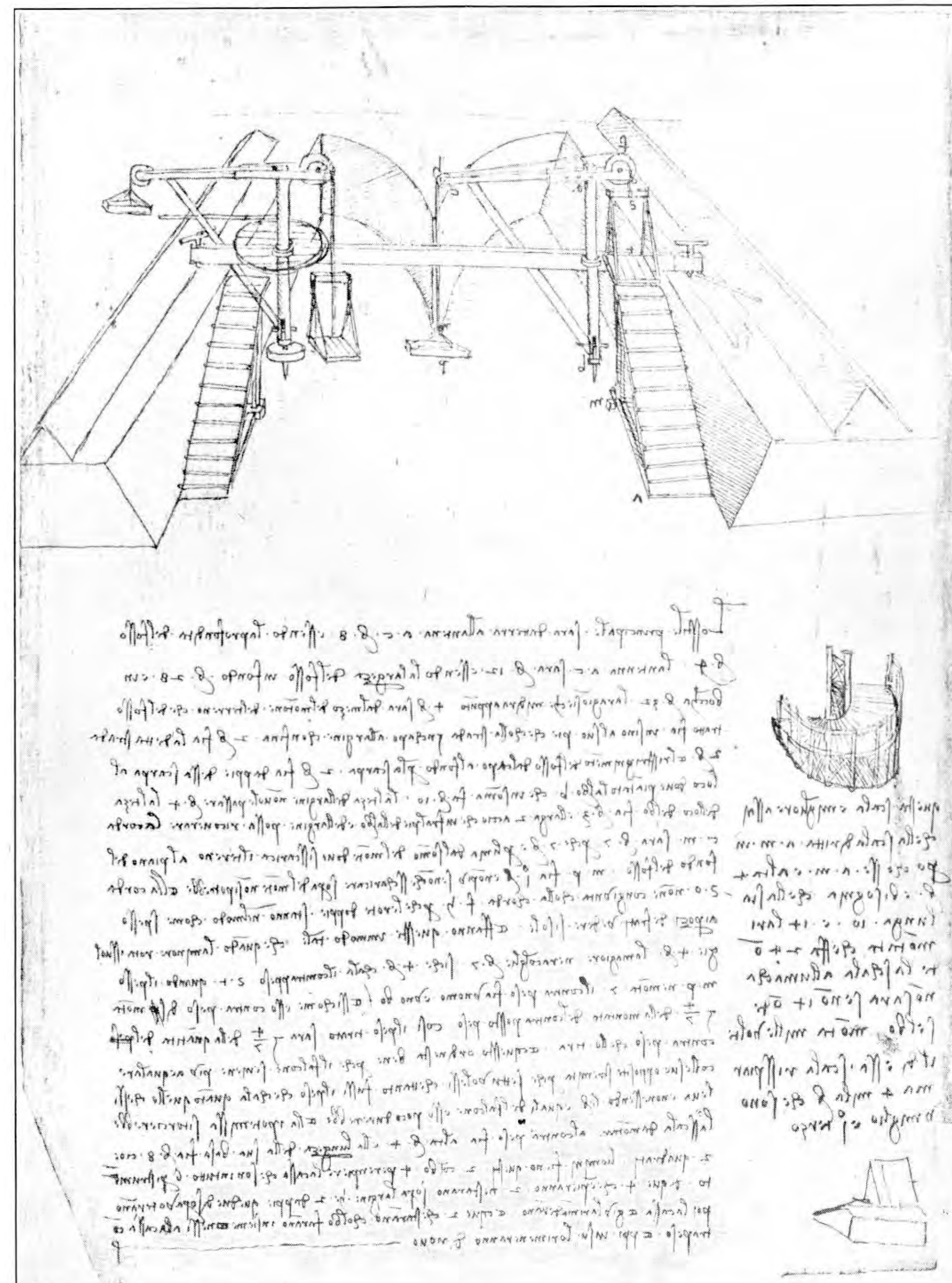


FIG. 2. CANAL CONSTRUCTION.

ENGINEERING DESIGNS OF LEONARDO DA VINCI.

(*For Description, see Page* 560.)

FIG. 3. DIVERS, AND DEVICE FOR SINKING SHIPS.

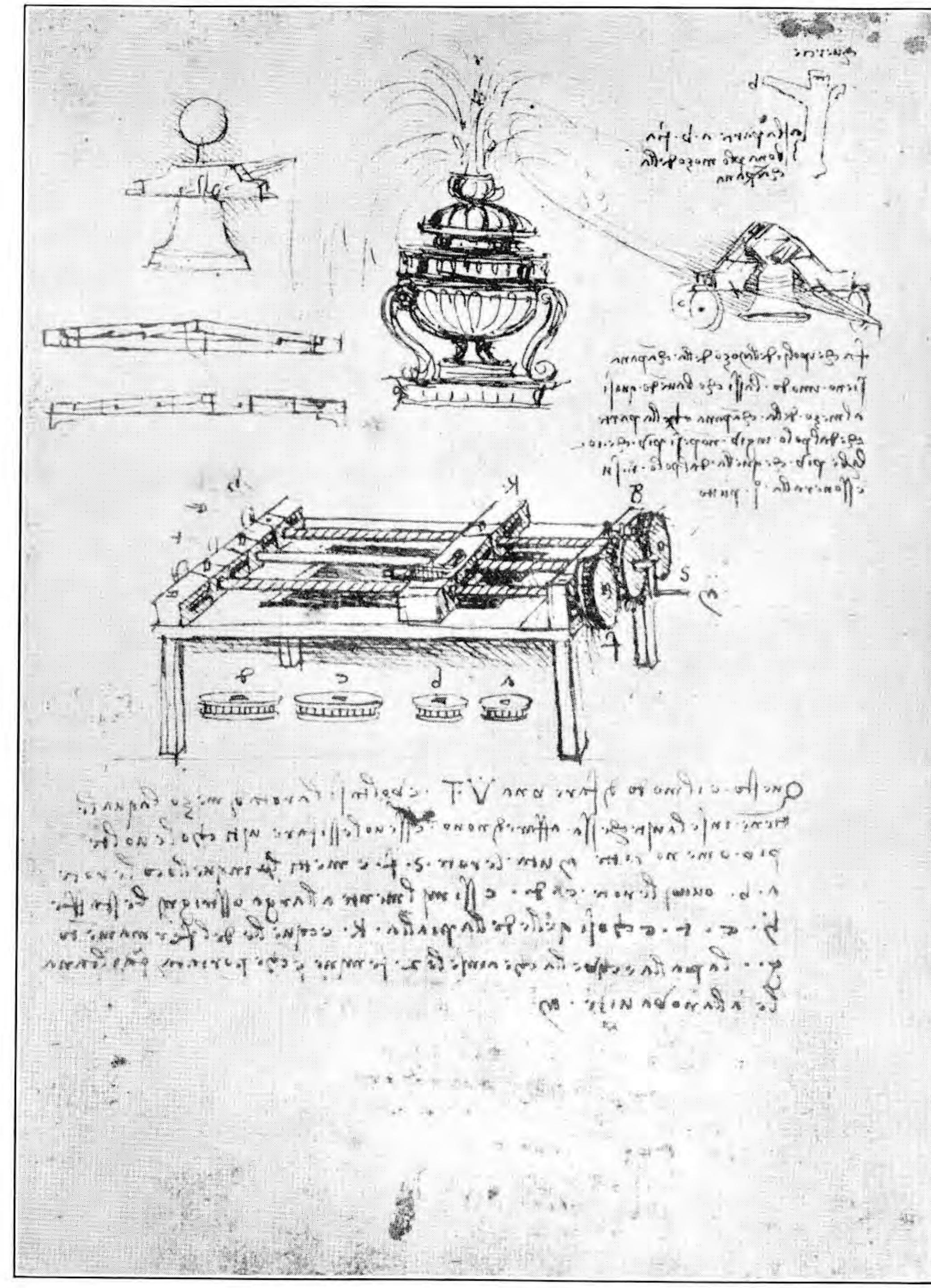


FIG. 4. SCREW-CUTTING MACHINE.

ENGINEERING DESIGNS OF LEONARDO DA VINCI.

(*For Description, see Page* 560.)

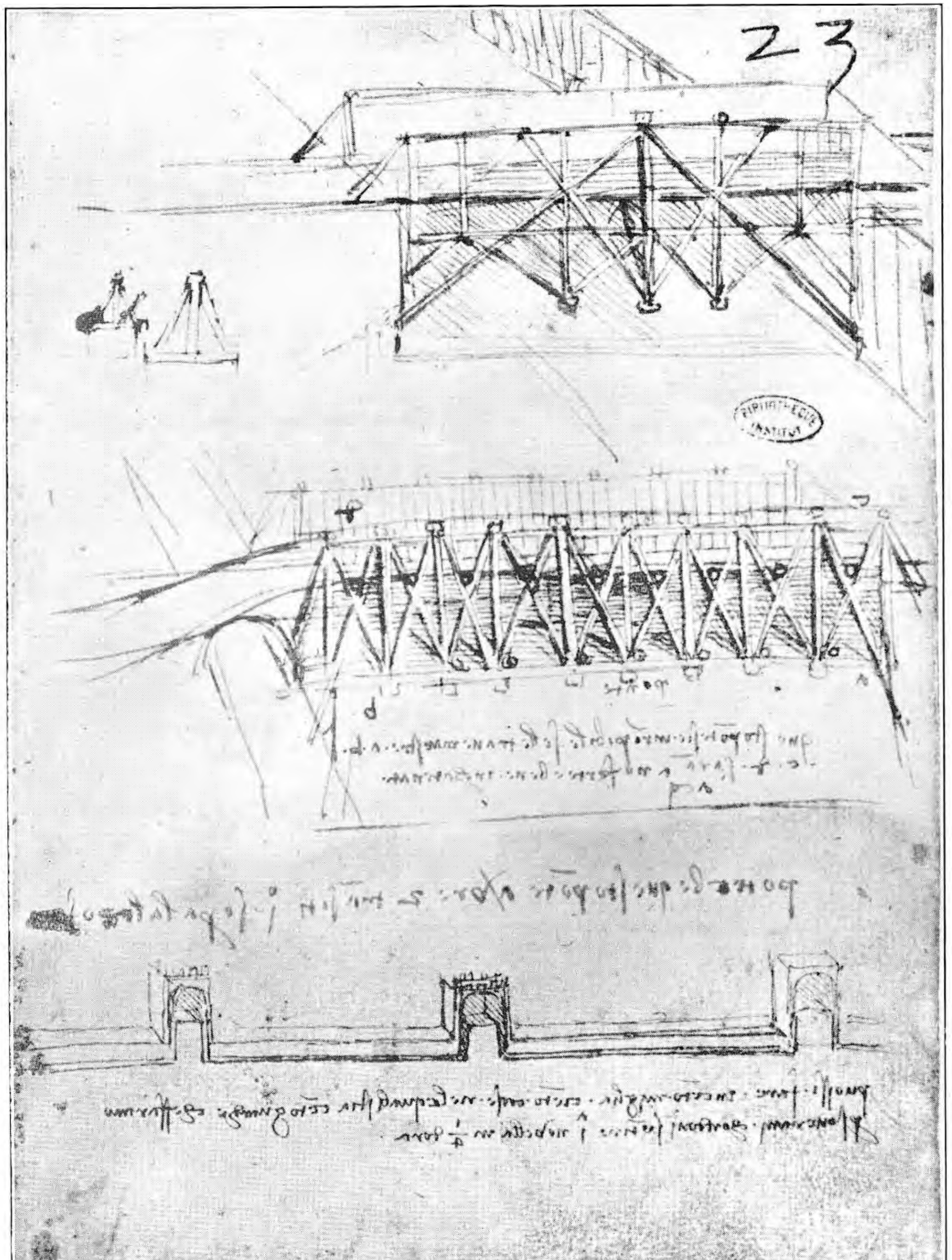


Fig. 5. Bridges.

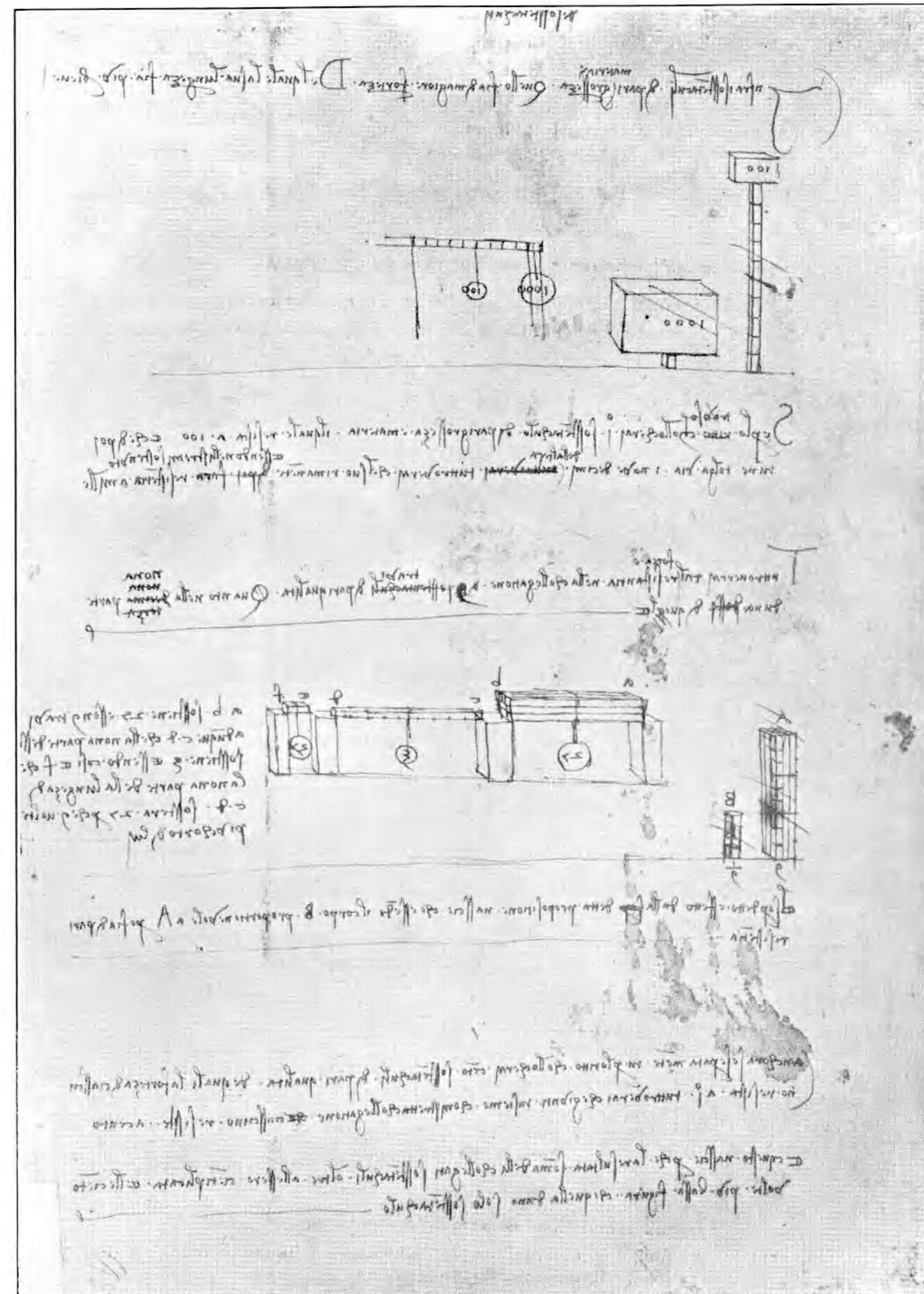


Fig. 6. Tests for Strength of Beams and Columns.

ENGINEERING DESIGNS OF LEONARDO DA VINCI.

(*For Description, see Page 560.*)

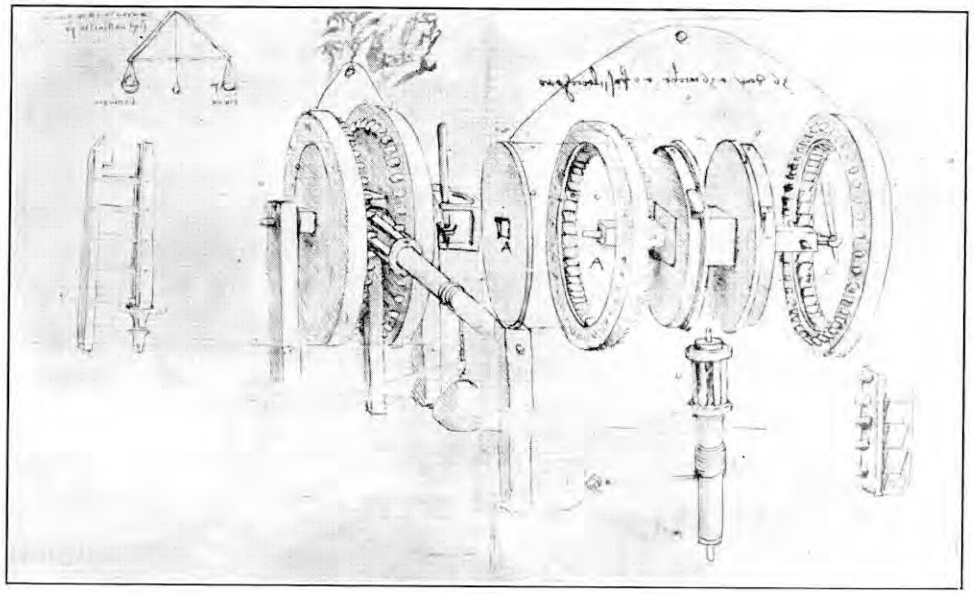


Fig. 7. Gearing.

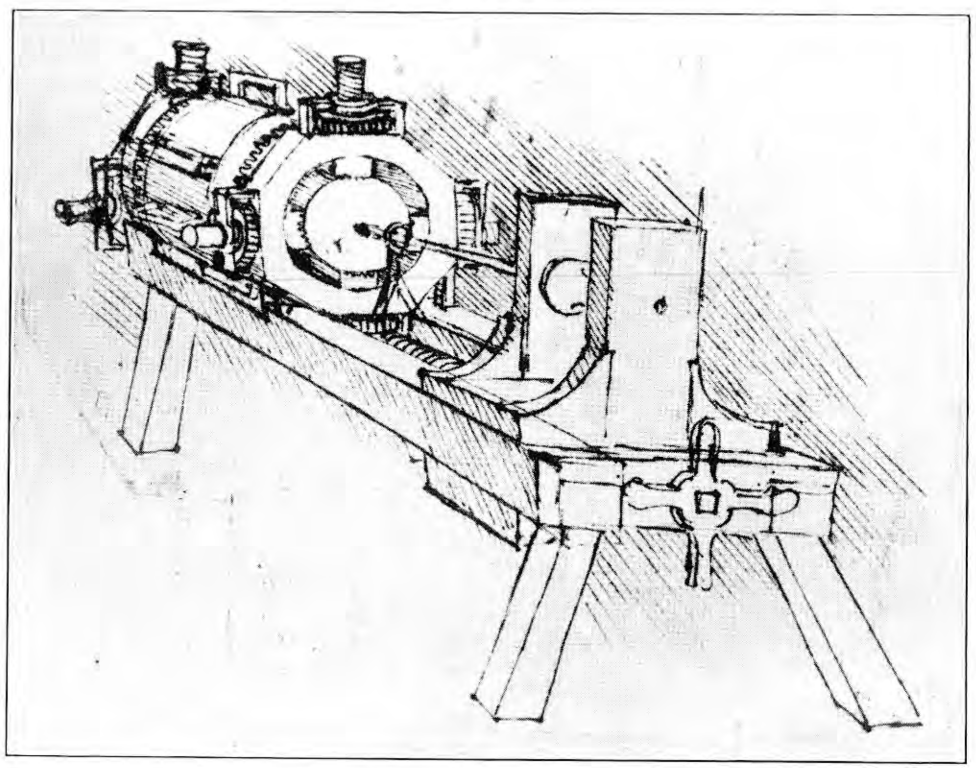


Fig. 8. Boring Machine.

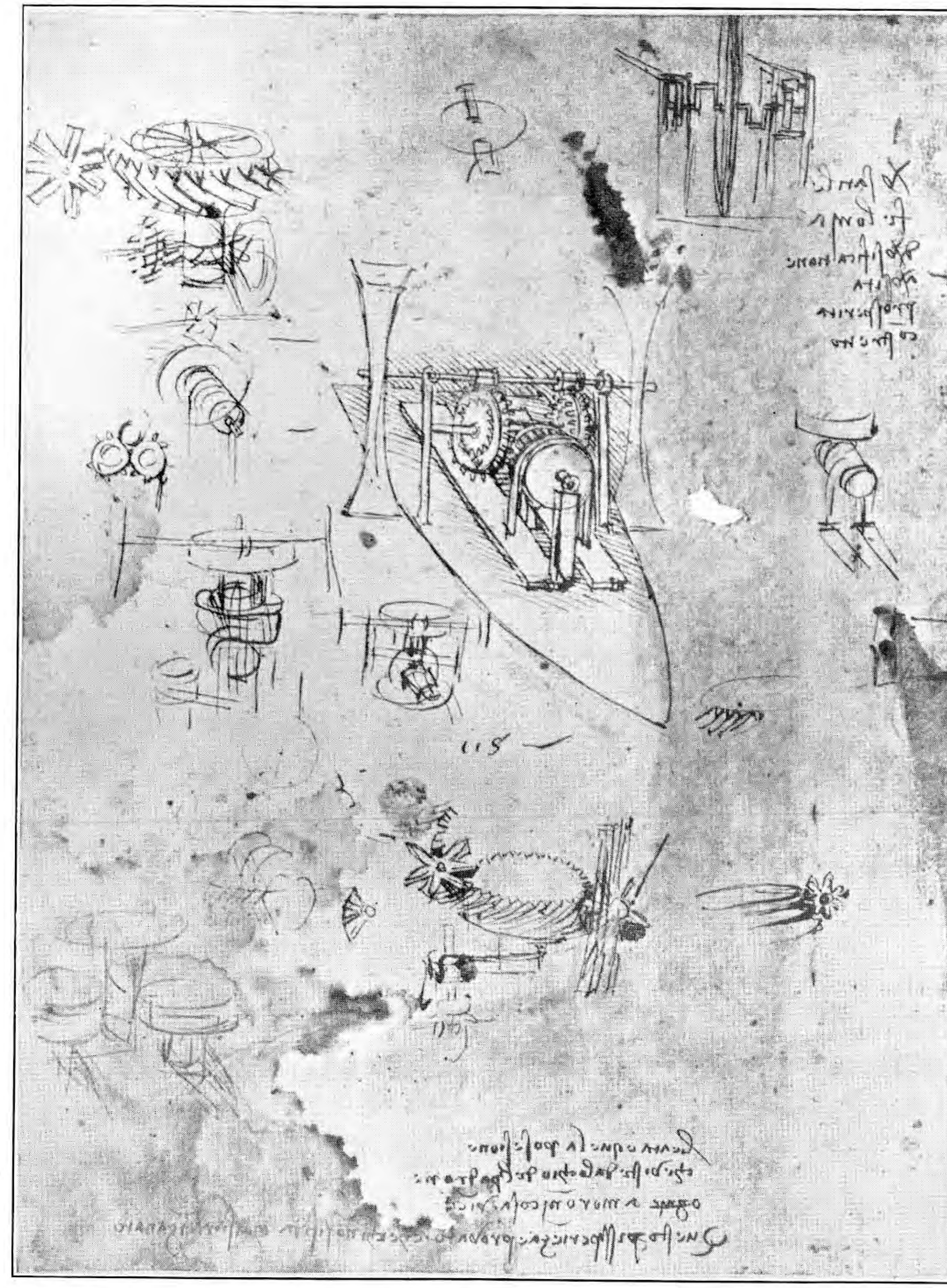


Fig. 9. Paddle-Boat, etc.

There is also an error of detail which gives a clue to the originality of the invention; Leonardo has incorrectly shown both lead-screws and the partially-cut blank with left-hand threads instead of with threads of opposite hand. It is difficult to believe that so abnormally acute an observer could have made this mistake, if he had been working from an existing model. It is easier to imagine that he set down on paper quickly and without attention to detail an original intellectual conception. The same consideration applies to the file-cutting machine, in which the first cuts are shown at the wrong end of the blank.

The central drawing in Fig. 5, on Plate XXV, is an excellent example of Leonardo's bridge designs. The use of an articulated truss enables a bridge to escape the limitation in length to that of the available timber. It is the earliest known illustration of a bridge of this construction. The strength of the structure is shown by the fact that the model-maker was able to walk over the 5-ft. model which was made for the Quincentenary Exhibition. The bridge is also original in having two roadways, one above the other.

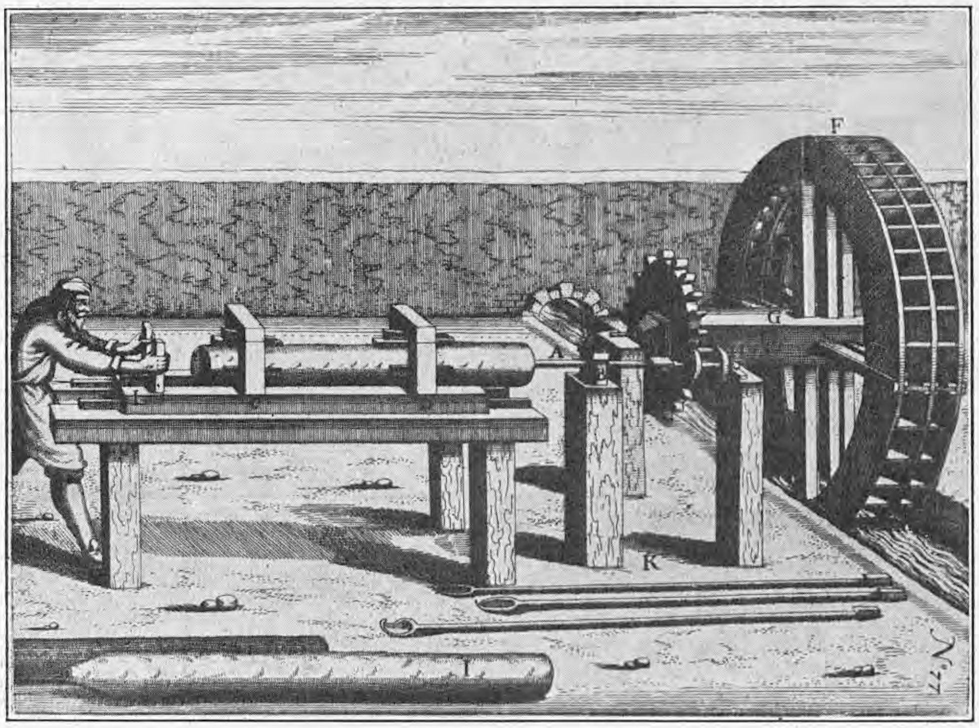


FIG. 10. BORING PUMP BARRELS.

Leonardo was, however, more than an ingenious inventor; he built on a basis of scientific knowledge founded on experiment. He was not willing to accept statements of authority which did not agree with his observations: "Many will believe," he wrote, "that they can with reason censure me, alleging that my proofs are contrary to the authority of certain men by their inexperienced judgments, not taking into account that my conclusions were arrived at as a result of simple and pure experience, which is the true mistress." His experiments had to be repeatable: "Before making this case a general rule, test it by experiment two or three times and see if the experiment produces the same effect." He studied friction and discovered its basic laws, and investigated problems on the strength of beams and columns (Fig. 6, Plate XXV). He also studied the strength of materials and described a well-conceived experiment to measure the tensile strength of wire.

Reuleaux* pointed out that the early mechanics regarded each machine as an irreducible whole and never analysed it into its components. Leonardo, however, studied the elements of machinery and, indeed, intended to write a book on the subject. He thus acquired a useful stock of mechanisms, which he was able to make use of in the design of particular machines. His notebooks contain numerous illustrations of gears, pulley systems, articulated driving-chains and tongs. On one page, Leonardo made a study of tilt-hammers and illustrated various methods of increasing the force of the hammer-blow and of raising the hammer after striking. To connect two shafts at right-angles he usually employed a contrate wheel and a lantern-wheel, as shown in Fig. 7, on Plate XXVI. He also drew helical gears, however, and was aware of the advantage provided by the wide contact in reducing wear and in giving smooth transmission.

The use of ratchet-wheels to enable a reciprocating motion of a handle to produce a rotary motion of a shaft was much favoured by Leonardo and is illustrated in Fig. 7. The mechanism is shown complete on the left and separated into its components on the right. Incidentally, the small diagram in the top left corner in Fig. 7 is a design for a hygrometer. A similar principle is used in the paddle-boat of Fig. 9, Plate XXVI, propelled by pressing the treadles alternately. A belt between the treadles passes round the lantern wheel. Ratches incorporated in the gearwheels ensure that the paddles revolve in the same direction, whichever treadle is pressed. In other paddle-boat sketches, Leonardo uses the simpler mechanism of cranks and flywheel,

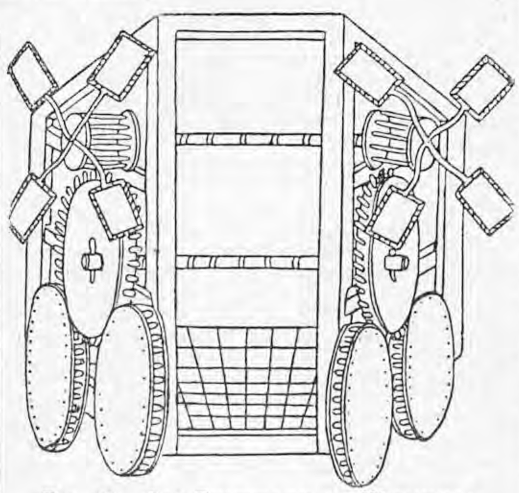


FIG. 11. CAR PROPELLED BY WINDMILLS.

as is shown in the upper drawing. His usual method of converting a rotary motion into reciprocating motion was to cause a follower to travel in the endless groove of a cylindrical cam.

(To be continued.)

* *Kinematics of Machinery*, by F. Reuleaux (1876).

PROPOSED NEW STANDARD LIMITS AND FITS.

IF, as seems likely, the proposed new British Standard on limits and fits for engineering is approved and issued substantially in the form in which it has been circulated for comment, it will provide a system which will meet the needs of engineering more comprehensively than the existing B.S. 164 : 1941. Considered as a whole, the new system is more complex than B.S. 164, but this is unavoidable, because B.S. 164 has proved to be quite unsuitable for many classes of engineering work. From the users' point of view, however, it will not be complex, since each industry will select groups of tolerances and fits which are sufficient for its purpose. The general background of the new system, which is based on the metric system of the International Standards Organisation, is dealt with in a leading article on page 556; here we are concerned with the system itself and what it will offer to the engineering industry.

Fundamentally, as might be expected, the system is simple. It covers sizes from 0·04 in. to 19·686 in. (though limits and fits for sizes above and below this range are being prepared by the I.S.O.), and this range is divided into 13 steps, e.g., 0·04 in. to 0·119 in.; 0·119 in. to 0·237 in.; 0·237 in. to 0·394 in.; etc. For each of these steps, there are 16 qualities of tolerance, known as fundamental tolerances, and designated IT. 1 to IT. 16. For example, the 16 fundamental tolerances for any nominal size within the step 0·237 in. to 0·394 in. are as given in the table below (expressed in units of 0·001 in.). It will be seen, therefore, that for a part which is nominally, say, 0·25 in. in diameter, there are standard tolerances ranging from as fine as 0·00006 in. to as coarse as 0·035 in. The larger the nominal size, the larger the tolerance; for example, with a component 12 in. in diameter, the designer can choose from tolerances which range from 0·00024 in. (IT. 1) to 0·130 in. (IT. 16).

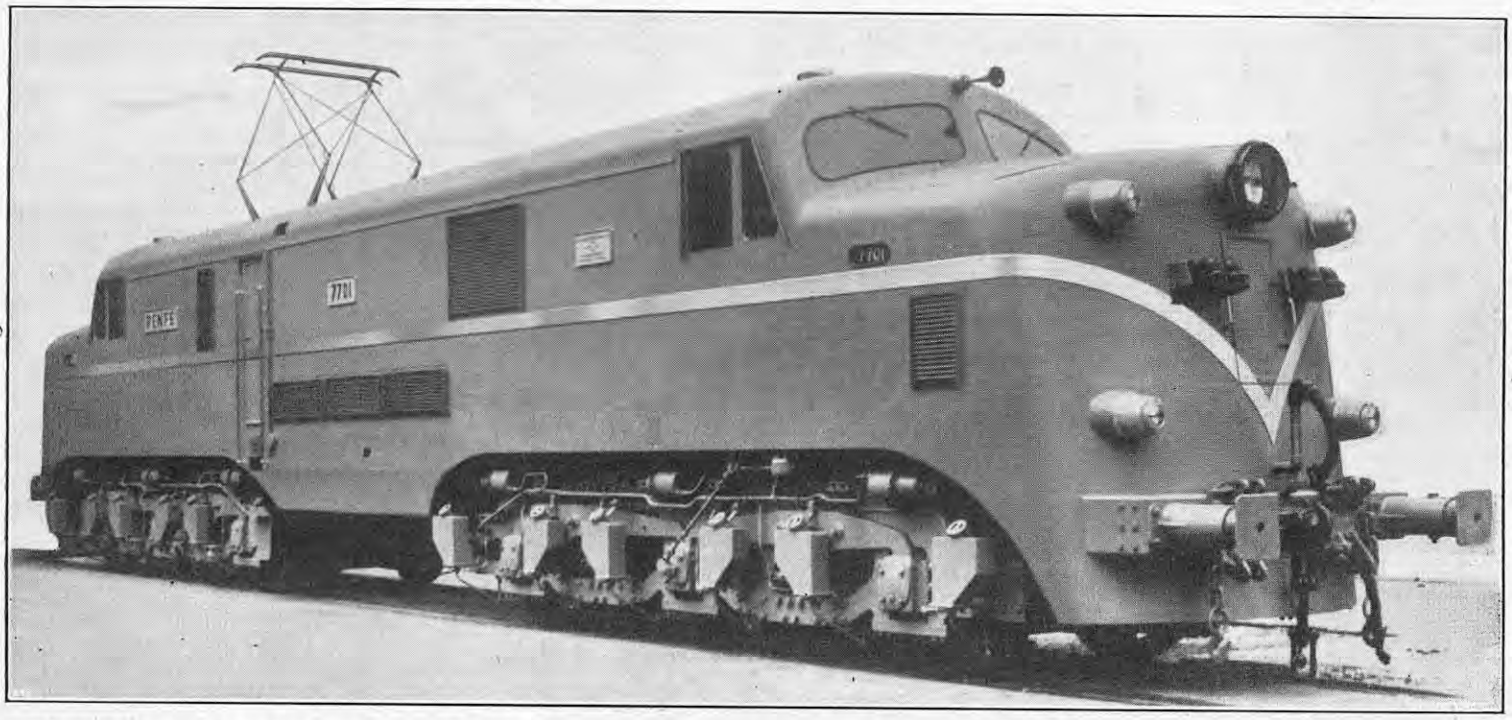
These fundamental tolerances are the difference between the low limit and the high limit in each case. Now with the new system, as with B.S. 164, the unilateral hole system is strongly recommended, which means that the low limit of the hole is exactly equal to the nominal size, the high limit is the nominal size plus the fundamental tolerance, and the positions of the high and low limits of the shaft in relation to the nominal diameter determine the class of fit, i.e., whether it is a clearance, transition, or interference fit. To express the conception another way: the tolerances on the shaft and hole decide the accuracy of manufacture, but the relation of the tolerance "band" (i.e., the zone of size between the high and low limits) of the shaft to that of the hole determines the class of fit; with the unilateral hole system the lower limit of the hole is made equal to the nominal size for convenience.

At this point in the new system, 21 different positions of the tolerance zone relative to the nominal size are provided, both for shafts and holes. These different positions are denoted by the letters A, B, C, D, E, F, G, H, J, K, M, N, P, R, S, T, U, V, X, Y, Z, for holes, and *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *j*, *k*, *m*, *n*, *p*, *r*, *s*, *t*, *u*, *v*, *x*, *y*, *z*, for shafts. With the unilateral hole system only H is used for holes, since H gives a tolerance-zone position such that the low limit corresponds to the nominal size and the high limit to the nominal size plus the tolerance. From A to G, the low limit is some amount above the nominal size, the amount being greatest for A and least for G; and from J to Z the tolerance zone is either wholly below the nominal size or straddles it. However, these 20 positions of the tolerance zone (i.e., all except H) would only be used for systems other than the unilateral hole system.

All general engineering requirements for holes will be met by H tolerance-zone positions, in conjunction with tolerance qualities IT. 6, 7, 8, 9, 10, and 11. Thus, for example, for nominal sizes from 0·237 in. to 0·394 in., the standard low limit being 0 in all cases, the high limits will be (in units

"IT." number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Fundamental tolerance ..	0·06	0·08	0·12	0·15	0·25	0·35	0·6	0·9	1·4	2·3	3·5	6·0	9·0	14·0	23·0	35·0

3,600-H.P., 3,000-VOLT ELECTRIC LOCOMOTIVE FOR SPAIN.



of 0·001 in.): + 0·35, + 0·6, + 0·9, + 1·4, + 2·3, and + 3·5, as obtained from the typical table already quoted for this size range. In general, the fine tolerance qualities IT. 1 to about 5 are intended for gauges and coarse qualities IT. 12 or 13 to 16 are not for fits.

Turning to shafts, and continuing to assume a unilateral hole system, almost all the tolerance-zone positions *a* . . . . *z* will be used, since it is these which give the various classes of fit. In general, the early symbols in the series (*a*, *b*, *c*, etc.) provide a tolerance-zone position well below the nominal size, thereby giving a free clearance fit; and the later symbols (*u*, *v*, *x*, *y*, *z*) provide positions well above the nominal size, corresponding to interference fits (assuming, in both cases, a unilateral hole system). Summarising the basis of the system, we may say there are three chief factors: firstly, the range of nominal sizes covered is divided into 13 steps; secondly, 16 qualities of tolerance are given for each step; and thirdly, 21 positions of the tolerance zone in relation to the nominal size are specified both for holes and shafts. Thus, any desired fit can be specified by two letters and two numbers, e.g., H7-*p*6, which signify, in order, the position of the tolerance and the tolerance quality for the hole, and the position of the tolerance and the tolerance quality for the shaft. The proposed standard recommends that the actual limits should be explicitly stated by one of the methods laid down in B.S. 308, but there are certain circumstances—for example, in general specifications, or on preliminary design drawings—in which it is convenient to be able to designate a particular type of fit by symbols only.

The proposed standard also deals with one other factor of great significance in engineering production, namely, preferred basic (or nominal) sizes. It will be appreciated that, quite apart from the advantage arising from standard limits and fits, there is as much, if not more, to be gained by confining the basic sizes used to a series of preferred sizes. Thus, for instance, for parts between 1 in. and 2 in. a designer would endeavour to select a size from the series $1\frac{1}{8}$ in., $1\frac{1}{4}$ in., $1\frac{3}{8}$ in., $1\frac{1}{2}$ in., $1\frac{3}{4}$ in. and 2 in.; only for some special reason would he turn to the second choice of preferred sizes in this range, i.e., $1\frac{1}{16}$ in., $1\frac{3}{16}$ in., $1\frac{5}{16}$ in., $1\frac{7}{16}$ in., $1\frac{5}{8}$ in. and $1\frac{7}{8}$ in.; and only in exceptional circumstances would he depart altogether from the preferred sizes. The proposed standard gives tables of preferred sizes in inches (decimals and fractions) and in the metric system, as well as the tables of limits and fits in inch and metric units. There are also appendices on the equivalent values of I.S.O. fits and those of B.S. 164 and the Newall system, and on rules relating to the method of converting the I.S.O. metric values to inch values. Copies of the draft B.S. 164; Part 1: 1951, are available from the British Standards Institution, 24, Victoria-street, London, S.W.1. Part 2 will give further guidance on tolerances for a wide range of fits.

3,600-H.P., 3,000-VOLT ELECTRIC LOCOMOTIVES FOR THE SPANISH NATIONAL RAILWAYS.

THE accompanying illustration shows the first of 60 3,600-h.p. direct-current electric locomotives, which are being built in this country for use on the northern section of the Red Nacional de los Ferrocarriles Españoles (the National System of Spanish Railways). The principal contractors for these units, which are intended for both passenger and freight haulage, are the English Electric Company, Limited, Queens House, Kingsway, London, W.C.2, and the mechanical parts of twenty of them are being built at their Preston works. The mechanical parts of the other forty, of which the locomotive illustrated is one, are being constructed by the Vulcan Foundry, Limited, Newton-le-Willows. The electrical equipment in all cases will be of English Electric manufacture.

As will be seen, the Co-Co wheel arrangement is being used and the locomotives are designed for employment on a running gauge of 5 ft. 6 in. The length overall is 67 ft. $9\frac{1}{4}$ in., the maximum width, 10 ft. 1 in., and the maximum height, with the pantographs lowered, 12 ft. $6\frac{3}{4}$ in.; the weight in running order is 118 tons. The body underframe consists of four rolled-steel channels, which are braced with cross members. The superstructure is also made up of channel members, which are welded together to form a frame of girder construction. This frame is attached to the underframe by welding and is panelled in steel sheet. The bogies are of the six-wheel bar-frame type and are braced by welded cross stretchers. The weight of the locomotive is transferred to the bogies through a fabricated bolster. This carries the bogie centre and rests on four nests of laminated springs, which are arranged at right angles to the centre line. These springs are supported on planks which are slung from the bogie frame by links. The bogie frames themselves are carried on four pairs of coil springs, which rest on equaliser beams. The axle journals are outside the wheels and the Timken roller-bearing axleboxes are fitted with manganese-steel liners bearing against liners of the same material which are fitted to the axlebox guides.

As will be clear from the illustration, the superstructure is streamlined and has a cab at each end. The equipment is arranged symmetrically between the cabs, there being first a 20-kW motor-generator blower, then two cubicles containing the main control equipment, and four frameworks in the centre for the main starting resistances. The doors of the compartments containing the high-tension equipment are interlocked and can only be opened when the pantographs are lowered. The power contactors, group switches and reversers are contained in steel cubicles and are electro-pneumatically operated. Each driver's cab is equipped with a cam-operated master controller which incorporates drums for power notching, motor-field weakening and regenerative braking. These drums are operated by separate handles. There is also a handle for operating the motor grouping switch when regenerative braking is being used. Incorrect operation is prevented by mechanical interlocking. The equipment in the cabs also includes the air and vacuum-brake handles, an instrument panel and an auxiliary-equipment board.

The locomotives are fitted with six traction motors, each of which has an output of 600 h.p. on a one-hour rating and of 500 h.p. at the continuous rating. The motors are of the forced-ventilated axle-hung nose-suspended type and drive the road wheels through single-reduction spur gearing. This gearing is enclosed in a welded sheet-steel case, which is supported from the motor frame. The pinion is shrunk and keyed on to the motor shaft and the gearwheel is pressed on to the axle. The gearwheel is designed so that there is a certain amount of torsional flexibility between the motor armature and the axle.

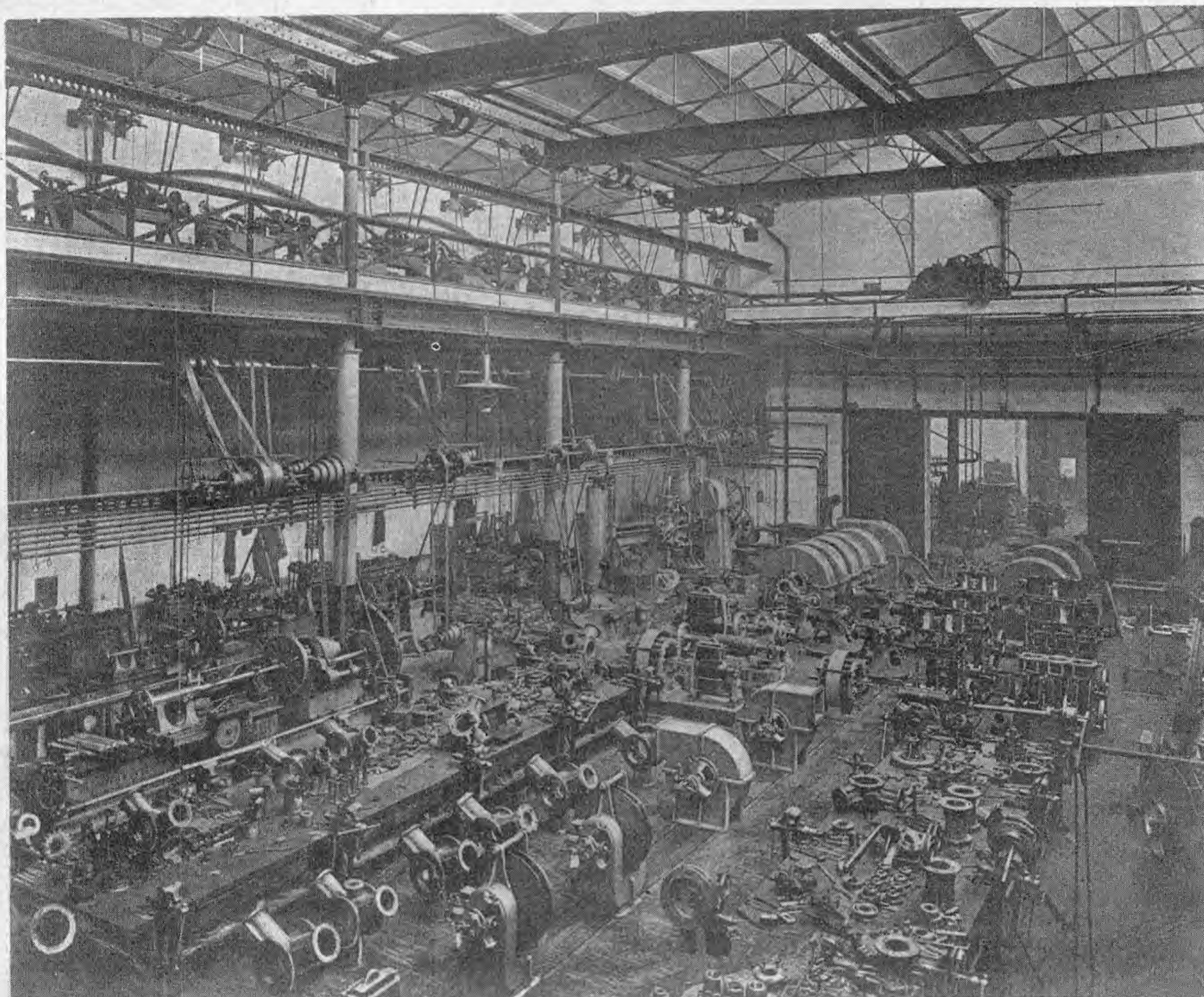
The auxiliary equipment includes two 20-kW motor-generator blower sets, each of which consists of a 3,000-volt motor driving a generator and a fan. These generators provide power at 110 volts for the auxiliary circuits, regenerative braking and battery charging. The fans supply cooling air to the traction motors. Compressed air for operating the control equipment and the locomotive brakes is obtained from two motor-driven air compressors, and there are two motor-driven exhausters for actuating the train brakes. An emergency supply for operating the low-tension apparatus can be obtained from a lead-acid battery.

Brake blocks are fitted on both sides of each wheel and give a braking power equal to 85 per cent. of the adhesive weight. As already mentioned, the locomotive brakes are of the compressed-air type and are controlled from the cabs by the same valves as operate the vacuum brakes of the train. They can also be controlled separately by a self-lapping valve. In addition, there are hand brakes, which are operated from a wheel in each cab and act on the adjacent bogie. Air-operated sanding gear is provided on all wheels and can be used in either direction of running.

B.O.A.C. ATLANTIC TOURIST SERVICE.—From May 1, British Overseas Airways Corporation are introducing the "Mayflower" fleet of five Constellation air liners, each with a capacity for 68 passengers, to operate across the Atlantic at "tourist" rates, approximately two-thirds of the corresponding standard fares. Between London-Boston-New York there will be, in the first place, one service a week in each direction; between London and New York, two services a week in each direction; and between London and Montreal, one service a week in each direction. After mid-June, the frequencies of these services will be doubled.

FOX TALBOT AND PHOTO-MECHANICAL ILLUSTRATION.

Supplement to ENGINEERING *July 20th 1883*



Sté Génle des Applications Photographiques — Phototypie — 7, Rue d'Argenteuil Paris

Mr. PETER BROTHERHOOD'S WORKS, LONDON

INTERIOR OF MACHINE SHOP

FOX TALBOT AND PHOTO-MECHANICAL ILLUSTRATION.

By Geoffrey D. M. Block.

The centenary occurred during the present week of an invention of far-reaching importance to the printing world. On April 29, 1852, William Henry Fox Talbot "did appear before our Lady the Queen in her Chancery," in the words of the old patent, and was duly granted Patent No. 565. It was entitled simply "Improvements in the Art of Engraving," but from the process that it described are derived practically all the photographic methods of reproducing pictures in use to-day. It is true that long before, in the 1820's, Nicéphore Niepce had succeeded in producing printing plates by the action of the sun, but Niepce used bitumen of Judaea dissolved in benzene as his sensitiser and his work had little practical result. Fox Talbot (following on a discovery of Mungo Ponton) discovered that gelatine, when sensitised with potassium bichromate and exposed to light, is insoluble and can be used as a "resist" for etching metal. This basic fact is the foundation of almost every photographic reproduction process—line or half-tone, relief or intaglio, and even photo-litho.

In Patent No. 565 of 1852, Fox Talbot described how a metal plate coated with gelatine and potassium bichromate was to be exposed to light under a suitable subject, such as a piece of lace or a plant. Washing the plate would dissolve away the unaltered gelatine, leaving a "resist" of gelatine outlining the shape of the subject. Etching in acid would produce an image of the subject in intaglio, from which prints could be struck off on paper. The inventor then proceeded to describe "a useful modification of the process," consisting in covering the plate with two or three folds of "black crape" or gauze and placing it in the sun. This gave a pattern all over. Then the plate was exposed again under the leaf, etc., which was the subject of the illustration. After washing and etching, the plate would produce prints of the subject in what appeared to the eye to be a uniform shading.

In this "useful modification," Fox Talbot gave the world the second basic feature of nearly all modern processes that reproduce gradations of light and shade, namely, the splitting up of the tones into a modulated pattern of dots. He was aware of the importance of his "useful modification." As an alternative to woven fabrics for producing a modulated pattern on the plate, his patent of 1852 suggested coating glass with a powder "consisting of distinct opaque particles" or the covering of glass with suitably ruled fine opaque lines. He wrote in this connection, "These things, which I believe have not been heretofore used in the fine arts, I would denominate photographic screens or veils." This must be the first use of the word "screen" in connection with photo-engraving—45 years before the date given in the *Oxford English Dictionary.*

The development of a satisfactory screen was particularly important in the evolution of the "half-tone" relief block (i.e., a type-high block reproducing gradations of light and shade that can be set up in a forme and printed simultaneously with letterpress type). Relief blocks of this sort are usually referred to to-day simply as "half-tone blocks." Some half-tone blocks in relief, produced by making electrotypes from swelled gelatine images, were exhibited at the London Exhibition of 1862 by Paul Pretsch, and other early workers had also worked along these lines; but the future lay with the "photographic screen or veil" first proposed by Fox Talbot. In 1882, Meisenbach successfully applied Fox Talbot's principle to produce an effective half-tone by photographing the original picture through a ruled-line screen, which he turned through 90 deg. after half the exposure. The turning of the screen produced a pattern of large and small dots. This was far ahead of the thin and thick parallel lines which earlier workers, using one exposure through single-line screens, had obtained. Four years later, Frederick Ives of Philadelphia showed how better results could be obtained by using lines running diagonally across the screen (instead of horizontal and vertical lines); and in 1888 Max and Louis Levy, also of Philadelphia, perfected the half-tone screen as it is used to-day. They ruled two plates of fine optical glass with diagonal lines by machinery and sealed the two together face to face with lines set at 90 deg. to form a single screen.

ENGINEERING made early use of relief blocks produced by these processes. Blocks made by photographic means were set in the text of this journal in the middle 'eighties; and earlier still, a single photo-mechanical block of Peter Brotherhood's works in Belvedere-road, Lambeth—then newly completed—was given as an inset with our issue of July 20, 1883. The illustration is reproduced on page 563. The original is a "phototype," made in Paris by the Société Générale des Applications Photographiques.

The foresight of Fox Talbot was remarkable. In 1852, he had apparently only made blocks from lace patterns and plants, but he definitely envisaged printing from a photograph—specifically mentioning the wet collodion process that had been discovered in the previous year. Furthermore, there was mention of applying an aquatint background of resin particles to the plate. This process was further developed by the inventor in his later patent of 1858. He used it in the 'sixties to produce intaglio blocks (i.e., blocks in which the ink is held in a pattern of pits or channels engraved into the surface, instead of on a pattern raised in relief) by photographic means. Fox Talbot was thus an important pioneer of the process that has come to be known as photogravure. In 1879, Karel Klič (Klietsch), a Czech, combined Fox Talbot's technique of applying resin grains directly to the plate and fixing them by heating, with the invention of another Englishman, Sir Joseph Swan's carbon transfer process, to produce the first practical commercial gravure process.

To-day, the grain of the photogravure block is produced by a fine screen, but this again is an application of one of the features of Fox Talbot's original patent of 1852. It is of additional interest to note that the use of zinc plates and the application of the patented process to lithography were also envisaged in the patent of 1852.

The fame of William Henry Fox Talbot (1800-1877) as a savant is firmly established. He was one of the first men to decipher cuneiform Assyrian inscriptions and he shares with Daguerre the honour of having been one of the "fathers" of photography in 1839. It is of considerable interest that he was also the first to discover the basic principles on which all modern illustrative processes of printing are founded.

SCIENTIFIC FILMS.—The Scientific Film Association have recently issued two publications: a revised edition of *A List of Films for Training in Industry*, price 7s. 6d., first published in 1951; and *A List of Distributors of Industrial Films*, price 3s. 6d. They may be obtained from the Association, 164, Shaftesbury-avenue, London, W.C.2.

EXPORT AND IMPORT TRADE OF RIVER TYNE.—Shipments of coal and coke from the River Tyne rose steadily during March, on account of the strike of Blyth trimmers and teemers, which caused coal intended for shipment at Blyth to be diverted to the Tyne. Figures issued by the Tyne Improvement Commissioners show that shipments in March amounted to 989,680 tons, an increase of 346,677 tons on the corresponding period of last year. For the first quarter of the year, shipments amounted to 2,485,546 tons, a rise of 392,924 tons over the first quarter of 1951. Shipment to foreign ports during the quarter amounted to 383,879 tons, which was an increase of 152,305 tons on January-March, 1951. For the first two months of the present year, however, shipments of general merchandise amounted to 61,638 tons, constituting a decline of 3,897 tons, as compared with January and February, 1951. The largest single export was a quantity of 11,730 tons of sulphate of ammonia. Imports of general merchandise for the first two months of 1952, at 377,354 tons, were 13,553 tons below the figure for the corresponding period of 1951.

LABOUR NOTES.

WOMEN engaged in the engineering industry have presented a wage claim parallel to that of the men employees and have asked their employers for a "substantial" advance in their wages, to meet the increasing cost of living. The five trade unions catering for the 200,000 women employed in the industry have requested the Engineering and Allied Employers' National Federation to meet their representatives on the same day as the Federation meets officials of the Confederation of Shipbuilding and Engineering Unions to discuss the men's demands. It may be recalled that, after some months of negotiations, women engineering employees aged 18 and upwards received an increase of 10*s*. 1*d*. a week in February last, against the 11*s*. a week conceded to men employees. The increase was, however, ante-dated to November, 1951, when the men's increase took effect. The five unions sponsoring the women's claims, and which are acting together in this matter, are the Transport and General Workers' Union, the National Union of General and Municipal Workers, the Amalgamated Engineering Union, the Foundry Workers' Union and the Electrical Trades Union.

This year's conference of the Scottish Trades Union Congress was held from April 23 to 26 at the City Hall, Perth. In the main, it may be stated that moderate tendencies prevailed at the conference, although most sessions appeared to be marked by a much freer spirit of criticism of economic and political matters than had been considered prudent during recent years, when there was a tendency to limit criticism in some directions in order to avoid embarrassing the then Government. Mr. John Brannigan, the President of the Scottish T.U.C., stated, in his opening address to the delegates, that the trade-union movement must be treated as a partner and an equal by the present Government and the employers, if these bodies were to continue to enjoy the movement's co-operation in the examination of economic and industrial problems. There must be evidence of a genuine desire to meet the movement on that footing, otherwise even its immense influence would be unable to stem the chaos which would arise from decisions such as those announced in the recent Budget.

He condemned attempts to interfere with nationalisation and advised the Government not to meddle with the trade-union conception of the public control of industry. If the nationalised road-transport or steel industries were tampered with by the Government, they would inevitably incur the condemnation of members of the trade-union movement in every other industry in the country. Mr. Brannigan's comments on rearmament were favourable to a policy of the utmost preparedness being undertaken. He said that he believed in rearmament and pointed out that this country, irrespective of the form of Government in office, had learned the lesson of 1939, when the dangers of being unprepared against possible attacks had been made obvious.

One of the most important sessions of the conference was that on the first day, when a motion put forward by the General Council on Scottish industry was debated. The principal contention of this rather long resolution was that, although the progress made in industry and employment in Scotland since the end of the war had been considerable and was to be appreciated, much concern was felt at the decline in the supplies of essential materials, which had taken place recently, and at Scotland's disproportionately high level of unemployment, compared with that obtaining in England and in Wales. The Scottish General Council's resolution stressed that this disparity had existed too long for "complacency" to continue. An amendment was moved, on behalf of the Aberdeen Trades Council, in which alarm was expressed at the effect of shortages of materials on such basic industries as steel, engineering, and shipbuilding. The amendment also referred to the serious position of new industries in Scotland, especially those in Lanarkshire, and demanded the complete modernisation of basic industries and the allocation of sufficient supplies of raw materials, especially steel.

In his speech submitting the main resolution, Mr. A. D. MacKellar, the vice-chairman of the General Council, expressed regret at any exaggeration of unemployment in Scotland. Orders had, in fact, been placed there in an endeavour to absorb labour which had been discharged. Scotland, which contained only 10 per cent. of the population of the United Kingdom, was producing no less than 41 per cent. of the ships, 73 per cent. of the boilers, 48 per cent. of the locomotives, 15 per cent. of the steel, and 68 per cent. of the coal-cutting machinery constructed in the United Kingdom. Although he had, he stated, no desire to minimise the position respecting unemployment in Scotland, the level of which had been increased by 10,000 during December, 1951, and January this year, and by 6,000 during January and February last, it had to be borne in mind that the figures for March showed a reduction of 6,600. After some debate, the Aberdeen Council's amendment was rejected by 222 votes to 163.

On the third day of the conference, the 425 delegates, who constituted one of the largest attendances recorded for the Scottish T.U.C., debated the question of wage claims on a resolution put forward by its General Council. This stated that all wage claims submitted by trade unions to meet the increasing cost of living had the full support of the Scottish T.U.C. in the present circumstances. Recognition was given by the resolution to the fact that wage increases during 1951 had been heavier than in any recent year, but it contended that these increases had been steadily outpaced by rising prices and that, therefore, the demands of the trade unions for higher wages were no more than an attempt to overtake the cost of living. There was complete agreement in the ensuing debate that trade unions must unite in protecting and improving the wages and working conditions of their members. Many delegates expressed their determination that rising costs of living should be strongly opposed in the political field. The resolution was declared carried unanimously.

A somewhat similar attitude to demands for increased wages was indicated at the meeting of the General Council of the T.U.C. in London on April 23. The Government's *Economic Survey for* 1952, which urges the exercise of as much restraint as possible in the claiming of larger incomes, was published just before the meeting took place. Members of the T.U.C. economic committee reported to the meeting that they had had a discussion with the Chancellor of the Exchequer, Mr. R. A. Butler, prior to the publication of the *Survey*, during which he had asked for the exercise of moderation in the presentation of wage claims. It is understood, however, that the contents of the *Survey* were not discussed by the General Council and that the members passed on to other business without debating the economic committee's report at length. Individual members of the General Council have expressed the opinion that attempts by that body to try to check the wage claims which are now pending would be bound to be a failure, because they are based mainly on advances in living costs and are very strongly supported among the rank and file.

Miners at Ferndale colliery in the Rhondda Valley went on strike last week as the result of a dispute concerning the length of coalface to be worked by individual miners. It was argued that each collier should be allocated the length of coalface which he felt he could work, according to his skill and physical capacity. The management, on its side, claimed that each man should have the same length of face allotted to him. In consequence of this, two miners were given notice and a decision to strike resulted. At a meeting of the area executive of the National Union of Mineworkers last week, the President of the area, Mr. Will Arthur, stated that lodges in South Wales had protested against the proposal of the Railway Executive to abolish workmen's fares. If implemented, this decision would lead to serious repercussions in the South Wales coalfield as it came immediately after a similar decision with respect to workmen's fares on omnibuses.

Only a small proportion of the workpeople who had become redundant at the radio-manufacturing factories on the Hirwaun Trading Estate, near Aberdare, remained unemployed, according to a statement by Mr. W. A. Griffiths, secretary of the Aberdare and District Employment Committee. It was feared, some months ago, that redundancy would affect some 1,000 people in the radio-products group on the estate, but many of these persons had been re-engaged in the industry, or had found alternative employment.

Changes in to full-time rates of wages, which came into operation in the United Kingdom during March, benefited about 760,000 workpeople, and the total cost of these increases is estimated by the *Ministry of Labour Gazette* for April to amount to approximately 184,000*l*. a week net. In the main, the increases principally affect manual employees in the service of local authorities, and workpeople in the iron and steel industry and in railway workshops.

During the first quarter of the present year, some 3,625,500 persons received net increases in their weekly full-time wage rates and the cost of these increases aggregated 1,432,100*l*. a week. Among those benefiting from these increases, 289,500 employees in the engineering, shipbuilding and electrical-goods industries received wage improvements during the three months which amounted, in all, to approximately 126,900*l*. During the corresponding three months of 1951, approximately 4,924,000 workpeople received increases in their full-time net wages, at a cost of 1,963,500*l*. a week.

FUEL DISTRIBUTOR FOR CHAIN-GRATE STOKERS.

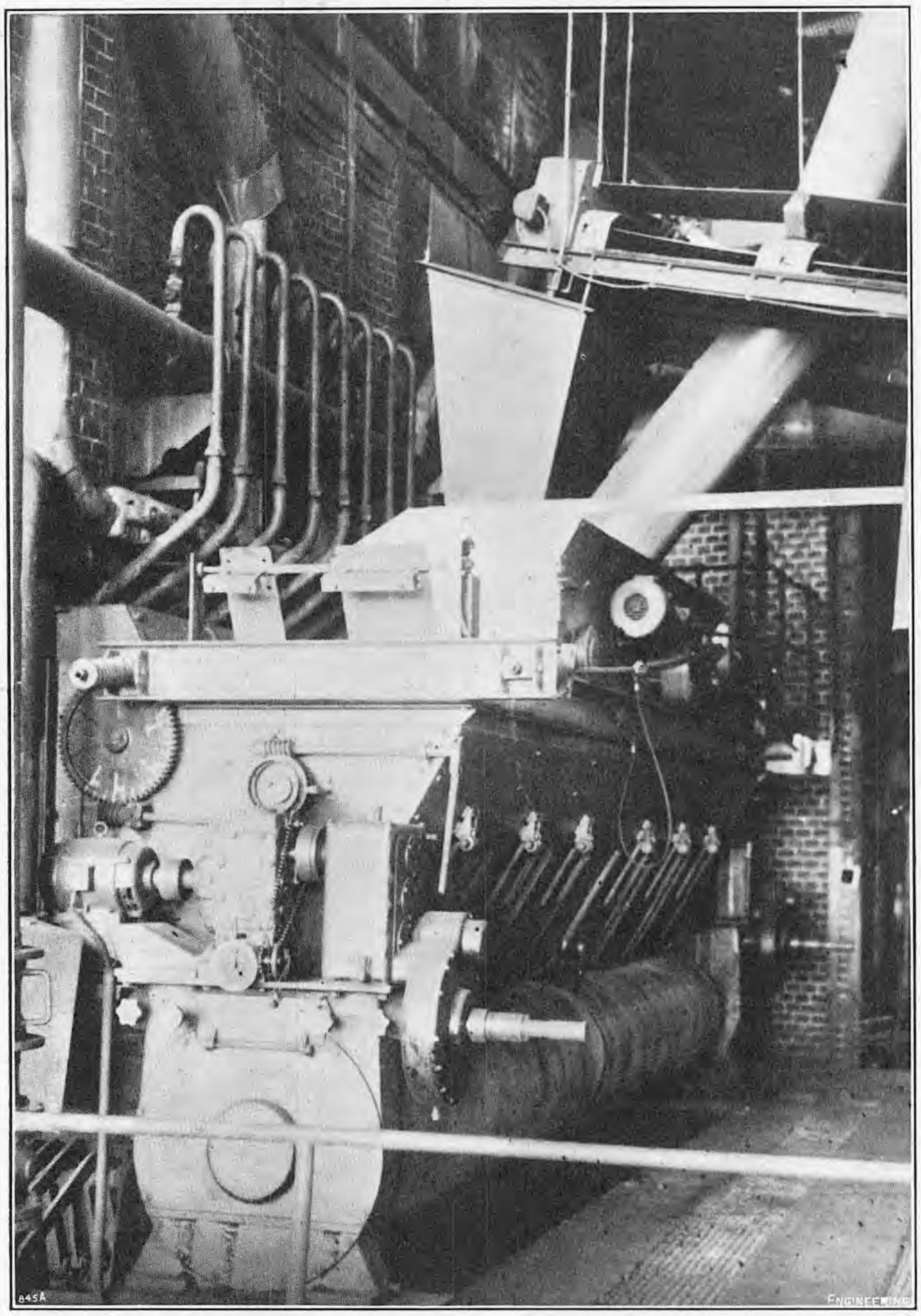


Fig. 1. Distributor for Two Types of Fuel.

Fig. 2.

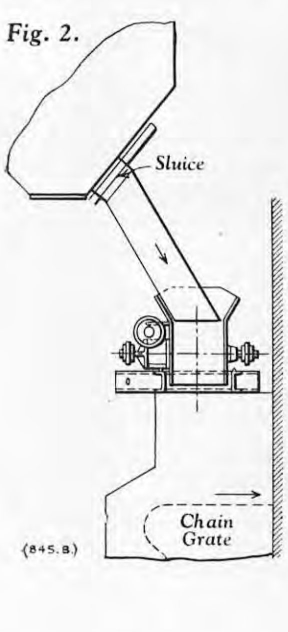
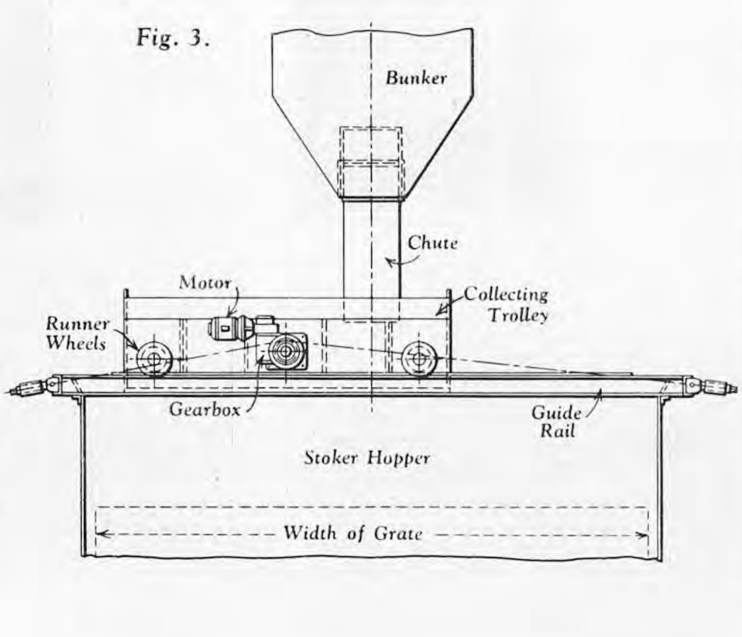


Fig. 3.



FUEL DISTRIBUTOR FOR CHAIN-GRATE STOKERS.

The problem of ensuring even distribution of fuel over the chain-grate stokers of water-tube boilers has been successfully solved, it is claimed, by an automatic fuel distributor which is made by a Continental firm. Arrangements have been made for the distributor to be made under licence and marketed in this country by the Reiss Engineering Company, Limited, Dalston-gardens, Stanmore, Middlesex. Uneven distribution is generally due to the fact that there is a tendency, when the coal is flowing into the hopper, for the large pieces to flow to the sides of the grate and the fine pieces to fall in the middle. Moreover, if two kinds of fuel are being used on a grate simultaneously, there is the difficulty of ensuring a thoroughly mixed feed on to the grate; this difficulty is also solved by the new fuel distributor. Fig. 1, herewith, shows a distributor which is suitable for feeding two classes of fuel, and Figs. 2 and 3 show the layout of a distributor for one class of fuel.

Distribution is effected by a collecting trolley which travels slowly and repeatedly, from side to side and back again, between the chute from the coal bunker and the top of the stoker hopper. The trolley is a rectangular box, open at the top and bottom, with four wheels which run on a pair of parallel guide rails. It is fitted internally with several vertical plates which divide it into compartments. When the distributor is in operation, the hopper is always kept full of fuel, so that fuel can only fall through the trolley when a void is created below it by the action of the chain grate. The trolley, moving slowly to and fro, has always one or two compartments below the chute; thus, they receive fuel of similar proportions of grades. In particular, the fuel delivered by the end compartments to the sides of the grate is comparable with that delivered to the centre of the grate. As the trolley travels slowly above the hopper each compartment remains full until it passes over a void in the fuel in the hopper.

A motor mounted on the trolley drives a cross-shaft through a reduction gearbox. Two sprocket wheels, one on each end of the shaft, engage with two chains which are stretched between the ends of the guide-rail frame, springs being fitted at the ends of the chains to keep them taut at all positions of the trolley. When the trolley reaches either end of the rails it trips a switch which reverses the motor. The overall rate of feed, however, is controlled by a pendulum which stops the trolley at either end of its travel and does not reverse it until the coal in the hopper has sunk. The power required to drive the distributor is quite low, being from $\frac{3}{4}$ to $1\frac{1}{2}$ h.p. on wide grates, though motors of from $1\frac{1}{2}$ to 3 h.p. are fitted to ensure reliable operation. In the event of an electrical breakdown, the distributor can be operated by hand. Where two fuels are used, fed from separate bunkers, the chutes deliver into a special double trolley, but in other respects the action is the same as for a single-chute trolley. A distributor of this type is shown in Fig. 1. Feed screws, belt conveyors and any existing scales can be interposed.

Uneven distribution, it may be noted, leads to the rate of air flow through the grate being too high at the sides, where the large pieces collect, and too low at the centre, where the fine coal is massed. The stoker chains or bars at the centre therefore deteriorate rapidly, owing to insufficient cooling air, and the fuel in that zone is only partly burnt. The makers claim that the distributor reduces the coal bill by ensuring more efficient combustion, higher carbon dioxide and lower carbon monoxide. It is readily fitted in existing or new boilers. The length of the frame is equivalent to half the width of the hopper plus slightly more than half the width of the coal chute. Its width depends on the width of the hopper, but is usually not more than about 20 in. to 24 in.; the height is a function of the rate of fuel consumption. The distributor is particularly useful where the available building height is restricted.

British and French Railways Exchange Staff.—British Railways have arranged an exchange training visit between four members of their traffic and technical staff and four corresponding officials of the French Railways. For a period of six weeks they will study the railway subjects in which they specialise in their own countries. Similar exchanges took place in 1949 and 1950.

Frodingham Steel Sheet Piling.—The Appleby-Frodingham Steel Co., branch of the United Steel Companies Ltd., 17, Westbourne-road, Sheffield, 10, have now added a No. 4 profile to their range of steel sheet piling sections. The new section has a minimum thickness of 0·45 in. and has a lock centre of $15\frac{3}{4}$ in. It is $10\frac{3}{4}$ in. deep and has a weight of 40·98 lb. per square foot of piling wall and a modulus of 43·75 in^3. per foot of wall.

CAVITATION MECHANICS AND ITS RELATION TO THE DESIGN OF HYDRAULIC EQUIPMENT.*

By Professor Robert T. Knapp, Ph.D.†

(*Continued from page* 536.)

Experimental Results and Conclusions.

Definition of Cavitation Parameter.—In the discussion of all types of cavitation problem, experimental results, and performance of equipment, some system of describing quantitatively the dynamic conditions under which the cavitation is taking place becomes necessary. Fortunately, such a system has won universal acceptance. It involves the use of a dimensionless quantity called the cavitation parameter, and is given by

$$K = \frac{p_L - p_B}{\rho \frac{V^2}{2}} = \frac{h_L - h_B}{\frac{V^2}{2g}}$$

where (in consistent units) p_L and h_L are the pressure and pressure head in the undisturbed liquid, p_B and h_B are the vapour pressure and pressure head corresponding to the liquid temperature, V is the relative velocity between the body and the liquid, normally measured where the liquid is undisturbed, ρ is the liquid density, and g is the acceleration due to gravity.

Physical Significance and Uses of Cavitation Parameter.—The physical significance of this parameter is clear. The numerator is the net pressure or head which acts to collapse the cavity. The denominator is the velocity pressure or head of the flow. Now the variations in pressure which take place on the surface of the body, or on any type of guide passage, are due basically to changes in the velocity of the flow. Thus the velocity head may be considered as a measure of the pressure reductions that may occur to cause a cavity to form or expand. From this point of view the cavitation parameter is simply the ratio of the pressure available for collapsing the cavity to the pressure available for inducing the formation and growth of the cavity. It transpires that this parameter, K, is a very useful measure for many different aspects of the cavitation phenomenon. For example, if the first traces of cavitation appear when $K = K_i$ (incipient cavitation), K_i can be interpreted as the maximum reduction in pressure on the guiding surface, measured in terms of the velocity head. Thus, if $K_i = 1$, the lowest pressure at any point on the surface is one velocity head below that of the undisturbed flow. It follows directly that K can be used to designate the relative cavitation resistance of a given nose shape or an entire piece of hydraulic equipment. This is accomplished by assigning to the object its measured value of K_i. The lower this value, the higher is the object's resistance to cavitation.

Many similar uses are found for this parameter. One convenient use is for the comparison of the condition of the flow with the cavitation resistance of the object. For example, consider a centrifugal pump installation. Assume that for the best available pump for this installation $K_i = 0 \cdot 4$, measured at the inlet. This means that the user must install the pump at an elevation low enough for the K value of the flow entering the pump never to be less than 0·4. If he is able to do this, then he can be sure of cavitation-free operation. If not, then cavitation can be expected to occur at all times when the K value of the flow drops below 0·4. It will be noted that the value of K varies if either the pressure or the velocity is changed. This is particularly important when K is used to define the character of the flow. Thus the K value of the tunnel working-section may be varied over wide limits by simply varying the pressure level while the velocity remains constant.

Inception and Life History of a Cavity.—The high-speed motion-picture technique makes it possible to trace in considerable detail the life history of a cavity, from its inception to its final disappearance. Fig. 12, herewith, shows a strip of pictures, taken at the rate of 20,000 frames per second. The portion of the test body seen is a very narrow band along the top. The cavities are practically in silhouette. Each horizontal line represents an individual photograph. The total length of time covered by this entire strip, which is seen in two sections, is about 0·006 second. A line drawing of the test body is seen just above each strip. It is drawn to the same scale as that of the photograph. The relative location of the cavity on the body is obtained by projecting any individual picture vertically upward on to the diagram. The test body is a cylinder with a pointed nose. The radius of curvature of the nose is 1·5 times the diameter of the cylinder, and is commonly referred to as a 1·5 calibre ogive. The tunnel was operated at 40 ft. per second, and the absolute pressure in the undisturbed flow was about 4 lb. per square inch. This is equivalent to $K = 0 \cdot 33$.

These pictures proved to be sufficiently sharp and clear to permit measurement of cavity diameters. The cavity indicated by the arrow was selected for study. It appears first as a smooth transparent bubble which has a relatively slow growth and a much more rapid collapse. After complete collapse it reappears, this time with a rough, irregular wall. Nevertheless, the growth and collapse cycle is repeated. A third cycle follows, and then a fourth, fifth, and sixth, each successive one being smaller. Measurements were made of this cavity on each frame. The average cavity radius was assumed to be one-half of the mean of the horizontal and vertical dimensions as measured in Fig. 12. Fig. 13, opposite, shows a plot of these measurements. The convention used is that the history of the first growth and collapse is plotted above the zero line, the second appearance, i.e., the first rebound, below the line, the next above, the next below, and so on. This is to simplify the determination of the time of complete collapse and to avoid confusion between the last stages of collapse and the first stages of rebound. The dotted line shows the volume history on the assumption that the cavity is a sphere.

MECHANICS OF CAVITATION.

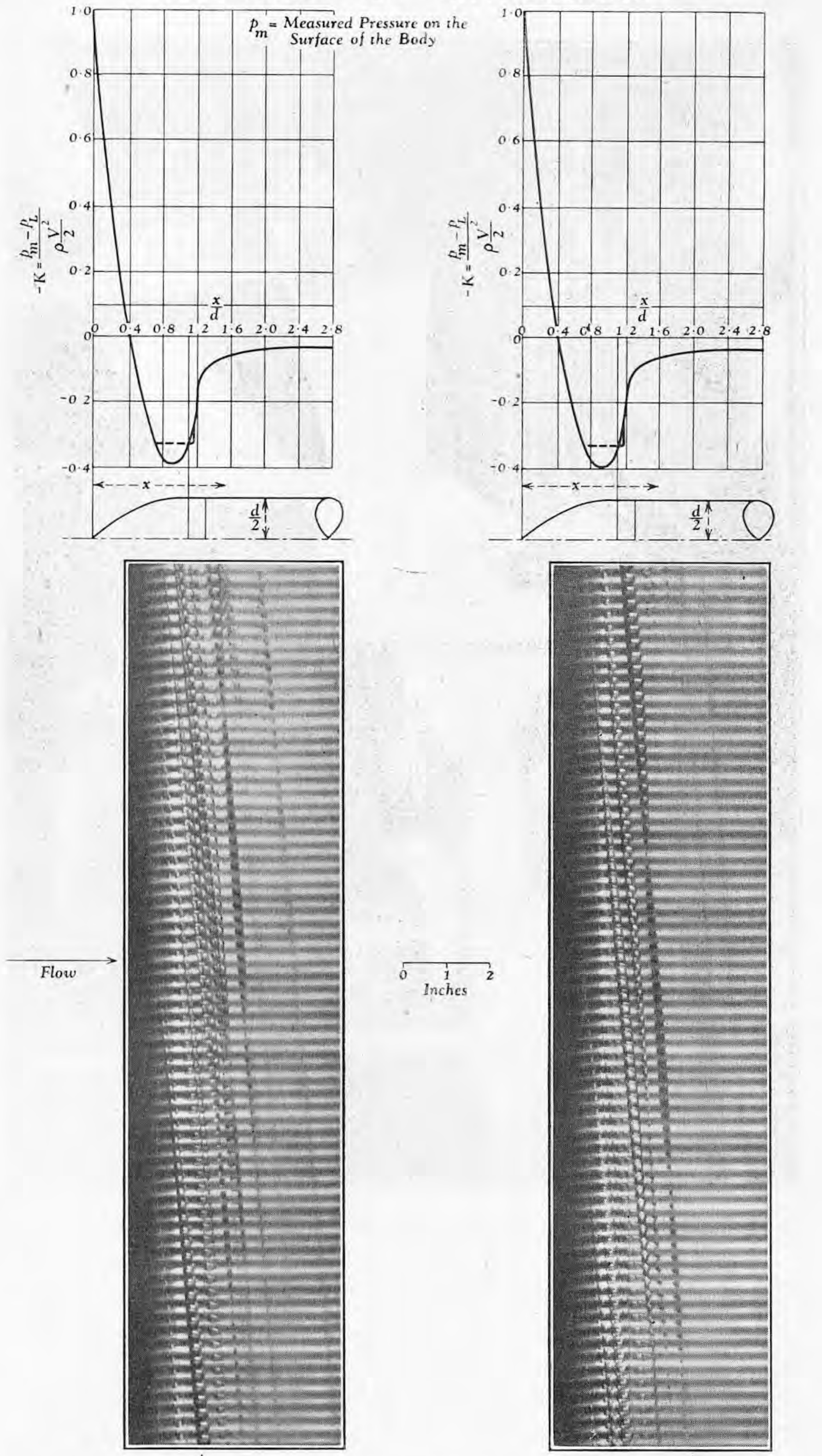


Fig. 12. Life History of Cavitation Bubble.

* James Clayton Lecture, delivered to the Institution of Mechanical Engineers, London, on April 18, 1952. Abridged.

† Professor of Hydraulic Engineering, California Institute of Technology, Pasadena, California.

MECHANICS OF CAVITATION.

Fig. 13. TIME-RADIUS CURVES OF BUBBLE.

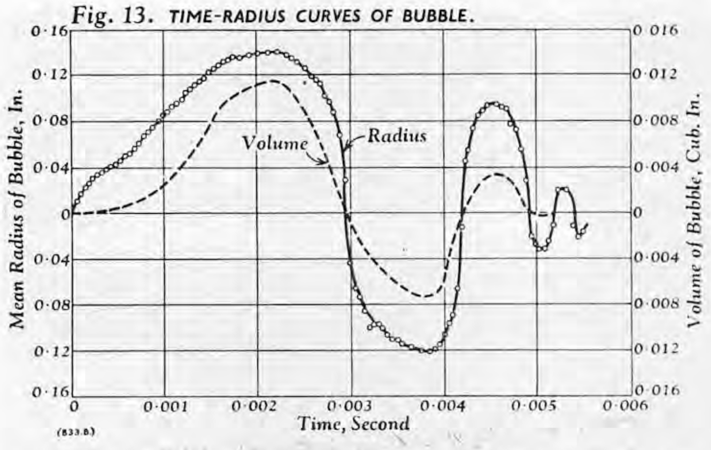
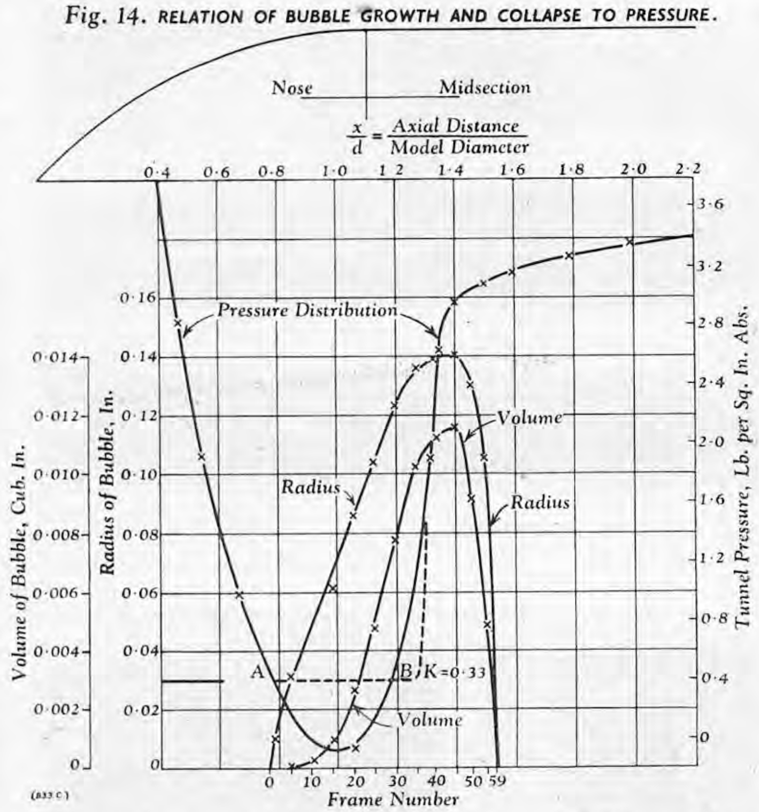


Fig. 14. RELATION OF BUBBLE GROWTH AND COLLAPSE TO PRESSURE.



Details of Cavity History.—It is possible to obtain considerable insight into the mechanics of this process by examining in detail the life history of this one cavity, which is typical for at least one important type of cavitation. Fig. 14, on this page, will assist in this study. At the top will be seen the half-profile of the test body. The graph below it, drawn to the same longitudinal scale, shows the pressure distribution on the surface of the body and the behaviour of the cavity from its inception to its first collapse. It will be noted that only the negative portion of the pressure distribution curve is shown. The ordinate for this curve is absolute pressure. The vapour pressure of the water, at the temperature of the experiment, is shown by the horizontal dotted line. The pressure distribution is that measured for non-cavitating conditions, i.e. for a high value of K. The dotted line having the horizontal section A-B shows the changed pressure distribution for K = 0·33. The curves showing the radius and volume of the cavity are the same as those seen in Fig. 13, with the exception that the abscissa is distance, measured along the test body, instead of time.

Point A shows the position on the nose of the body at which the pressure has been reduced to the vapour pressure of the water. It will be seen that this is also very nearly the position at which the cavity is first detectable as a tiny bubble. Fig. 12 shows that the cavity moves downstream on the body. As seen from Fig. 14, it is moving into a region in which the pressure tends to decrease below the vapour pressure. Therefore, it is not surprising to observe that the cavity grows at a rapid rate. This high rate of growth continues nearly to point B, which corresponds to the position on the body at which the pressure climbs up back to vapour pressure.

Cavity Hydrodynamics.—It must be remembered that references to the behaviour of the cavity and the motion of the cavity wall are really only figures of speech. So far as the dynamics of the system are concerned, the cavity is nothing but an empty space surrounded by the liquid. What is seen, and what is important, is the motion of the free surface of the liquid. Thus during the rapid growth of the cavity the liquid is moving radially outwards at a high speed. From points A-B, this outward radial flow is taking place in the direction of the pressure gradient. From point B onwards, it is against the pressure gradient. Thus, as the curves for both radius and volume show, this motion is decelerated, and finally ceases at the point of maximum radius. The cavity radius then begins to shrink at a rate that indicates a high radially-inward acceleration. This is confirmed by reference to the pressure diagram. If it is assumed that the pressure inside the cavity is the vapour pressure, there is a pressure difference of approximately 2·5 lb. per square inch acting to produce this acceleration. It will be recognised that this pressure difference is the numerator of the cavitation parameter. Viewed with respect to the pressure distribution diagram, the behaviour of the cavity is very rational; indeed, it could have been predicted from Newton's laws of motion. On the other hand, such a prediction requires a knowledge of the pressure distribution diagram.

The question might well be asked as to the physical explanation of the pressure variation on the body. It is not difficult at this point to become confused as to whether the motion of the liquid produces the pressure variations on the body or whether the pressure variations on the body cause the motion of the liquid. Such confusion is largely a confusion of terms. Any fluid particle may be considered as a free mass with an associated force system. Consider such a particle of liquid in the flow which impinges on the nose of the body near the point and follows along the surface. Since the particle cannot penetrate the surface of the body, it has to move laterally to get around it. To move laterally, however, the particle must push other particles out of the way. The effect of these collisions, combined with force applied by the body to prevent the liquid from passing through its surface, is manifested in the pressure field that develops. The lateral outward acceleration of the original particle continues until it and all of the adjacent particles are moving parallel to the body surface. It will be found that when this state is reached, the pressure on the surface has decreased until it is equal to the static pressure in the undisturbed flow, i.e., the particles have acquired a lateral component of motion high enough to keep them out of the way of the body. Downstream from this point the surface of the body curves away from this tangential path. This takes away the constraint on the side of the particle next to the body, i.e., the force acting between the particle and the body is reduced. The resulting unbalance of the force system causes the particle to accelerate towards the body, along a curved path. If the surface of the body falls away from this path so rapidly that all constraint on the particle is removed, then the pressure between the body and the particle is zero. The minimum radius of curvature of the particle in this case will be determined by the free stream pressure. If the body falls away from the path of the particle even more rapidly than this, there are two possibilities: either a tension force must be set up between the surface of the body and the particle, to constrain the particle to follow the curvature of the body, or the particle will leave the body surface. In the latter case a cavity must form.

Thus it is seen that cavitation will take place only in regions in which the guiding surface is curving away from the local direction of flow. Whether or not cavitation actually takes place will be determined by whether the radius of curvature of the surface at the point under consideration is greater or less than the minimum radius of curvature of the filament of liquid next to the surface, if the pressure on the concave side of this filament is assumed to be vapour pressure. If the surface radius of curvature is greater than the minimum filament radius, no cavitation will occur. If it is less, then cavitation takes place, i.e., the liquid flow breaks away and produces voids. The salient features of this cavitation process are: (1) the cavity starts to form at the point on the guiding surface where the pressure is reduced to vapour pressure; (2) cavity growth continues as long as the surface pressure is at or below vapour pressure; (3) as the pressure on the surface increases until it is again above vapour pressure, the rate of cavity growth decelerates; the cavity quickly reaches the maximum size, and immediately starts to collapse; (4) the collapse rate is much higher than that of formation.

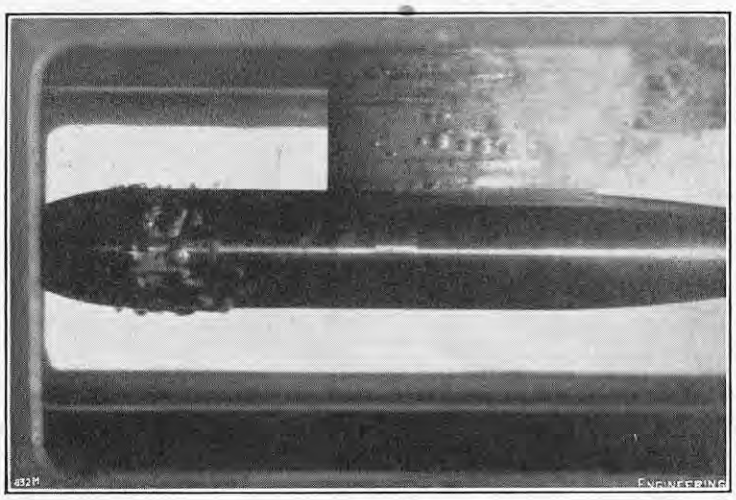
Cavitation Types.—Fig. 15, on page 568, shows two single-flash pictures both taken of the same test body but at slightly lower values of K than that of the motion-piecture strip seen in Fig. 12. It will be observed that the cavitation seen in Fig. 15 (*a*) appears the same as that shown in the strip; whereas that seen in Fig. 15 (*b*) seems quite different. This illustrates clearly that there are different types of cavitation, and, furthermore, that at least these two types can exist under nearly the same conditions. The differences between these two types will be discussed later, but first an examination will be made of the similarities which are more significant than is obvious at first glance. They are: the cavities first appear at the same point on the guiding surface, i.e., at about the point where the vapour pressure is reached; the cavitation zones cover the same part of the body; and the thickness of the cavitation zones seems to be about the same. Therefore, in these important features the two types of cavitation are equivalent.

One of the most obvious points of difference is found in the zone immediately downstream from the main cavity region, i.e., the zone in which the travelling cavities, seen in Fig. 12 and Fig. 15 (*d*), go through several cycles of rebound and collapse. The corresponding history of the fixed type of cavity, typified by Fig. 15 (*b*), seems to be that large sections of it are entrained by the flowing stream of liquid and are swept downstream, where they disappear. Fig. 16, on the same page, shows entrainment on the upper and lower surfaces of a hydrofoil, and Fig. 17, on page 569, shows motion-picture strips of this phase of the cavitation phenomenon as it appears in profile on cylindrical bodies with (*a*) the 1·5 calibre nose, and (*b*) the hemispherical nose. It should be remembered that this entrainment takes place at the downstream end of the low-pressure zone, and collapse and disappearance occur in a region where the pressure is above vapour pressure. In this type of cavitation the cavity elements are extremely irregular in shape and by no stretch of imagination could be considered as spheres. Thus the mechanics of their collapse is complicated; presumably, much of the energy associated with it is dissipated in the process, as it is difficult to find clear evidence of repeated rebounds and recollapses. It should be emphasised that, even with this apparent difference in appearance, these parts of the cavitation process are basically similar for the two types.

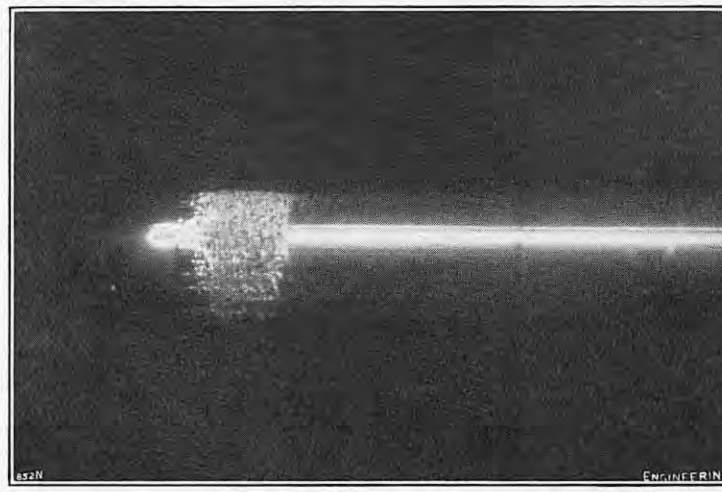
Analysis of Cavity Collapse.—In collapse of the spherical travelling cavities it is possible, on the basis of some simple assumptions, to calculate the size of the cavity from the time it has reached its maximum diameter until it has completely collapsed. This was first done by Lord Rayleigh,* who considered the collapse of an empty spherical cavity in an incompressible fluid, having a constant pressure at infinity. He equated the kinetic energy of the resulting motion of the fluid to the work done at infinity by the constant pressure acting through a change of volume equal to the change of the cavity volume. Fig. 18, on page 569, gives a comparison of the observed collapse with that predicted on the basis of these simple assumptions. It will be seen that the agreement is surprisingly good, so good that it leaves little reason to doubt that the basic mechanics are as Lord Rayleigh visualised. He also calculated the pressure that would result if the cavity collapsed concentrically on to a small infinitely-

* *Phil. Mag.*, vol. 34, page 94 (1917).

MECHANICS OF CAVITATION.

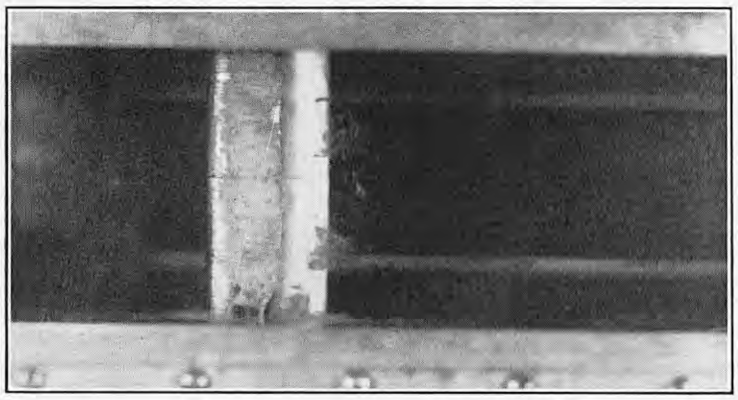


(a) Travelling Cavities, K = 0·26.

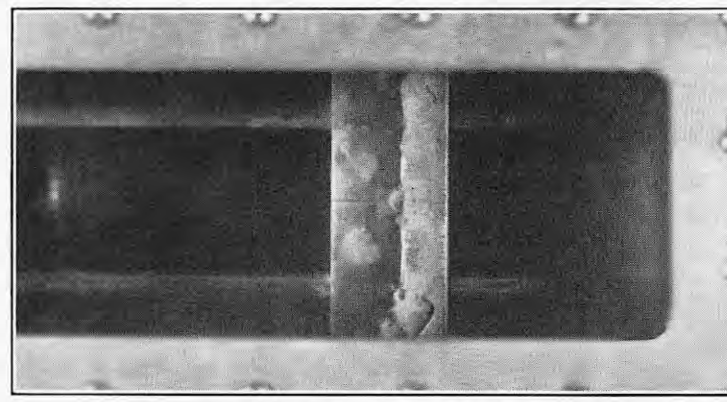


(b) Fixed Cavity, K = 0·27.

FIG. 15. LIGHT CAVITATION ON 1·5 CALIBRE OGIVE.



(a) Upper Surface, K = 1·36.



(b) Lower Surface, K = 0·82.

FIG. 16. ENTRAINMENT FROM FIXED CAVITY ON SURFACES OF HYDROFOIL.

rigid sphere. He abandoned the assumption of the incompressible fluid at the instant that the cavity wall touched the surface of the sphere, and proceeded to determine the pressure on the surface of the sphere on the basis that the kinetic energy present in the liquid just before the instant of contact was converted to potential energy of compression as the liquid came to rest. This is the same physical picture that underlies all calculations of water-hammer pressure. If the slope of the theoretical or experimental curve in Fig. 18 is used to compute the radial velocity of the water as the bubble radius approaches zero, it will be found that, even for this small bubble, these velocities are measured in hundreds of feet per second. Thus the maximum pressure obtained must be very high, certainly of the same order as the elastic limits of metals used in hydraulic machinery.

Cavitation Noise.—The prediction of these high pressures during the collapse phase sheds some light on another aspect of the cavitation phenomenon. Everyone familiar with cavitation is aware that the process is noisy. The collapse zone must be a very effective sound source. The pressures are high and the pressure fronts are steep. Undoubtedly some of the energy involved will be dissipated in the form of pressure pulses. This probably accounts, in part, for the damping observed between the successive rebounds of the cavity of which the history is plotted in Fig. 13. It might be mentioned in passing that many investigators have found it discouraging to work in a field that Lord Rayleigh has reaped. The gleaning of what little is left of the harvest usually requires a large amount of labour. Certainly the best of the crop is gone. Thus, in the analysis of the collapse of these cavities, it is obvious that the liquid is neither incompressible nor infinite in extent and the pressure is not constant at the boundary. Furthermore, the cavity is not empty but is vapour-filled and possibly contains some permanent gas. The amount of higher mathematics and labour required to make even approximate corrections for these additional factors is very discouraging, especially when a second glance at Fig. 18 shows that Lord Rayleigh's predictions are correct to within 10 per cent.

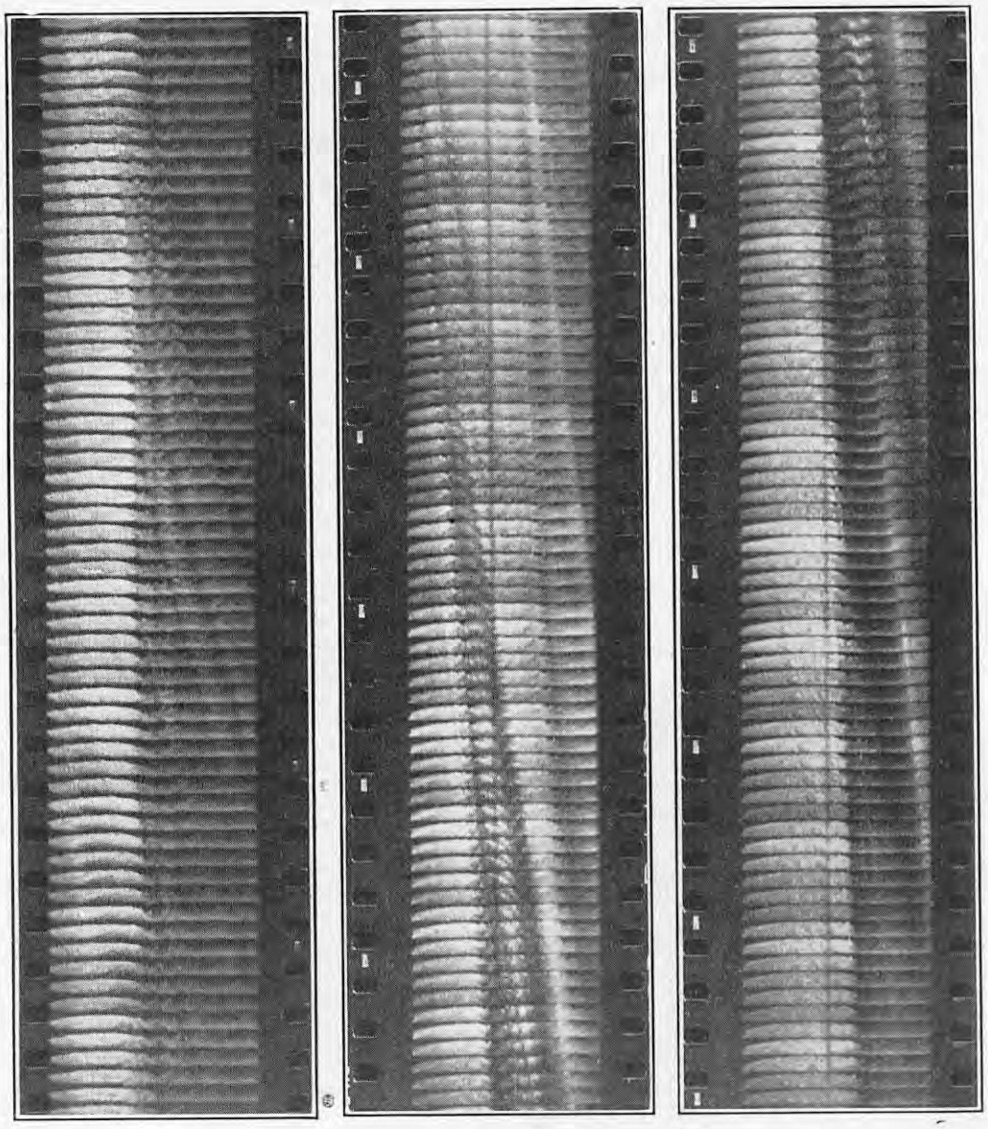
Cavitation Nuclei.—It is apparent from a continued comparison of Fig. 15 (a) and (b) that, although in many essentials these cavities are equivalent, there are major differences, at least in the details of cavity formation and collapse. Thus it is a challenge to try to clarify some of the reasons for this difference. A consideration of this phase of the problem quickly leads to the investigation of the mechanics of cavity formation in a homogeneous liquid. The first reaction of the average individual, whether or not he be technically trained, is that nothing could be easier than to create a cavity in a liquid. Apparently, all that is necessary is to attempt to apply a tension to the liquid, and it will rupture. At least, all the common liquids seem to have no tensile strength. However, even a brief survey of the literature on the subject shows that this common belief is erroneous and that, if a liquid is truly homogeneous, it can support a high tension. Therefore, cavities should not be expected to form when vapour pressure is reached. The next thought that arises is that most liquids, and certainly water, contain a relatively large amount of air in solution, and that this air would " obviously " destroy the ability of the liquid to sustain tension. More careful investigation shows that this is not at all obvious.

About a decade ago, Professor Newton Harvey* put samples of air-saturated water in a cylinder and compressed them for a few minutes at about 10,000 lb. per square inch. He then removed them and tested their tensile strength. He found that after this simple treatment many of the test samples would stand tensions of 300 to 400 lb. per square inch. This indicates clearly that dissolved gas in itself does not destroy the tensile strength of a liquid. Harvey assumed that the effective tensile strength of the ordinary liquid was destroyed by the presence of large numbers of small, undissolved gas nuclei, and that each nucleus represented a rupture of the liquid. This assumption implies that any nucleus can be made to grow into a cavity of any desired size if the pressure is reduced to that of vapour. One difficulty of this simple concept of the nucleus is that surface tension forces on very small spherical bubbles are tremendous, and would tend to raise the pressure of the gas in the bubble to such high values that it would be forced to dissolve completely in the liquid, thus destroying the nucleus. To eliminate this difficulty, Harvey assumed that the tiny gas cavities are located in crevices on small hydrophobic (non-wetting) solid particles, such as dust particles, which are present in great numbers in water and most liquids. One of the objectives of his pressure experiments was to demonstrate the possible existence of this type of nucleus. He reasoned that, if the pressure on the liquid were raised to a high enough point, the gas pockets on the solid particles would be forced to dissolve, and then the liquid would be able to withstand a tension. Harvey's experiments have been repeated and are now being extended in the Hydrodynamics Laboratory. His results have been confirmed. One of the simplest methods of measuring change in tensile strength, both before and after the pressure treatment, is the determination of the boiling point of the liquid at atmospheric pressure. In Pasadena this boiling point averages about 211 deg. F. However, after pressurising, samples have been found that do not boil until they have been heated to over 450 deg. F. A glance at the steam table shows that this implies a tensile strength of over 400 lb. per square inch. Cavitation in such water would be nearly impossible at any velocity normally encountered in engineering practice.

Effect of Nuclei on Cavitation Type.—If the need for an existence of these nuclei is tentatively accepted, the explanation of some of the observed cavitation phenomena is simplified. However, it is necessary first to consider in more detail some of the other nuclear characteristics. If these nuclei exist, there is reason to suppose that they may be found in a wide variety of sizes, the largest ones being at least large enough to be seen in a strong beam of light, while the smallest ones may well be below the range of the most powerful microscope. If cavitation is investigated in a stream of liquid containing a supply of relatively large nuclei, it would be expected that visible cavitation would appear just as soon as the lowest pressure in the system reached that of vapour, because one of these large nuclei could grow into a visible bubble practically instantaneously. However, if the liquid contained only extremely small nuclei, it would be anticipated that a relatively long growth period would be required before they would become large enough to be observed

* E. N. Harvey, W. D. McElroy, and A. H. Whiteley, *Jl. of Applied Physics*, vol. 18, page 162 (1947).

MECHANICS OF CAVITATION.



(a) (b) (b) *contd.*

(a) 1·5 Calibre Nose.
K = 0·25, V = 96 ft. per sec.

(b) Hemispherical Nose.
K = 0·37, V = 50 ft. per sec.

FIG. 17. MOTION PICTURES OF ENTRAINMENT OF CAVITATION BUBBLE.

or, indeed, to make an appreciable difference in the flow. Thus, if the low-pressure region in the test were a very short one, a nucleus might pass through it without ever forming a visible cavity. If the pressure were reduced well below that of vapour, all sizes of nuclei would be expected to have an accelerated rate of growth.

This discussion implies that, if a given body were tested for cavitation inception in two different steams of liquid, one containing large and the other very small nuclei, two different results would be obtained. The body would be expected to cavitate at a higher value of K in the liquid containing the large nuclei, i.e., its cavitation resistance would be lower than in the other stream. This is unfortunate, because it would be much more convenient if the cavitation resistance as measured by K_i would prove to be a property of the body alone and not also of the liquid. It will be recalled that in the previous discussion of the behaviour of a fluid element or filament it was tacitly assumed that liquid cannot sustain a tension, and that it breaks away from the body when vapour pressure is reached. The discussion of the growth of cavities from nuclei implies that the cavities move with the stream. If a nucleus, even a small one, should be at rest, or nearly at rest, with respect to the surface of the body, instead of moving at the velocity of the stream, then the time available for growth would be greatly increased, but the resulting cavity would be fixed with respect to the body instead of travelling downstream with the liquid. This alternative seems to offer a mechanism by which sufficient cavity volume can be formed to relieve tension in a liquid in which the nuclei may be too small or too few to permit the formation and growth of an adequate volume of travelling cavities.

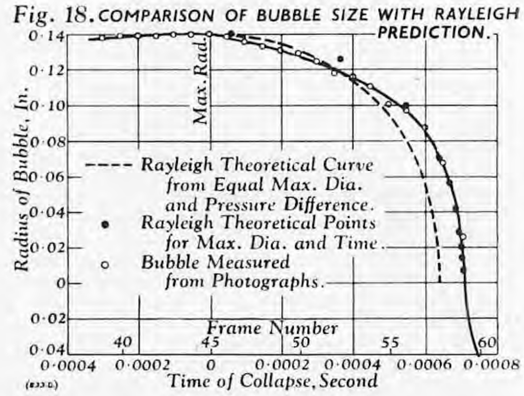
It is now possible to advance a tentative explanation of the two different types of cavitation that were observed to occur under apparently the same flow conditions. Fig. 15 (a) was made when the tunnel was operating under conditions favouring the existence of large nuclei. The water was maintained saturated with air at atmospheric pressure, and a portion of the flow was circulated constantly over either a free-fall or a spray-type cooling tower, in which there was ample opportunity for large nuclei to be formed. The conditions of the liquid under which Fig. 15 (b) was obtained are quite different. Here the tunnel was operating with a completely closed circuit, cooling was done through a heat interchanger, and a resorber had been added to the system, in which each element of the liquid was held at a pressure well above atmosphere for 80 per cent. of the time. These circuit changes should act to decrease continuously the number of large nuclei originally present in the water; thus making cavitation increasingly difficult to produce, and increasing the probability of the development of the fixed type of cavitation seen in Fig. 15 (b), instead of the travelling cavity type found in Fig. 15 (a).

(*To be continued.*)

EXTENSION OF HACKNEY POWER STATION.—The British Electricity Authority have received the consent of the Minister of Fuel and Power to the extension of the Hackney power station, London. A 30,000-kW set and a boiler with a capacity of 300,000 lb. of steam per hour are to be added.

THE LATE MR. O. G. R. BEERE.—We note with regret the death of Mr. Orlando George R. Beere, which occurred on April 7 after a prolonged period of ill-health. Mr. Beere, who was in his 75th year, had been a director of the Selson Machine Tool Co., Ltd., for the past 15 years, and was well known in the machine-tool industry. He was elected an associate member of the Institution of Mechanical Engineers in 1914 and was also an associate member of the Institution of Production Engineers.

Fig. 18. COMPARISON OF BUBBLE SIZE WITH RAYLEIGH PREDICTION.



INCREASED PRODUCTIVITY IN STEEL FOUNDING.*

PRODUCTIVITY in the steelfounding industry has been increased in the last two or three years. It is particularly difficult to compare productivity in foundries, but the British Steel Founders' Association, at the end of last year, assessed the overall increase as about 15 or 20 per cent., though scrap supply difficulties at the present time restrain output. Catton and Company, Limited, during the last five years, have doubled their output and reduced man-hours per ton of output by 47 per cent. The Clyde Alloy Steel Company, Limited, report an increase in output per man-hour for all employees of 20 per cent. in the last few years. Jarrow Metal Industries, Limited, have reported an increase in output, with the same labour force, of some 10 per cent. since 1949. William Jessop and Sons, Limited, have increased output by a third since the war, without any proportionate increase in the labour force. Lake and Elliott, Limited, have increased the tonnage per man-hour (all employees) by about 7½ per cent. since 1949; this firm's total hours of direct labour per ton of net good castings have been lowered from 77·5 in 1949 to 69·4 in 1951—a gain in productivity of 10 to 11 per cent. At F. H. Lloyd and Company, Limited, average tons of net good castings per man per annum have been increased from 11·6 in 1946 to 16·4 in 1951. Hadfields Limited have achieved a steady decrease in man-hours of direct labour per ton of net good castings from 19·5 in 1948 to 18·7 in 1950-51. K. & L. Steelfounders and Engineers, Limited, have cut down the man-hours per ton of net good castings from 147 in 1949 to 130 in 1951. Osborn Foundry and Engineering Company, Limited, have lessened man-hours per ton of net good castings, including all workers, from 320 hours in 1946 to 150 hours in 1951. The welders' output at Bonnington Castings, Limited, has been increased by about 15 per cent. since 1949. David Brown Foundries, Limited, have increased the productivity of their aircraft castings foundry by 10 to 15 per cent. since 1949. Head, Wrightson and Company, Limited, increased the productivity of the moulding shop by 20 per cent. since 1945.

In addition, other examples of increased productivity have been reported to the B.S.F.A. For example, one firm has increased the output per man-hour of its moulding shops by 41 per cent. and of its dressing shops by 32 per cent. since 1949; and another foundry has increased its output by 15 per cent. with no increase in labour force. Others have reduced the man-hours required per ton of castings. One company has reduced man-hours per ton in sand-slinging by 14 per cent., in machine moulding by 47 per cent., and in dressings by 51 per cent. Another has reduced the man-hours required per ton of net good castings from 185 to 167 hours; and still another was producing in 1949 at the rate of 213 man-hours per ton for all employees (except office staff) and by the first nine months of 1951 was producing at the rate of 193 man-hours per ton. Another firm, since 1946, has doubled its tonnage output of castings with a 47 per cent. reduction in man-hours per ton of output. It is not possible to give completely homogeneous examples. Each firm's figures cannot usefully be compared with those of another firm. The B.S.F.A. has, since March, 1950, received returns from foundries showing productivity in man-hours per ton for all individual departments. Returns from about 18 firms are now collated and average figures are sent to all members interested, but these figures are confidential. There has been some

* Report, entitled "Something has been Done: Productivity in the British Steelfounding Industry," on the value of the visit of a productivity team from the British steelfounding industry to the United States in 1949. Issued to the Press by the Anglo-American Council on Productivity, 21, Tothill-street, London, S.W.1. Abridged.

discussion among steelfounders of how best to evaluate comparative productivity in the industry, but there is no simple way. Perhaps the most convincing proof of increasing productivity in the industry is the trend of selling prices. From 1939 to April, 1951, the Board of Trade price index for general industrial materials and manufactures rose to 345 per cent. of its 1939 figure; in the same period, the price index of steel castings only rose to 165 per cent. of the pre-war figure.

The British steelfounding industry had expanded heedlessly in the first World War, had suffered slump thereafter, had recovered and then expanded more soberly in the second World War. The year 1936 was the watershed of the inter-war period; it was in that year also that the General Steel Castings Association was formed, the first such association, both national and all-embracing in its scope, and the precursor of the B.S.F.A. The revival of the industry was cut short by the war, which brought large batch orders, a shortage of skilled men, the infiltration of women, and greater intercommunication between firms. After the war the industry was amenable to change. New ideas, new methods and new techniques were studied by many firms; yet, for various reasons, change was often delayed. The impact of the American visit on the industry was sharp. The printed report was followed up by the B.S.F.A.'s Productivity Convention in November, 1949, at which some 130 representatives of 40 firms attended, covering some four-fifths of the industry by tonnage output. The members of the team travelled widely, giving lectures to technical societies and institutes, talks to firms and trade unions and taking part in innumerable discussions. A productivity committee was set up by the Association and the team-leader was made the chairman of it. A second Productivity Convention was held in April, 1950, with official trade-union participation. Meetings and discussions on American practice are still being held in the industry; a third conference is planned for 1952. The team's energetic work in spreading the ideas of the report by means of conferences and lectures has meant that it has been discussed throughout the industry. Steelfounding is a compact industry, including only about 100 firms, of which some 60 are in the B.S.F.A., and the influence of the report on it is real.

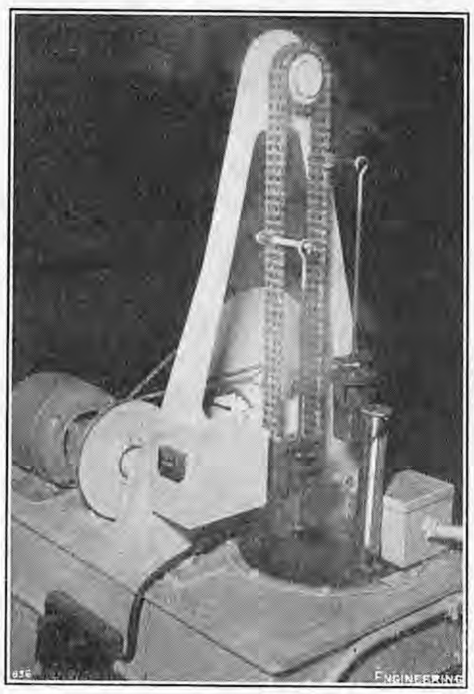
Nevertheless, the effects of such an occurrence in this industry, as in others, are, to some extent, intangible. The moulder, the furnaceman, the pattern-maker, the foreman, the foundry manager, and the works director have become more critical of customary methods; a stranger's eye has, as it were, been cast over established layouts. This leaven of critical perception is still working its way through the industry. Change was in motion during and since the war; but it has been accelerated. Co-operation between firms has been increased. The most interesting example of co-operation is perhaps the annual exchange visits, lasting a day, of the personnel of Catton's of Leeds and Osborn's of Sheffield; each man spends the day with his opposite number. The bringing together of the team itself on the trip to America and on meeting-hall platforms, and the assembling of the industry in two conferences awakened greater readiness to co-operate.

Much of the report concerned the industry as a whole. Apart from holding the two conferences, the Association has acted in various matters on lines recommended by the report, though obviously not purely as a result of it. Undoubtedly the most important action of the B.S.F.A. has been the setting up of the Research and Development Division in 1950. It was planned many years before, but its establishment was accelerated by the team's emphasis on the need to bring the results of research to the practical foundryman on the foundry floor. The Division is doing this not only by personal visits of its staff to foundries all over the country, but also by the publication, since October, 1951, of a journal which contains reports of the meetings of the various technical committees, as well as articles and papers. Much of the research being undertaken has a direct bearing on productivity, such as the pioneering work on the mechanical problems of jolting moulding machines, the study of the penetration of moulding sand by molten steel which augments the labour of cleaning the castings, the testing of dielectric core-drying stoves with the co-operation of Hadfields and other firms, and the experimental work with the Linde flux injection burner, the use of which would ease the recurrent bottleneck in fettling. The Division is also investigating the toxicity of atmospheric dust from foundry processes, dust being one of the main hazards of the industry.

The B.S.F.A. has encouraged standardisation, and, in collaboration with the British Standards Institution, has made about a dozen new standard specifications for steels since 1948. Some individual firms have limited their range of castings, both in weight and in steel specification, and a number of firms are persuading their customers to modify the design of products in order to increase standardisation. Yet most steelfounders maintain a wide catalogue and, subject to raw material supplies, are willing to take on almost any job. The B.S.F.A. prices committee has considered the possibility of agreed specialisation, but so far without conclusion. Other general matters considered by the team in its report, such as simplification of the wage structure and national incentives, lie largely outside the control of the industry. Little has been done to simplify the wages system. The problem of incentives to earn more by increasing output has been solved, at least temporarily, by the sharp rise in the cost of living since the team reported. Mention must be made of the difficulties felt by companies, arising from the effect of inflation on replacement costs of machinery and from high taxation, and of the inadequate supplies of scrap.

FATIGUE-TESTING MACHINE FOR THERMOSTATS.

THE machine shown in the accompanying illustration has been constructed by Leyland Motors, Limited, Leyland, Lancashire, for determining the life of the bellows and valve gear of thermostat units that are fitted in the water-cooling systems of Leyland vehicles. The testing machine is fitted with a ¼-h.p. electric motor which drives, through reduction pulleys and a ratchet, a vertical endless chain above a water tank. Three thermostat units are suspended at intervals from bars attached to the chain links so that, as the chain rotates once in every 72 seconds, the units are dipped in turn into the water tank, which contains sandy water to simulate the most unfavourable conditions in which



a thermostat is likely to operate. The water in the tank is maintained at a temperature of 195 deg. F. by a 1,000-watt electric-kettle element in the base of the tank. The thermostat unit is thus alternately heated in the tank and cooled, in its passage through the air, ensuring the full expansion and contraction of the bellows and the operation of the valve gear. The number of immersions is recorded by an electric counter; the total running hours of the machine are indicated on a separate meter.

At present, three thermostats of different makes are undergoing tests. They have withstood 1,000 hours satisfactorily, i.e., 50,000 immersions, and the tests will be continued to destruction. On a vehicle, the thermostat seldom opens or closes fully, and it is difficult to correlate the number of immersions of a thermostat on the testing machine with vehicle mileage, but it is estimated that the tests so far completed are equivalent to about 20 years of road operation.

ELECTRICITY SUPPLY STATISTICS.—According to the official returns, 5,549 million kilowatt-hours were generated during March at the stations under the control of the British Electricity Authority, the North of Scotland Hydro-Electric Board and the Lochaber Power Company, compared with 5,550 million kilowatt-hours during the corresponding month of 1951. Of this total, 5,361 million kilowatt-hours were generated by steam power. The total electricity sent out so far during 1952 amounts to 16,708 million kilowatts, an increase of 4·9 per cent. over the figure for the first three months of 1951. At the end of March, 1952, the installed capacity of the generating plant was 15,855 MW.

RESEARCH ON TIN.

A NEW tin-nickel alloy electroplating process, involving the use of two parts of tin and one part of nickel, has been found satisfactory for coating a wide range of motor-car parts, electrical appliances including radiators, and domestic metal ware. The coating, which is deposited bright in one operation, has an attractive metallic lustre, with a faint rose-pink colour and is claimed to be hard and as untarnishable as chromium plate. The process, it is stated in the recently issued report of the Tin Research Institute for the year 1951, was invented in 1950 and reached the stage of commercial development during the year covered by the report. On its own merits the process has received a very favourable reception which, moreover, has been stimulated by the saving of nickel which results by its use. Another tin-alloy plating process, namely, tin-zinc coating, consisting of the deposition of three parts of tin and one of zinc, is now well established and it is felt that its adoption will grow steadily. The process was originated some six years ago in the Institute's laboratory as a possible substitute for cadmium plating. The coating is white and can be used as a "utility" decorative finish.

The Institute's speculum electroplating process, which gives a coating comprising 40 per cent. of tin and 60 per cent. of copper, has now been in commercial use for the past six years and, although not entirely tarnish-resistant, its employment continues to grow. Investigations on bearing-metal alloys have continued, and those under examination have included a selection of aluminium-tin alloys. Exploratory tests have shown them to have a fatigue resistance superior to that of tin-base Babbitt metal. The bonding of the aluminium-tin alloys to steel, however, is difficult, but as many bearing manufacturers are anxious to use the new alloys, the problems are being studied by several organisations on both sides of the Atlantic. Investigations on electro-tin-plate include work in which the electrolyte is circulated at speed around a fixed steel specimen, constituting the reverse of industrial practice. The estimation, by rapid methods, of the corrosion resistance of the plate produced has also been studied profitably. Further progress has been made with an equipment for producing bars, rods and thick-walled tubes of bronze by casting the molten metal by a semi-continuous method. Another interesting alloy studied, a new pewter which can be hardened by heat-treatment, thus giving greatly enhanced resistance to mechanical damage, has been introduced to industry during the year.

LAUNCHES AND TRIAL TRIPS.

M.S. "EGREMONT."—Twin-screw ferry vessel to carry 1,472 passengers, built by Philip & Son, Ltd., Dartmouth, for the Liverpool to Seacombe service of the Corporation of Wallasey. Second vessel of an order for two. Classed and equipped for carrying 700 passengers when on cruising service on the River Mersey. Main dimensions: 145 ft. between perpendiculars by 34 ft. by 12 ft. 3 in.; mean load draught, 7 ft. 4 in. Two eight-cylinder direct-reversing two-stroke Diesel engines, together developing 1,200 b.h.p. at 330 r.p.m. in service, constructed by Crossley Brothers, Ltd., Openshaw, Manchester. Speed on trial, 13·1 knots. Trial trip, March 27.

S.S. "HOWARD SMITH."—Single-screw tug, built and engined by Hall, Russell & Co., Ltd., Aberdeen, for the Australian Steamships Proprietary, Ltd., Sydney, Australia. Main dimensions: 125 ft. between perpendiculars by 32 ft. by 17 ft. 3 in. Triple-expansion direct-acting steam engine developing 1,320 i.h.p. at 118 r.p.m., and two cylindrical coal-burning boilers. Trial trip, March 26.

M.S. "BARRINGTON COURT."—Single-screw cargo vessel, built by Short Brothers, Ltd., Sunderland, for the United British Steamship Co., Ltd. (Managers: Haldin & Co., Ltd.), London, E.C.3. First vessel constructed for these owners. Main dimensions: 445 ft. between perpendiculars by 59 ft. 9 in. by 37 ft. 7 in. to shelter deck; deadweight capacity, about 10,000 tons on a draught of 25 ft. 9½ in. Kincaid-Harland and Wolff-B. and W. six-cylinder four-stroke single-acting Diesel engine, developing 3,300 b.h.p. at 110 r.p.m. in service, constructed and installed by John G. Kincaid & Co., Ltd., Greenock. Trial trip, April 9.

M.S. "LONDON ENDURANCE."—Single-screw oil tanker, built by Sir James Laing and Sons, Ltd., Sunderland, for the London and Overseas Freighters, Ltd., London, W.1. Second vessel of a series of three. Main dimensions: 475 ft. between perpendiculars by 67 ft. 4½ in. by 37 ft. 4 in.; deadweight capacity, about 15,300 tons on a draught of 29 ft. N.E.M.-Doxford four-cylinder oil engine, developing 4,250 b.h.p. at 110 r.p.m., constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Service speed, 12½ knots. Trial trip, April 17 and 18.

RADIO TELESCOPE FOR MANCHESTER UNIVERSITY.*

IN 1931 an American scientist, Jansky, made the very surprising observation that radio waves were reaching the earth from outer space. Little notice was taken of Jansky's discovery, and by the end of the second World War it was generally accepted that these radio emissions were being generated by atomic processes in the rarefied hydrogen gas in interstellar space. At the close of the war, however, the radio and radar techniques which had been so highly developed for military purposes, were applied to this problem by groups of workers in England and Australia. In the first experiments the receiving aerials were of conventional types—that is "radio telescopes" or aerial arrays which received the radiation in a beam 10 or 20 deg. wide. The early results of Jansky were confirmed; but the resolution of these radio telescopes was very poor compared with the resolution of even a small optical telescope and it seemed unlikely that they could give much further information about the origin of these radio waves. The difficulty is fundamental because the wavelength of the radio emissions is over a million times longer than the wavelength of light. By 1948, simultaneous developments in Sydney, by Bolton and Stanley, and in Cambridge, by Ryle and Smith, led to the construction of a new type of radio telescope which, to a certain extent, overcame the severest difficulties of resolution. In principle, these systems used two separate aerials spaced by several hundred metres, the signals from the two aerials being connected to the common input of a radio receiver. Whereas the reception pattern of a single aerial consists of a main broad lobe, which narrows as the size of the aerial is increased, the reception pattern of these spaced aerial "interferometers" consists of a closely-packed system of lobes, resembling the corrugations of a fan. As the earth rotates and this lobe system sweeps over the sky, the intensity of the signal in the receiver output will remain steady, or vary only slowly, provided the source of the radiation subtends an angle large compared with the separation of the lobes. If, however, the radio signals are coming from a source which subtends an angle small compared with the lobe separation, then the signal at the receiver output will go through a series of maxima and minima.

In 1948 both groups of workers in Sydney and Cambridge used their radio interferometers to study the radio emissions from the Galaxy with the most startling results. Firstly, from Sydney, Bolton and Stanley announced that they had found an intense source of radio emission with an angular diameter of less than 8 minutes of arc in the constellation of Cygnus. Shortly afterwards Ryle and Smith discovered an even more intense source in Cassiopeia. The most remarkable feature of this work was not so much the discovery of localised sources of intense radio emission, but the complete inability to identify them with any particular visual objects in the sky. Although lacking the precision of optical telescopes, the radio interferometers can locate these intense sources with considerable accuracy. In the region of space which contains the Cygnus and Cassiopeia sources there are, of course, many visible stars, but none of outstanding visual characteristics. In fact, the most recent conclusion is that no star brighter than the 16th or 17th magnitude is near either the Cygnus or Cassiopeia radio source. Since the original work in 1948, many more of these localised sources of radio emission, or radio stars, have been located, but no one has yet been able to identify any object or class of visual objects in the Galaxy with the source.

The question arises immediately as to the number of these radio stars contained in the Galaxy. So far, the number discovered has increased with improvements in the sensitivity of the radio equipment. The answer as to how long this process of discovery will continue is not known, but the most plausible speculation is that the hundred or so now known are merely the nearest and most intense of a very large number in the Galaxy. From the strength of the unresolved emission and the strength of the signals received from known radio stars it is possible to make an intelligent guess at the total number of radio stars in the Galaxy. The answer is that the population of radio stars in the Galaxy must be very similar to the population of the visible stars. The Galaxy contains some 10^{11} stars which emit light and can be seen with the human eye and telescope. Does it also contain a similarly vast number of dark objects which generate intense radio waves and can only be seen by the radio telescope? The problem of the nature of these radio stars is certainly one of the most puzzling in present day astrophysics.

Meanwhile, at Jodrell Bank, Cheshire, Dr. A. C. B. Lovell, Professor of Radio Astronomy at Manchester University, was making a different attack on the problem of resolution—that of constructing a giant radio telescope receiving only in a single very narrow beam. The instrument is 220 ft. in diameter and with its aid, in 1950, Hanbury Brown and Hazard succeeded in detecting the radio waves from the great nebula in Andromeda, 750,000 light years distant. The implications of this experiment are far-reaching. The only reasonable conclusion is that the radio stars must populate the Andromeda nebula as well as the Milky Way system, and a comparison of the total radio emissions of the two stellar systems indicates that their radio star population must be very similar. These are merely two nebulæ in an assemblage of millions of similar ones scattered throughout the universe. It therefore seems highly probable that the objects which generate these radio emissions exist in all the external nebulæ, and the most recent experiments strongly support this view. The detection of the radio emission from the Andromeda nebula with the large radio telescope has recently been followed by the measurement of similar emissions from five other individual nebulæ, both with the radio telescope at Jodrell Bank and with the radio interferometer at Cambridge. Perhaps even more significant is the detection by Hanbury Brown and Hazard of the radio emissions from three great clusters of nebulæ which are far too closely grouped to be resolved individually by the beam of the radio telescope.

During the last few years equally startling results have been obtained in other branches of radio astronomy. The atmosphere of the sun has been found to emit radio waves and the study of these emissions is throwing new light on the conditions in the solar atmosphere; also when the solar surface is disturbed by sun spots very intense radio emission is received on the earth. The solar flares which occasionally occur in the region of sun-spot groups are accompanied by immense bursts of radio energy. The solar corpuscular streams of charged atomic particles which are then ejected take about 24 hours to reach the earth and then cause severe terrestrial disturbances, such as fade-outs of long-distance radio communication and displays of the aurora borealis. Radio astronomy also provides a new method of studying the aurora. Pulses of radio energy are transmitted through the radio telescopes and their reflection from the auroræ enable them to be studied under all conditions of daylight and cloud. These new solar and aurora studies seem destined to be a powerful factor in the study of the sun and of solar terrestrial relationships.

The radio echo or radar pulse technique has been mentioned in connection with the aurora; but the most striking application of this technique to astronomy has been in the study of meteors. For the first time in history it has been possible to study the activity of the daytime sky, and the existence of great streams of meteors incident on the sunlit hemisphere of the earth has been revealed. These move in short-period orbits and whether they are associated with comets, disintegrated minor planets or have some other origin, is not yet known. Radio techniques have also given new methods for the measurement of the very high velocities with which these meteors enter the atmosphere. The age-old controversy as to whether half the meteors come from interstellar space has been settled, and it can now be concluded that all meteors are confined to the solar system. The radio pulse technique has also been used to obtain echoes from the moon thus providing a new avenue for the investigation of the ionosphere and of the lunar surface.

The present fixed radio telescope at Jodrell Bank, though the largest in the world, is inadequate to carry this research to all regions of the sky. Manchester University, therefore, asked the D.S.I.R. for a substantial grant to pay for a large steerable radio telescope, which could be directed at will to scan any part of the sky or to follow the course of any particular star, and could also be used for research on meteors, auroræ, the sun, moon and the planets. Although D.S.I.R. was anxious to help, it seemed likely that, in view of existing commitments, the need for economy in Government expenditure might make it necessary to postpone the project. At this stage the Nuffield Foundation approached the Lord President of the Council with an offer to bear half the total cost, which is expected to approach 336,000*l*. This offer was gratefully accepted by the Lord President. The staffing and part of the running expenses of the Jodrell Bank Experimental Station will remain as before the responsibility of Manchester University. The work of constructing the world's largest radio telescope should begin this summer and will, it is hoped, be completed in less than four years. Dr. A. C. B. Lovell will be in charge of the research at Jodrell Bank, Cheshire, where the radio telescope will be constructed. The consulting engineers who have designed the radio telescope are Messrs. Husband and Company, of Sheffield and London. The diameter of the paraboloid aerial will be 250 ft. The diameter of the platform on which the radio telescope will rotate will be 310 ft. The height, to the top of the horizontal axis, will be 185 ft. When the beam from the aerial is horizontal, the total height will be 300 ft. Experimental work in relation to wind pressures on the structure has been carried out at the National Physical Laboratory. The total weight of the radio telescope carried on the rails will be 1,270 tons.

In Great Britain, climatic conditions severely handicap visual astronomy. Since the war the techniques of radar and radio, applied to astronomy, have yielded a series of discoveries about the universe. In this field of radio astronomy the pioneering work of research scientists at the Manchester and Cambridge Universities has given Great Britain a prominent, even pre-eminent, position. This work has been financed in the past both by the D.S.I.R. and the Nuffield Foundation. In 1945, the Foundation made a five-year grant to the Physics Department at Manchester University, part of which was used to develop research in radio astronomy at an experimental station at Jodrell Bank. In 1947, the D.S.I.R. began, from money voted by Parliament, to support the work both at Manchester and Cambridge. At Cambridge, important results have been obtained using interferometric methods, while at Manchester the fixed radio telescope has been used to pick up radio waves reaching the earth from sources as far distant as the great spiral nebula of Andromeda. At both universities radio waves have been recorded from sources in space which do not coincide with known visible stars, and the existence of these sources has presented a puzzle of interest to laymen as well as scientists.

The new radio telescope will be used in all aspects of radio astronomy. The priority programme will be to continue the study of the galactic and extra galactic radio emissions with particular reference to the number and nature of the dark radio stars. It will also be used to plot the intensity of the radiation, particularly from those important regions of the Milky Way system which are obscured from normal vision by the great dust clouds in interstellar space. As and when this urgent programme permits, the instrument will then be applied to solar and terrestrial studies, to meteors, the moon, and perhaps the study of the nearer planets. It is anticipated with confidence that this great instrument will do for radio astronomy what the large telescopes in America have done for classical astronomy.

* Statements issued by the Department of Scientific and Industrial Research and the Nuffield Foundation, April 25, 1952. Abridged.

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.

Protection of Packages Against Spoilage.—Exporters of non-metallic materials often have to contend with spoilage of their products resulting from attack by moulds, bacteria, insects, mites and rodents. The avoidance of such attack presents a difficult problem because it is necessary, in each case, to consider the compatibility of possible protectives with the article itself and with the material from which the container is made. Moreover, climatic conditions and other factors have to be taken into account. Guidance on these matters is contained in a newly-published section (No. 5) of the British Standard Packaging Code, B.S. No. 1133. [Price 2*s*., postage included.]

Colouring and Marking Wooden Foundry Patterns.—A revision of B.S. No. 467 : 1932, covering the colouring and marking of wooden pattern equipment for foundries, has now been issued. The new edition provides a simpler colour system than that given in the publication of 20 years ago. One colour scheme is now laid down for all patterns, irrespective of the metal to be used for the castings. The specification illustrates, by means of a diagram of a typical pattern and core box, and a corresponding lettered key, the appropriate colouring of patterns and core boxes for ferrous and non-ferrous metal castings. For the convenience of pattern shops, a wall chart, B.S. No. 467C, has been prepared; this is an enlargement of the diagram and key appearing in the specification and is intended for display in the shops. [Price of the specification, 2*s*., and of the chart, 1*s*., both postage included.]

Methods for Analysis of Aluminium and Aluminium Alloys.—Two new parts in the series of "Methods for the Analysis of Aluminium and Aluminium Alloys," B.S. No. 1728, have now been published. These comprise Part 2, covering the analysis of magnesium by the mercury-cathode method and Part 3, dealing with the analysis of zinc by the mercuric potassium thiocyanate method. An alternative method for the determination of zinc, using a polarographic technique, is in course of preparation and will be issued shortly as Part 4. Part 1, which dealt with the analysis of copper, was published in March, 1951. The methods given are recommended primarily for referee purposes. [Price of each part, 2*s*., postage included.]

NOTES ON NEW BOOKS.

The Welding of Non-Ferrous Metals.

By E. G. West, Ph.D., B.Sc., F.I.M. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 55s. net.].

Professor Leslie Aitchison, who contributes a foreword to this book, describes it as " most interesting and valuable " ; a judgment with which none will quarrel who studies it. Dr. West combines with an encyclopædic knowledge of non-ferrous metallurgy an exceptional ability to write about it clearly and concisely, and covers, in his 14 chapters, a general consideration of " weldability "—a term which, he admits freely, is rather a matter of personal opinion than of precise definition—and the various processes of welding as well as the application of these processes to the joining of aluminium, copper, nickel, lead and zinc and their alloys, and the alloys of magnesium. The last three chapters deal, respectively, with the welding of metals of low and high melting points, and of precious metals. There is an extensive bibliography, containing no fewer than 353 references, a name index—which might be even more useful if the initials of the individuals had been given in every case, and not only in two instances where surnames are duplicated ; and a good general index—in which, however, we note that oxygen-free high-conductivity copper (inadequately listed only as " O.F.H.C. copper ") is shown as being mentioned on page 311 instead of page 314. This, however, is a trivial matter in so excellent a book.

Symposium on Welding and Riveting Larger Aluminium Structures.

The Aluminium Development Association, 33, Grosvenor-street, London, W.1. [Price 6s. 6d. in cloth cover, and 4s. in boards.]

The symposium which is reported in this volume was held in London in November, 1951, and was divided into two parts, the papers on welding being presented at one session and those on riveting at another, later on the same day. The papers on welding dealt with " Recent Researches on the Arc Welding of Thick Aluminium-Alloy Plate " (by Mr. P. T. Houldcroft, Mr. W. G. Hull and Dr. H. G. Taylor), and " Practical Aspects of Argon-Arc Welding of Aluminium Alloys " (by Mr. J. R. Handforth). At the second session, Mr. J. C. Bailey presented a paper on " The Properties and Driving of Large Aluminium-Alloy Rivets," and Professor S. C. Redshaw delivered one on " The Design Characteristics of Aluminium Riveted Joints." The papers and discussions are fully reported, with the addition of some written contributions and the introductory remarks of the President (Mr. E. Austyn Reynolds) and the chairmen of the meetings. The result is a volume which should be of considerable value for purposes of reference.

CONTRACTS.

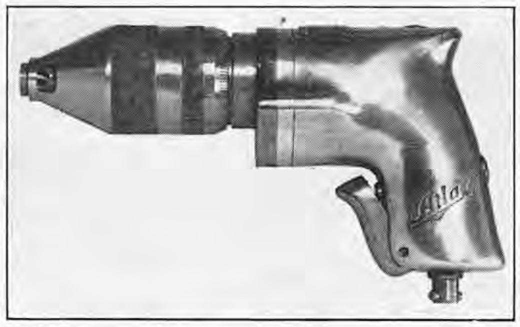
The General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2, have received an order for a 62·5-MVA 12·3-kV 428·6-r.p.m. horizontal-shaft alternator for coupling to an Escher Wyss Pelton wheel to be installed at Aura Kraftonlegg in connection with a new aluminium-producing plant now under construction at Sunndalsora, Norway. The alternator will weigh over 310 tons, the rotor alone accounting for about 170 tons. The machine will be designed and constructed so that it can be shipped in sections.

David Brown & Sons (Huddersfield) Ltd., have received an order from the Bristol Aeroplane Co. Ltd., for a set of high-speed increasing gearboxes of special design for testing engine compressors. These will replace existing plant supplied by David Brown & Sons; they have become necessary to accommodate the increased output speeds and power of the latest types of engines. One of the new gearboxes will contain single-helical, spiral-bevel and double-helical increasing gears. The remaining two gearboxes will be torque-reaction coaxial units, each with two sets of double-helical increasing gears.

The Burntisland Shipbuilding Co. Ltd., Burntisland, Fife, have obtained an order from Huddart Parker Ltd., of Melbourne, Australia, for a single-screw cargo motorship of 4,500 tons deadweight capacity. She will have a length, between perpendiculars, of 320 ft., a breadth moulded of 49 ft., a draught of 20 ft. 6 in., and a speed of 12 knots. The propelling machinery will consist of a 2,000-b.h.p. four-cylinder Ailsa-Doxford Diesel engine constructed by the Ailsa Shipbuilding Co., Ltd. Another order received by the Burntisland Company concerns two cargo motorships, each of 3,550 tons deadweight capacity, for the Prince Line, Ltd., London. The dimensions of each vessel are : length 322 ft., breadth 46 ft. 6 in. and draught 19 ft. 4 in., while the speed will be $13\frac{1}{2}$ knots. Each ship will be driven by a 2,300-h.p. four-cylinder Ailsa-Doxford Diesel engine.

PNEUMATIC TOOL FOR SHAVING COUNTERSUNK RIVET HEADS.

The accompanying illustration shows a pneumatically-operated tool for shaving off countersunk rivet heads on high-speed aircraft, where a high degree of surface smoothness is essential. The tool has been developed by the Atlas Diesel Company, Limited, Beresford-avenue, Wembley, Middlesex, and has been used successfully in Sweden by the Svenska Aircraft Company in their light jet-fighter aircraft, which call for a tolerance of not more than 0·0006 in. in the projection of the rivet head above the skin surface after shaving. The maximum size of rivets which the



tool can shave is $\frac{3}{16}$ in. diameter. It operates at 6,000 r.p.m., weighs 3 lb., and is $7\frac{1}{2}$ in. long.

The rivet shaver comprises a four-flute cutter, surrounded by an inner spring-loaded movable sleeve and an outer fixed, but adjustable, sleeve. By means of a screwed adjustment ring with a lock nut, the outer sleeve can be adjusted to give a specified distance between the end of the sleeve and the cutting edges of the cutter. The adjustment ring is provided with a circumferential scale, each graduation of which corresponds to a distance of 0·0002 in. The distance between the end of the sleeve and the cutting edge corresponds to the final projection of the rivet head above the skin surface. In use, the tool is placed with the movable sleeve surrounding the head of the rivet. The tool is then started and is carefully pushed forward against the rivet.

TRADE PUBLICATIONS.

Loudspeakers.—Shrouded loudspeakers of high electro-acoustic efficiency are described in a catalogue published by the Plessey Co., Ltd., Ilford, Essex.

Television Components.—Various television components manufactured by them are described in detail in a catalogue recently issued by the Plessey Co., Ltd., Ilford, Essex.

Wire Rope Lubrication.—The Vacuum Oil Co., Ltd., Caxton House (East), Tothill-street, London, S.W.1, have sent us a brochure, entitled " Wire Rope Lubrication." It is No. 3 in their well-known Technical Series.

Industrial Ventilation and Air-Conditioning.—An illustrated pamphlet issued by the Visco Engineering Co., Ltd., Stafford-road, Croydon, describes some of the industrial air-conditioning, heating and ventilating installations that they have carried out.

Flourescent Lighting Fittings.—A publication received from the General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2. deals fully with the fittings, control gear and accessories which they manufacture for 5 ft. 80-watt and 4 ft. 40-watt fluorescent lamps.

Tilting Mercury-Tube Relay.—A leaflet giving details of the tilting mercury-tube relay they manufacture has been received from Electrical Remote Control Co., Ltd., 13, Evanston-avenue, Highams Park, London, E.4. It is capable of operating several tubes with a switching capacity of up to 40 amperes alternating current at 230 volts.

Floor Cleaning and Treatment.—Joseph Crosfield & Sons, Ltd., Warrington, Lancashire, have issued an illustrated leaflet describing the use of Metsopol, a detergent containing sodium metasilicate and a wetting agent, for cleaning heavily soiled floors ; and of sodium-silicate treatment for hardening concrete floors to reduce the amount of cleaning required.

Crushing, Grinding and Conveying Machines.—We have received from Sturtevant Engineering Co., Ltd., Southern House, Cannon-street, London, E.C.4, three illustrated leaflets, one of which describes in detail their range of crushing rolls for producing granular material. Another leaflet gives particulars of the Moritz grinding mill for materials of moderate and extreme hardness, and the third describes their air-flow conveyors, for cement, cereal flour, pulverised coal, and similar materials which are " fluidised " by the air current in the conveyor and can be conveyed down inclines in the same way as liquids.

BOOKS RECEIVED.

Geschichte des Klosters Paradies. By Karl Schib. Georg Fischer Aktiengesellschaft, Schaffhausen, Switzerland.

Selected Government Research Reports. Vol. 8. *Wood.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1 guinea net.]

An Introduction to Mathematical Physics. By Dr. R. A. Houstoun. Blackie and Son, Limited, 16-18, William IV-street, London, W.C.2. [Price 25s. net.]

The Structural Analysis of the Dome of Discovery. By Dr.-Ing. T. O. Lazarides. Crosby Lockwood and Son, Limited, 39, Thurloe-street, London, S.W.7. [Price 25s.]

Engineering Industries Association Classified Directory and Buyers' Guide. 1952. The Standard Catalogue Company, Limited, 26, Bloomsbury-way, London, W.C.1. [Price 32s. 6d.]

Reports on Progress in Physics. Vol. XV. 1952. Edited by A. C. Stickland. The Physical Society, 1, Lowther-gardens, Prince Consort-road, London, S.W.7. [Price 27s. 6d. net to Fellows of the Society ; 50s. net to non-Fellows ; postage 1s. 6d.]

Diffusion in Solids, Liquids, Gases. By Professor W. Jost. Academic Press Incorporated, 125, East 23rd-street, New York 10, U.S.A. [Price 12 dols.]

Treatise on Powder Metallurgy. Vol. III. *Classified and Annotated Bibliography.* By Professor Claus G. Goetzel. Interscience Publishers Incorporated, 250, Fifth-avenue, New York 1, U.S.A. [Price 22 dols.]

Overseas Economic Surveys : British West Indies. By Aubrey R. Starck. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3s. net.]

Stock Control and Store Keeping. Formerly B.S. 1100 : Part 5. Revised edition. British Institute of Management, Management House, 8, Hill-street, London, W.1. [Price 4s. to members and subscribers ; 5s. to others.]

Productivity Team Report. Cakes and Biscuits. Report of a visit to the U.S.A. in 1951 of a Productivity Team Representing the British Cake and Biscuit Industries. Anglo-American Council on Productivity, 21, Tothill-street, London, S.W.1. [Price 4s. 6d. post free.]

Leeds Association of Engineers. Eighty-Sixth Annual Report and Journal. Year ending 31st December, 1951. The honorary secretary, Mr. Thomas Cooke, 86, Alwoodley-lane, Alwoodley, Leeds. [Price 5s.]

The Principles of the Control and Stability of Aircraft. By Professor W. J. Duncan. Cambridge University Press, Bentley House, 200, Euston-road, London, N.W.1. [Price 40s. net.]

Fuel Saving Charts. By Walter Goldstein. Reprinted from *The Steam Engineer.* John D. Troup, Limited, 90, High Holborn, London, W.C.1. [Price 7s. 6d., post free.]

Industrial Heat Transfer. By Professor F. W. Hutchinson. The Industrial Press, 148, Lafayette-street, New York 13, U.S.A. [Price 6 dols.] ; and Bailey Brothers and Swinfen, Limited, Minerva House, 26-27, Hatton-garden, London, E.C.1. [Price 51s.]

Exhaust Hoods. By Professor J. M. Dallavalle. Second revised and enlarged edition. The Industrial Press, 148, Lafayette-street, New York 13, U.S.A. [Price 3.50 dols.] ; and Bailey Brothers and Swinfen, Limited, 26-27, Hatton-garden, London, E.C.1. [Price 30s.]

Fluid Flow in Pipes. By Clifford H. McClain. The Industrial Press, 148, Lafayette-street, New York 13, U.S.A. [Price 3 dols.] ; and Bailey Brothers and Swinfen, Limited, 26-27, Hatton-garden, London, E.C.1. [Price 25s. 6d.]

Plastics Moulding. By John Delmonte. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 9 dols.] ; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 72s. net.]

Kempe's Engineer's Year-Book for 1952. Revised under the direction of B. W. Pendred. In two volumes. Morgan Brothers (Publishers), Limited, 28, Essex-street, Strand, London, W.C.2. [Price, two volumes in case, 70s. net.]

The Transactions of the Fourth World Power Conference. London, July 11-14, 1950. In five volumes. Edited by W. O. Skeat. Percy Lund, Humphries and Company, Limited, 12, Bedford-square, London, W.C.1. [Price 18l.]

Elements of Statistics. By Dr. C. G. Lambe. Longmans, Green and Company, Limited, 6 and 7, Clifford-street, London, W.1. [Price 8s. 6d.]

National Coal Board (Production) Codes and Rules. Surveying Practice and Statutory Plans. Part I. National Coal Board, Hobart House, Grosvenor-place, London, S.W.1. [Price 20s. net, or 13s. 6d. to students ordering through universities, technical colleges, or the Board's organisation.]

Department of Scientific and Industrial Research. Report for the Year 1950-51. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 7s. 6d.]