BRISTOL "BRITANNIA" PROPELLER-TURBINE AIR-LINER.

(*Concluded from page* 247.)

FUSELAGE.

THE fuselage structure is conventional and comprises, mainly, a 19-s.w.g. sheet skin, stiffened locally at points of stress concentration, and reinforced by continuous Z-section stringers and Z-section ring frames. It is well shown in Fig. 9, on page 246, *ante*. The lower part of the frames are of deeper section and form horizontal transverse beams for the freight-hold floor, which is designed for a general loading of 75 lb. per square inch and a maximum unit load of 600 lb. on 3 sq. in. At the stations corresponding to the wing shear webs are two heavy box-section frames; one of these can just be seen in Fig. 13, below, which actually shows the full-scale test structure in the final assembly jigs. The forward and rear walls of the main frames are extended and riveted to the shear webs. The forward pressure bulkhead, which includes the windscreen structure, is hemispherical, and extends down to a pressure floor, below the pilot's floor. The pressure floor is reinforced by two deep longitudinal shear webs, leaving an unpressurised nose compartment for housing the retracted nose wheel and the radar scanner. The rear pressure bulkhead is made of a flat plate reinforced on its forward face with a Redux-bonded corrugated skin, and stiffened on its rear face, as illustrated in Fig. 16, on Plate XI, with vertical and horizontal I-section extrusions which provide the forward three-bolt attachment point for the fin, and two single-bolt forward attachment points for the tailplane.

The cabin floor, which is stressed for a distributed load of 33 lb. per square inch and a maximum unit load of 200 lb. on 1 sq. in., is carried on stiffened transverse beams, each of which is supported by two vertical pillars extending from the base of the fuselage frames. Eight longitudinal seat bearers are carried on the transverse beams, and readily-detachable floor panels are mounted between the seat bearers. The floor panels are of sandwich construction with Durestos (a reinforced-asbestos plastic) outer laminations and a balsa-wood core. This type of construction is said to give the best available combination of heat insulation, fire resistance, wear, and low weight.

The cabin windows are elliptical and have double Perspex windows with a dry air space between the panels. Their frames are of hot-formed and welded magnesium-zirconium extruded sections. Five of the windows on each side are specially large and can be used as emergency escape hatches. The door frames are also formed from magnesium-zirconium. All the doors and freight-loading hatches are arranged to open inwards, but the passenger doors, on the port side, slide forwards after an initial inward movement. They are provided with emergency-pin release so that they can be lowered to form crash exits. Door sealing is by rubber tubes permanently inflated with nitrogen.

ASSEMBLING THE FUSELAGE.

In building up the fuselage panels, the skin is laid on a panel jig and the stringers and frame sections, already drilled, are then located in the same way as the wing skin. After jig-drilling the skin, the panel is dismantled for countersinking the rivet holes for flush riveting. In the case of the lighter-gauge fuselage skin, however, the Bristol process of close-tolerance "spin dimpling," which eliminates inter-rivet buckling, has been adopted instead of cut-countersinking. Fig. 14, on page 259, shows one of the power-operated spin-dimpling machines, which comprise a rotating male die, which spins the work into a female die, with no cutting action. The machine is foot-controlled and is automatically timed to give a controlled depth of dimple.

After dimpling, the skin panel, with the stringers and the frames, is replaced on the jig and the panel assembly is squeeze-riveted by a specially-developed machine, illustrated in Fig. 17, on Plate XI, and similar in principle to the wing squeeze-riveter. After spraying on a protective rubber coating to avoid damaging the skin surface, the riveted skin panels and the floor structure are assembled, with the butt straps for the skin joints in a series of contoured fuselage jigs, and the final dimpling and squeeze riveting of the various fuselage sections—front, intermediate, rear, and stern portion—is carried out in a similar manner. In Fig. 20, on Plate XII, can be seen the servicing tower, with adjustable working platforms, used in assembling the fin and rudder. The fuselage sections are then removed from the jigs on to fitting-out trolleys, where various items of fixed equipment are installed. They are then placed on the mobile jigs, similar to those used for the finished wing sections, and are transferred to the assembly hall for final assembly of the structure. Fig. 13, below, gives a good idea of the method of locating the jig trolleys on the ground.

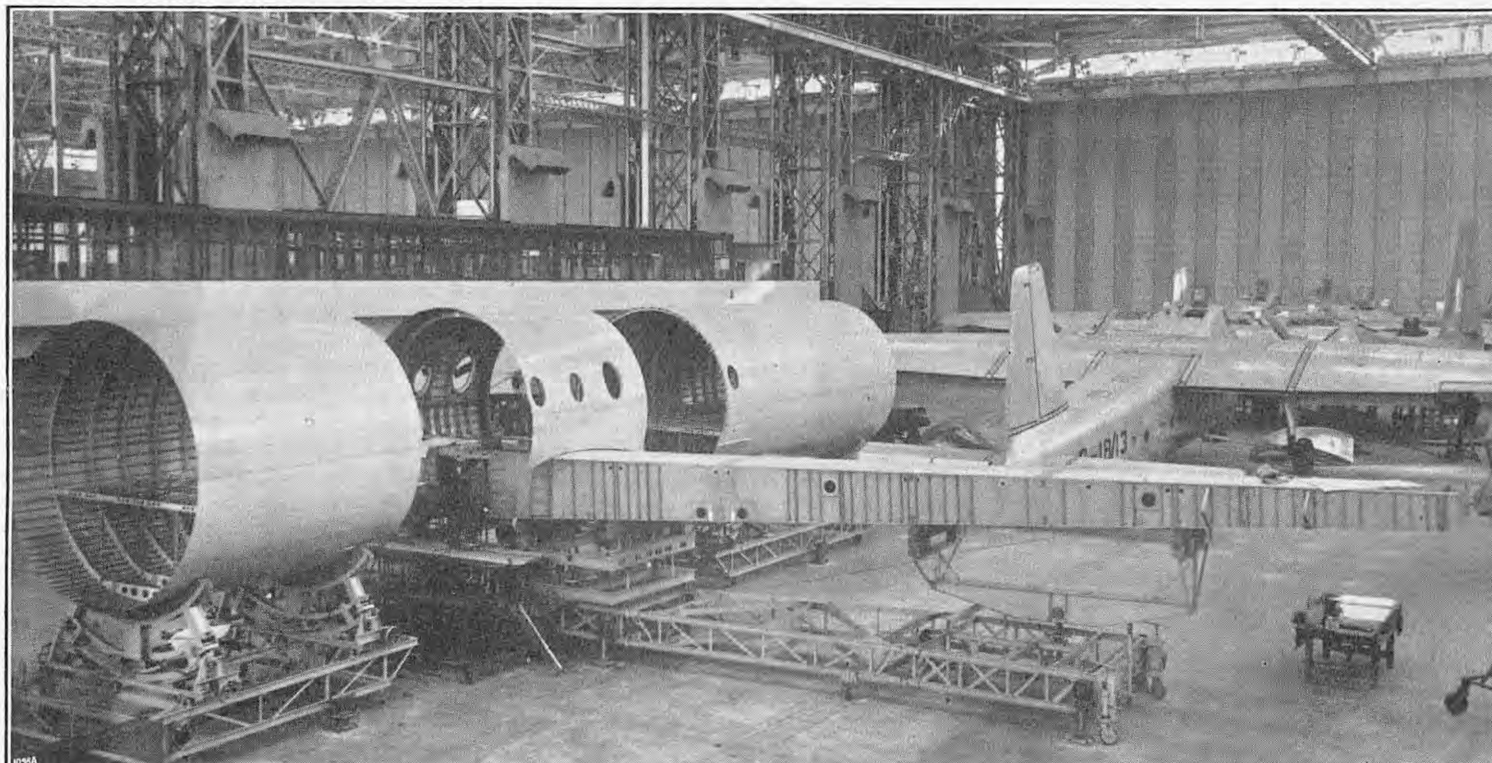

FIG. 13. MOBILE FINAL-ASSEMBLY JIGS.

WING FLAPS.

The flaps are constructed in two sections—an inner section extending between the fuselage and the inboard nacelle, and an outer from the inboard nacelle out to the aileron rib. Fig. 21, on Plate XII, shows the outer flap on the port wing. As already noted, they are of the double-slotted type; the first slot, formed between a fixed leading-edge slat and the main flap surface, is exposed after 20 deg. of flap movement, i.e., the take-off flap setting. The second slot, between the wing trailing edge and the flap slat, opens after 35 deg. The maximum flap deflection is 45 deg. The flaps run on steel rollers along circular-arc tracks carried on the trailing-edge ribs. They are electrically operated by two 112-volt direct-current motors, within the fuselage. The motors are coupled through a differential epicyclic reduction gearbox, so that, should one motor fail, it is still possible to drive both pairs of flaps using the other motor. The failed motor is automatically stopped by an electrically-actuated brake. The drive is taken through universally-jointed torque shafts, supported from the rear wing spar, to two screw jacks in each flap section.

Four pre-selected flap positions are available, the motor field circuits being switched off by a two-segment drum switch driven through a gearbox on the flap torque shaft when the selected position is reached. A follow-up from this gearbox is arranged to re-trim the aircraft automatically as the flaps are lowered. In addition to the pre-selector switch, there is an independent inching switch to allow for operating the flaps, in conjunction with the flap position indicator, in the event of failure of the drum switch or pre-selector.

FLYING CONTROLS.

The flying-control system adopted in the Britannia is unusual in an aircraft of its size and speed, in that no power assistance is used. Thus the necessity for providing duplicated controls, to guard against failures of power-operated components, has been avoided, and it seems likely that the maintenance work will be correspondingly less. A full-span servo-tab system is used on all three controls: the pilot's controls are connected only to the tabs on the elevator rudder and ailerons, and the main surfaces, which are free to float, are operated by the aerodynamic loads imposed by the tabs. All three surfaces are aerodynamically balanced, a horn balance being fitted on the elevator to ensure good longitudinal stability. Since the tab hinge moments transmitted to the pilot are quite small, artificial "feel" proportional to the surface deflection is provided by a torsion spring anchored to the airframe at one end and, through a lever, to the control circuit at the other end. The position of the spring anchorage can be varied to trim the control loads. A mechanism for varying the "feel" in response to changes in air speed is under development, but it is not fitted on the prototype aircraft.

The pilot's control movements are transmitted by levers and push-pull rods to step-up gearboxes below the pilot's floor, and thence through universally-jointed torque shafting below the cabin floor; in the case of the elevator and rudder, the torque shafts drive variable-ratio reduction gearboxes at the rear end of the fuselage, and thence through a lever and push-pull rod linkage to the servo tabs on the control surfaces. The variable-ratio gearbox, which employs elliptical gears, reduces the rate of control-surface movement at high deflections. The torque-shaft drive to the ailerons is divided and changed in direction by a 1-to-1 bevel gearbox, and thence through a variable-ratio drive. The use of torque shafting for transmitting the control movements has been adopted instead of push-pull rods or cables, because it is lighter, is not seriously affected by temperature, and offers the minimum of backlash.

In order to lock the control surfaces for parking, a hydraulic locking jack is provided at each surface, operated by the pilot from the main hydraulic system. Five warning lights indicate when the surfaces are locked. To provide against taking off with the controls locked, the pilot's locking lever and the engine control levers are interlocked so that, in the locked position, it is impossible to open all four throttles to give full power. It is, however, possible to open up one engine at a time for checking maximum r.p.m.

UNDERCARRIAGE.

The undercarriage, comprising two main four-wheel bogie units and a twin nose-wheel unit, is designed and built by British Messier, Limited, Cheltenham, who are also responsible for the design of the hydraulic system which provides for the retraction of the landing gear, the operation of the Dunlop hydraulic brakes on all the main bogie wheels, and the flying-control locking system. The bogie units, which consist of an oleo strut with a bogie beam pivoted about its lower end, retract backwards into the inboard nacelles. In order to do so, the bogie beam has first to be rotated by a hydraulic jack so that it lies parallel with the oleo strut. At the end of this movement, a sequence valve directs oil pressure to the main retraction jack, and the whole unit retracts backwards into the nacelle. When the undercarriage is in the down position, the bogie can pivot through about 15 deg., but is restrained from violent oscillations by a damper. The main wheel brakes are operated by toe pedals on the rudder pedals.

The nose-wheel unit retracts forward into the nose of the fuselage below the pressure floor. The nose wheel can castor freely, or it can be steered hydraulically by a double-acting jack, through 50 deg. on each side of the centre-line. Sharper turns than this are not desirable since the side loads imposed upon the bogie wheels would cause excessive tyre wear. The undercarriage doors are mechanically operated; the main units are each enclosed, when retracted, by three pairs of doors, and the nose wheel by two pairs. In order to reduce drag for take-off, the aft pair of main-unit doors and the forward pair of nose-wheel doors are arranged to close when the undercarriage is down.

HYDRAULIC SYSTEM.

The high-pressure hydraulic system developed by British Messier, Limited, is supplied by four engine-driven hydraulic pumps, connected in parallel, two being driven from each inboard accessory gearbox. The pump suction inlets are connected to a hydraulic reservoir in the unpressurised under-floor space forward of the wing. The common pump delivery line is connected to a hydraulic accumulator, and to the various services. An automatic cut-out is arranged to unload the pumps at a line pressure of 4,000 lb. per square inch, and to bring them in again when the pressure falls to 3,500 lb. per square inch. In addition, a relief valve is provided in the pump circuit to guard against failure of the automatic cut-out. The return lines from the services are taken to the hydraulic reservoir. All the hydraulic components and pipelines are located below the cabin floor, and great care has been taken to ensure that there shall be no undetected leakages which could give rise to a fire hazard. Fig. 22, on Plate XII, shows a typical set of pipe unions, grouped on a metal tray and spread conveniently to allow for easy dismantling. They are enclosed by a Perspex cover, which, in the event of leakage, becomes spotted by the fine high-pressure spray, and thus gives a visible indication that servicing is required.

The Dunlop wheel-brake hydraulic system is operated, through duplicated lines, at a reduced pressure of 1,500 lb. per square inch. Hydraulic accumulators are provided in the brake hydraulic circuit and in that of the flying-control locking jacks in order to maintain the services under pressure. The undercarriage selector valves are electrically operated.

In addition to the main hydraulic system, an emergency hydraulic system is provided for lowering the undercarriage. The emergency system employs the same undercarriage jacks and up-locks, but it uses completely separate pressure lines and is fed from a separate hydraulic reservoir by its own electrically-driven pump or by a hand pump. When the emergency system is in use, the main system is isolated from the operating jacks by shuttle valves adjacent to the jacks.

POWER PLANTS.

The photograph reproduced in Fig. 18, on Plate XI, shows clearly the engine mounting and cowling arrangements of the Proteus 625 engines installed in the prototype Britannia; the production Proteus 705 engine is somewhat more compact, as described on page 792 of our 173rd volume (1952), and the mounting will be slightly modified. Both power plants, however, are designed for convenient access and speedy engine changes. All the engine controls are electric, and an 11-gallon oil tank and oil cooler, installed in one of the fixed cowling panels (which, as may be seen in Fig. 18, are double-skinned), form part of the interchangeable power plant. The power plant also includes primary heat exchangers for the wing de-icing system. The number of pipe connections, therefore, are kept to a minimum. The space between the inner and outer skins of the cowling panels form heating ducts into which gases from the turbine casing may be bled for anti-icing the engine.

The nacelle is divided into three fire zones, by stainless-steel ribs and fireproof bulkheads, and all piping, wiring and equipment in the fire zones is, so far as possible, flameproof. Fire detectors are located at strategic points in each zone, and are connected to warning lights in the cockpit. A fire-extinguisher spray ring is provided in each zone, into which can be discharged, simultaneously, the contents of two 12-lb. Graviner methyl-bromide bottles carried in each power plant. The engine fire-extinguisher system is operated electrically through push-buttons controlled by the pilot. It is also operated automatically, in the event of a crash, by inertia switches in the nose of the fuselage and the inboard nacelles, which close when the aircraft deceleration exceeds $3g$.

ENGINE CONTROLS.

In the Proteus, one turbine drives the compressor and a second turbine drives the propeller. The two turbines are not mechanically coupled, and therefore the speeds of the compressor and of the propeller are controlled quite independently. The compressor speed controls are supplied by Ultra Electric, Limited. The system provides remote actuation of the high-pressure fuel cocks regulating the fuel supply to the combustion chambers, in response to the pilot's throttle-lever movements; and, by a completely separate electronic circuit, it automatically governs the speed of the compressor to within $\pm \frac{1}{4}$ per cent., over a maximum control range of 20 per cent. The Ultra controls also automatically close the high-pressure fuel cocks, in response to signals from thermocouples installed in the engine tailpipe, if the jet-pipe temperature exceeds the maximum permitted value.

The remote actuation of the engine fuel cock is carried out by means of a resistance potentiometer operated by the pilot's throttle lever and a resetting potentiometer which is driven by a rotary electric actuator operating, through a reduction gearbox and a differential gear, the high-pressure fuel cocks. An emergency standby rotary actuator is coupled through the other side of the differential. The two potentiometers are connected in a bridge circuit, so that when the pilot shifts his throttle lever the bridge is unbalanced, causing a relay to be energised, which switches in the rotary actuator. The latter rotates until the resetting potentiometer is again balanced with the pilot's potentiometer. If, however, a fault develops in the bridge circuit so that the rotary actuator tends to "run away," a relay breaks the circuit as soon as the relative displacement between the two potentiometers, which is normally small, exceeds a predetermined value.

PROPELLERS AND THEIR CONTROLS.

The Britannia is the first British air-liner to be fitted with de Havilland hollow-steel propeller blades (other than an Ambassador aircraft that served as a flying test-bed for proving the propellers). The construction of the hollow-steel blades was described on pages 161, 193, and 225 of our 172nd volume (1951). The 16-ft. Hydromatic propellers are fully-feathering and reversible in pitch, and are provided with electro-thermal de-icing elements. One propeller is shown in Fig. 19, on Plate XI. The pitch-changing mechanism is hydraulically operated, using oil drawn from the engine tank, and is regulated by a controller which is electrically actuated in response to the pilot's signals. An automatic hydraulic pitch lock is provided in the pitch-changing mechanism which, in the event of failure of the controlling oil pressure to the propeller, automatically locks the blades at the pitch in which they happen to be in. Should, however, the failure be due to the control valve in the constant-speed unit sticking in the fully-fine position, serious overspeeding could occur; to overcome this, an automatic pitch-coarsening circuit, actuated by an engine-driven tachometer-generator, is introduced, which comes into action when, and for as long as, the propeller speed exceeds the maximum permissible

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BRISTOL AEROPLANE COMPANY, LIMITED, FILTON, BRISTOL.

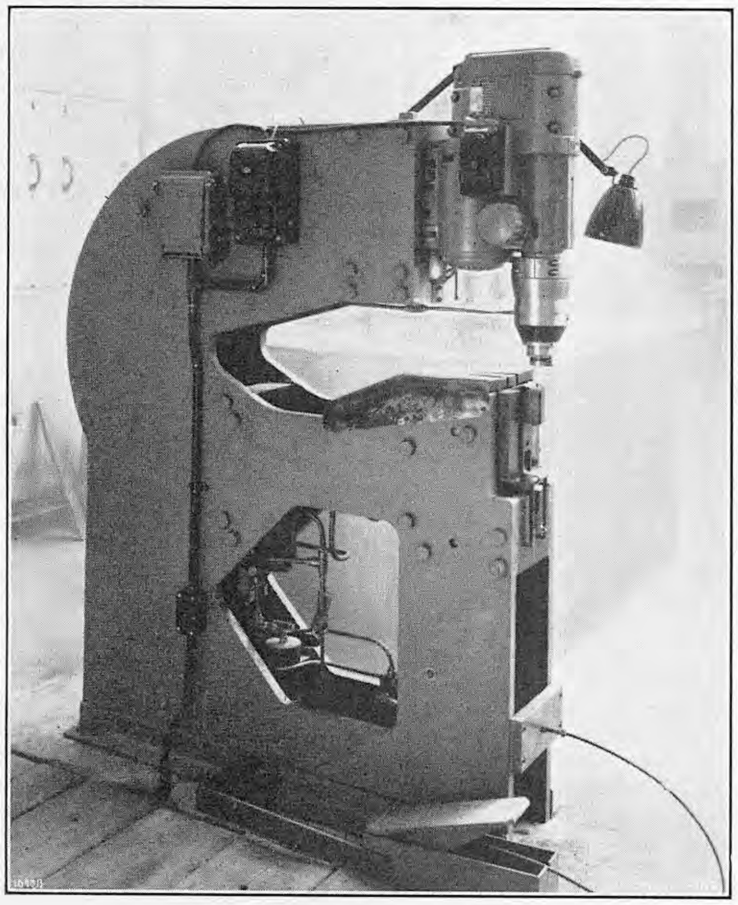


Fig. 14. "Spin-dimpling" Machine.

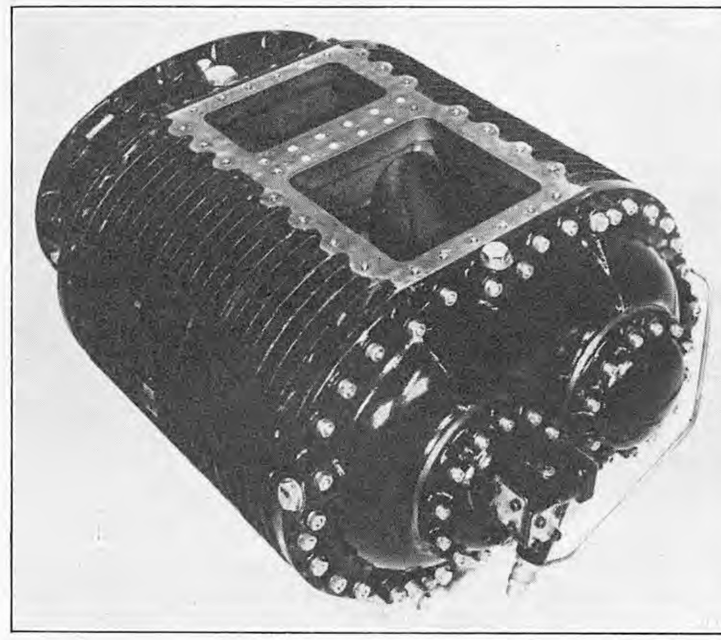


Fig. 15. Godfrey Cabin Supercharger.

revolutions by about 5 per cent. Another speed-sensitive circuit, responding to the rate of change of speed, coarsens the pitch at a predetermined value of engine acceleration.

The three-phase rotary actuator which controls the setting of the constant-speed unit can be used either for individual speed selection on each propeller, or for synchronising all the propellers with a master propeller. The pilot has a control unit on which are mounted individual and synchronising selector switches, with their corresponding speed "increase-decrease" switches, together with an over-riding switch for selecting maximum revolutions per minute in an emergency, and ground-test switches. When the pilot is setting the speed of a selected propeller the three stator windings of the electric actuator are connected to the aircraft 28-volt direct-current supply by relay contacts; the relays act in sequence and give rise to a rotating field in the stator windings which is followed by the permanent magnet rotor. In an emergency, when the "maximum revolutions per minute" switch is operated, the ordinary speed setting switches and the synchronising circuit are over-ridden and the actuator stators of all the propellers are connected to the sequence relays, which then operate at the high-speed rate. After individually setting the propeller speeds, the pilot can switch over to synchronising; the tachometer-generator driven from the "slave" propeller turbine and that on the "master" propeller turbine (which may be either the port inner or starboard outer) are connected to a three-phase bridge rectifier system, so that any out-of-phase relationship between the slave and the master results in voltage variations in the bridge rectifier networks, which bring in another set of sequence relays. These relays feed the stator coils of the slave actuator, which adjusts the speed of the slave-propeller turbine to that of the master.

During feathering, which is carried out by a feathering pump supplied from a separate reserve compartment in the engine oil tank, the rotary actuator also moves in the coarse-pitch direction. In the case of a master propeller being feathered, the synchronising circuits are automatically switched off. When unfeathering, another over-ride circuit operating from the tachometer-generator is arranged to come into action and cut out the unfeathering circuit when the propeller speed has risen to about 30 per cent. of the maximum revolutions per minute.

To reverse the pitch of the propellers for braking, the throttle levers are retracted to the "flight idling" position, and a brake selector lever is then engaged. This actuates a linkage reversing the direction of the throttle control movements, so that further backward movement of the levers increases the propeller speed in reverse pitch. It also closes a relay energising the braking circuits. The throttle levers are then shifted to a "brake idling" position; this action energises three solenoids, one controlling a reversing valve which directs "coarse pitch" oil from the coarse-pitch port into the fine-pitch line to the propeller, one controlling the coarse-pitch valve, which directs the output of the constant-speed pump into the fine-pitch line, and one restraining a low-pressure relief valve in the fine-pitch line from opening at the normal value. This allows hydraulic pressure to build up to 300 lb. per square inch and to open a valve controlling a servomechanism which withdraws the fine-pitch stop that normally restrains the blades from "fining" beyond the take-off position.

Fuel System.

There are nine flexible bag tanks in each wing, made of Hycatrol, a synthetic material that remains adequately flexible down to − 70 deg. C. They are connected in two groups of five outboard and four inboard tanks. The total fuel capacity is 6,800 Imperial gallons. The two groups of tanks on one side feed by gravity through tank-isolating cocks and a non-return valve into an 11-gallon collector box, in which there are two electric fuel pumps. The latter deliver fuel through a non-return valve and a wing isolating valve, into a common feed line from which branch pipes are taken to the two engines on the same side. In each engine line there is a flowmeter transmitter unit and a shut-off cock. The fuel systems in each wing are interconnected by a cross-feed which is, however, normally closed by a cross-feed cock. All the fuel cocks are electrically operated. Pacitor fuel contents gauges are provided in each group of tanks.

In each outer nacelle there is an underwing pressure-refuelling point, which is used both for delivering and for off-loading fuel. Fuel can be delivered to the aircraft tanks at a maximum rate of 150 gallons per minute at a bowser-pump pressure of 25 lb. per square inch. The refuelling galleries, however, are designed to withstand a pressure of 50 lb. per square inch. Float-operated shut-off valves in each tank close automatically when the tank is filled. The tanks are also fitted with gravity fuelling points.

A fuel-jettisoning system is also provided. The jettison pipes are retractable, and can be lowered electrically provided that the flaps are extended. The jettison valves can only be operated when the jettison pipes are lowered.

Electrical System and Radio.

The Britannia has three electrical supply systems—a 200-volt alternating-current system supplying the electro-thermal de-icing circuits for the propellers, windscreen and tail surfaces, the air-conditioning and refrigerator fan motors; a 112-volt direct-current system supplying the engine starter motors, the flap motors, cabin lighting, pantry and toilet services, and inverters supplying alternating current at a controlled frequency to the gyroscopic instruments and the automatic pilot; and a 28-volt direct-current system supplying the essential and emergency lighting services, radio, instruments, fuel cocks and engine controls.

Each propeller-turbine drives a 32-kVA dual-wound alternator; one winding provides the 200-volt alternating supply, and the other winding a 104-volt alternating supply which furnishes the direct-current supplies through a 112-volt 10-kW metal rectifier and a 28-volt 2·5-kW rectifier. The alternating voltage is not regulated, and depends upon the loads in the 112-volt system. In each direct-current system, the four rectifiers are connected to a common 'bus-bar, and load-balancing and current-limiting circuits ensure that the load is shared equally by the four rectifiers. The 112-volt direct-current system is regulated to within $\pm$ 3 volts by a carbon-pile voltage regulator in each supply line. A 15-ampere hour battery is connected to the 112-volt 'bus-bar, providing a reserve of power for 20 minutes. The output voltage of the 28-volt direct-current rectifier is regulated to within $\pm$ 5 per cent. by a saturable-choke control in each rectifier channel. A 50-ampere-hour 24-volt battery gives a 20-minute reserve for operating the essential services. The cooling of the alternators is satisfactory, both in flight and during ground running. During flight the rectifiers are adequately cooled by ram air, but require additional cooling on the ground. For ground running, therefore, only the outboard power-supply system is used, since the outboard rectifiers only are cooled by a jet pump connected to the compressor turbine, switched on by a ground-selector switch.

Provision is made for installing duplicated high-power high-frequency radio transmitters and high-frequency receivers, which can be controlled either at the radio-operator's station or by the pilot; a single medium-frequency/high-frequency high-discrimination receiver controlled at the radio-operator's station; a multi-channel very-high frequency transmitter-receiver for remote operation by the pilot; twin manual/automatic direction-finding sets; instrument-landing system equipment; visual omni-range equipment; distance measuring equipment with homing facility; cloud and collision-warning radar; intercommunication system; and a passenger entertainment and public address system. Apart from "ramshorn" aerials for the instrument landing system and visual omni-range, and a sword aerial for the very-high-frequency equipment, the aerials are "buried" in the aircraft structure.

Cabin Air Conditioning.

The pressure in the cabin, flight deck, and freight holds can be maintained at the value equivalent to an altitude of 6,000 ft. up to an actual altitude of 35,000 ft., the maximum pressure differential between the inside of the cabin and the atmosphere being 8·3 lb. per square inch. Most of the air-conditioning plant—the superchargers, refrigerators, water separators, and ground-conditioning fans—were developed by Sir George Godfrey and Partners, Limited. Automatic cabin-pressure controls, supplied by Normalair Limited, enable the height at which pressurising begins to be pre-selected, and the cabin "rate of climb" to be regulated at any value between 100 and 1,000 ft. per minute. The cabin temperature can be regulated between 17 deg. and 24 deg. C., with an ambient temperature ranging from $-$ 70 deg. C. to $+$ 24 deg. C.

Two independent pressure systems are provided, one in each wing, so that, should one system fail, the other will continue to maintain the cabin pressure, but the mass flow of fresh air will be halved. Fresh air enters through leading-edge inlets adjacent to the outboard engines, and is supercharged and heated by two positive-displacement Root's-type two-stage cabin superchargers, one driven by each outboard engine. One of these superchargers is shown in Fig. 15, on page 259. With both blowers in operation, the maximum mass flow of fresh air to the cabin, at altitude, is 104 lb. per minute at 27,500 ft., falling to 76 lb. per minute at 35,000 ft. The rate of air flow within the cabin, however, is increased by re-circulation. The mass flow of air is controlled by Normalair spill valves in the ducting, which direct excess air overboard through outlets in the underside of the wing. A "dump" valve is also provided to isolate either blower from the cabin system if it is desired to ventilate the cabin directly by ram air. The spill valves are normally regulated automatically by a Venturi controlling a pressure switch. From the blower, hot pressurised air passes through a silencer and thence through an aftercooler cooled by ram air, in the outboard nacelle. Air leaving the aftercooler is ducted to the inboard nacelle, where it passes through a filter and a temperature-regulating throttle valve, which is electrically-controlled by a thermostat pre-set by the steward. In hot and humid conditions, the air, after passing the throttle valve, can be led through a refrigerator, or, alternatively, it can by-pass it. The refrigerator by-pass valve also is controlled by the pre-set thermostat regulating the throttle valves.

The refrigerator is a Godfrey cold-air unit comprising a free-running centrifugal compressor coupled to an inward-flow turbine, the latter being driven by the cabin-ventilating air itself. The cycle of operations is as follows: hot pressurised air enters the compressor inlet and is further compressed and heated. From the compressor outlet, it enters a heat exchanger cooled by ram air, and is cooled at constant pressure to about the same temperature as the compressor intake temperature. From the heat-exchanger outlet, the air expands across the turbine and in doing so is further cooled. For ground operation, a cooling fan for the refrigerator operates only when a selector switch is on, and a jet pump in the outboard nacelle operated by a bleed from the compressor turbine entrains cooling air through the aftercooler.

The refrigerator by-pass duct is joined by a direct-ventilation duct, served by ram air from the main inboard-engine intake, but normally kept closed by a valve which can be opened in the event of both pressure systems failing. The pressurised and temperature-conditioned air is then ducted into the unpressurised wing centre-section, and through a water separator which, in conjunction with the temperature controls, automatically maintains the relative humidity below 70 per cent. when operating in very humid conditions. The dry air then enters the main pressure-cabin distribution duct through a non-return valve, and the two pressure systems from each wing unite. In the port system only, a branch duct, by-passing the water separators, introduces a fresh-air supply, at a lower temperature, which is led through individual louvres in the cabin below the luggage racks, controllable by the passengers. The main fresh air supply is mixed with filtered and deodorised cabin air by two Godfrey recirculating fans driven by induction motors. Air from the toilets and the galley is not, however, recirculated, but is discharged directly to atmosphere.

Fresh dry air is distributed to the cabin and the flight deck through ducts formed by the Fibreglass cabin insulation, which is 1 in. thick, and the trim-cloth. It enters the cabin at ceiling level through perforations in the trim-cloth. At the high altitudes at which the Britannia will normally fly, the pressurised warm air entering the cabin will usually be very dry. An electrically-heated boiler is therefore provided in the cabin for injecting steam into the ventilating air. It is controlled by a humidistat to maintain the relative humidity between 27 per cent. and 32 per cent. The air is discharged, through floor grilles, to aneroid-controlled Normalair cabin-discharge valves which regulate the cabin pressure. There are additional safety valves to limit the maximum differential pressure to 9·3 lb. per square inch, and an inwards-relief valve prevents the cabin pressure from falling by more than $\frac{1}{2}$ lb. per square inch below that of the atmosphere, as could happen during descent. All the air-conditioning valves were supplied by Normalair Limited.

Below the cabin floor, the fuselage walls are not insulated. The freight holds are ventilated by an adjustable supply of dry fresh air and their temperature can be regulated between 0 deg. C. and 10 deg. C. Should fire break out in the freight holds, the ventilation is automatically cut off when the carbon-dioxide fire extinguishers, installed in the holds, are discharged.

De-Icing Systems.

To give warning to the pilot when the aircraft is entering ice-forming weather conditions, two ice detectors are mounted on the fuselage nose, operating warning lights in the cockpit. As mentioned already, the wing leading edges contain ducts which, under icing conditions, may be fed with hot air to prevent the formation of ice on the wing surface. The hot air supply is provided by a heat exchanger in each power unit, the primary circuit of the heat exchanger being supplied with hot gas bled from between the compressor and propeller turbines. A valve controlling the bleed is automatically regulated by thermostats on the wing skin near the nacelle, provided that the pilot's master icing switch is on. The engine air intakes are also heated automatically in icing conditions by hot gas, bled from between the compressor and propeller turbine stages, and diluted by air drawn in by a jet pump. The Proteus engines themselves are protected against ice formation in the compressor by feeding hot air from the compressor through the first row of stator blades, which are hollow.

Electro-thermal cyclic de-icing systems are provided for the fin, tailplane, and elevator horn balances, and for the propeller blades and spinners. On the tail surfaces, there are external heater mats extending back to about 15 per cent. of the chord on both the upper and lower surfaces. Strips along the leading edge and at the end of each mat are continuously heated when the tail de-icer system is switched on; the remainder of the heater mat is divided into 16 areas which are heated cyclically. The cycle time can be regulated by the pilot, according to the ambient temperature. The propeller blades and spinners have internal heater elements, and are fed on a 1-in-4 cycle by one of the engine-driven alternators, which supplies each propeller in turn. A choice of two cycle frequencies can be selected by the pilot, according to the ambient temperature.

The windscreen is also electrically heated, but in this case the supply is continuous. The six front panels are of sandwich construction, comprising a plastic vinyl sheet between tempered glass panes. A Nesa electrically-conductive coating is applied between the outer pane and the vinyl layer. The latter embodies a temperature-sensitive element which regulates the voltage applied to the heating film. A second temperature-sensitive element is provided to guard against the failure of the first element and to prevent the panel from overheating. The heat applied to the Nesa element can be controlled in three stages to allow for gradual warming up. At low altitudes, a moderate degree of windscreen heating is recommended even in non-icing conditions, in order to raise the impact strength of the windscreen in case of chance collisions with birds.

Emergency Services.

The Britannia's power-plant fire-protection system, consisting of flame-detector switches, crash switches, and electrically-operated methyl-bromide fire-extinguishers has already been described briefly, and reference has also been made to the carbon-dioxide fire extinguishers installed in the under-floor freight holds. There are two such extinguishers—semi-portable manually-operated 12-lb. bottles, one in each hold near a floor hatch through which access can be made from the cabin during flight. The bottles, which are also connected to the crash inertia switches, have flexible nozzles that are connected when not in use, to the wing roots. Thus, in the event of a crash, they operate automatically and flood the wing roots with carbon dioxide.

"BRITANNIA" PROPELLER-TURBINE AIR-LINER.

BRISTOL AEROPLANE COMPANY, LIMITED, FILTON, BRISTOL.

(*For Description, see Page* 257.)

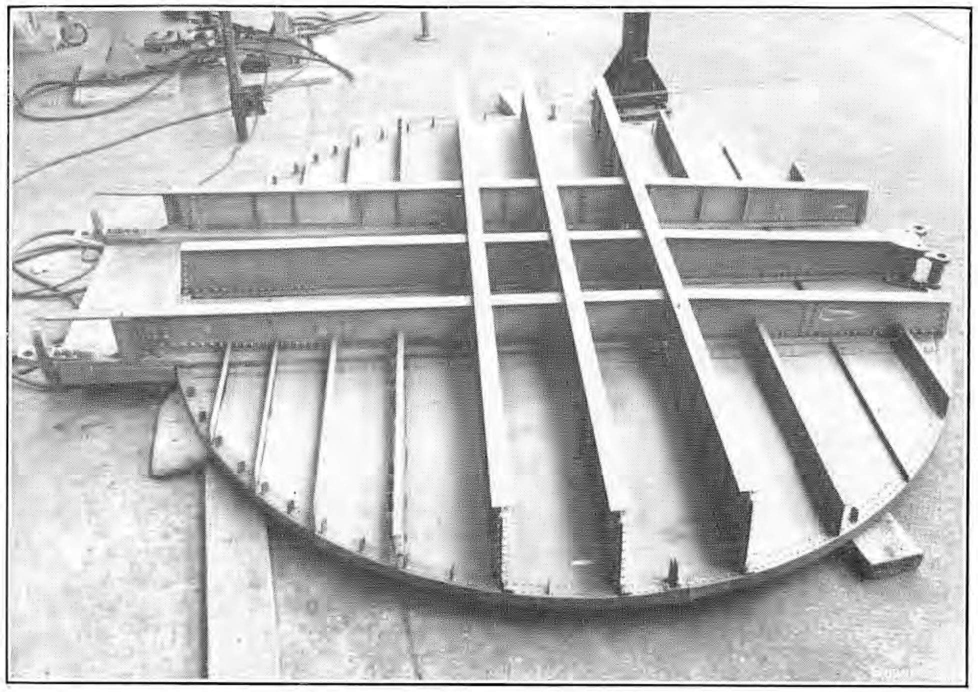


FIG. 16. AFT SIDE OF REAR PRESSURE BULKHEAD.

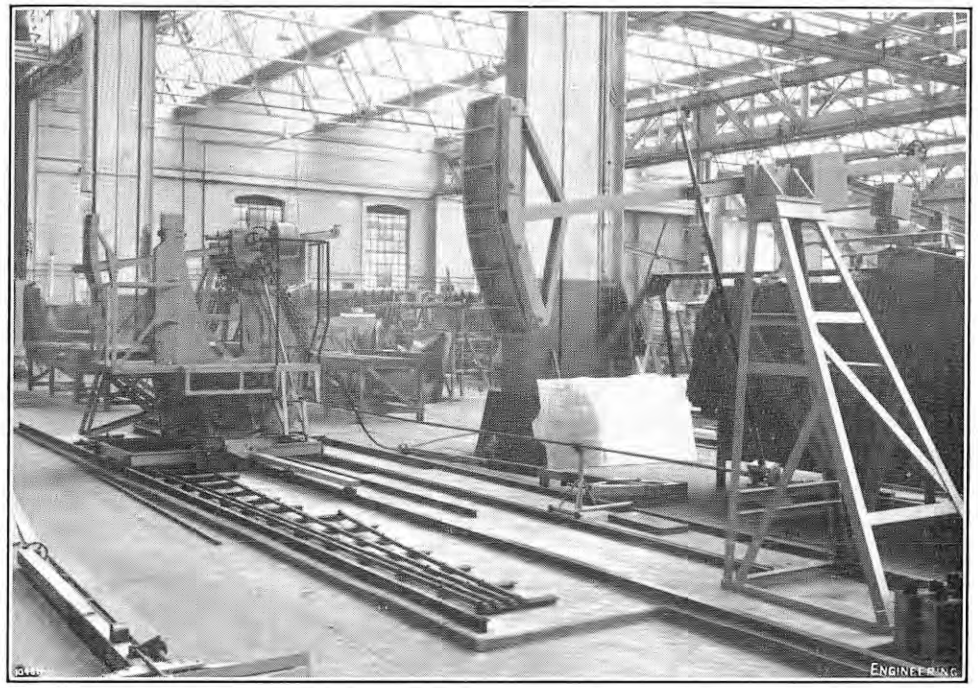


FIG. 17. HORIZONTAL SQUEEZE-RIVETER FOR FUSELAGE PANELS.

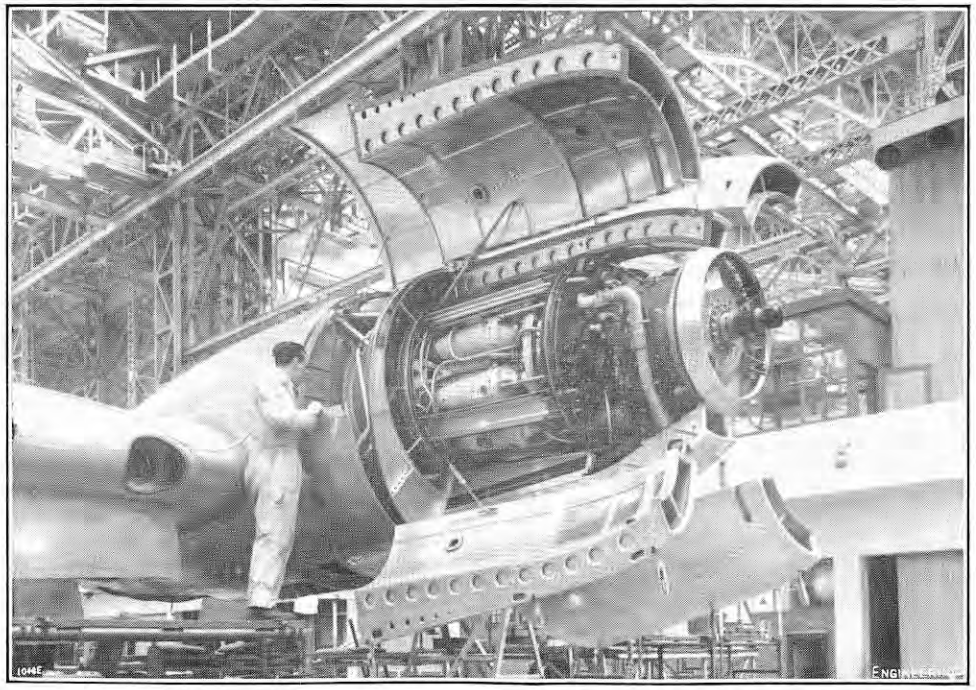


FIG. 18. "PROTEUS 625" POWER PLANT, BEFORE FITTING PROPELLER.

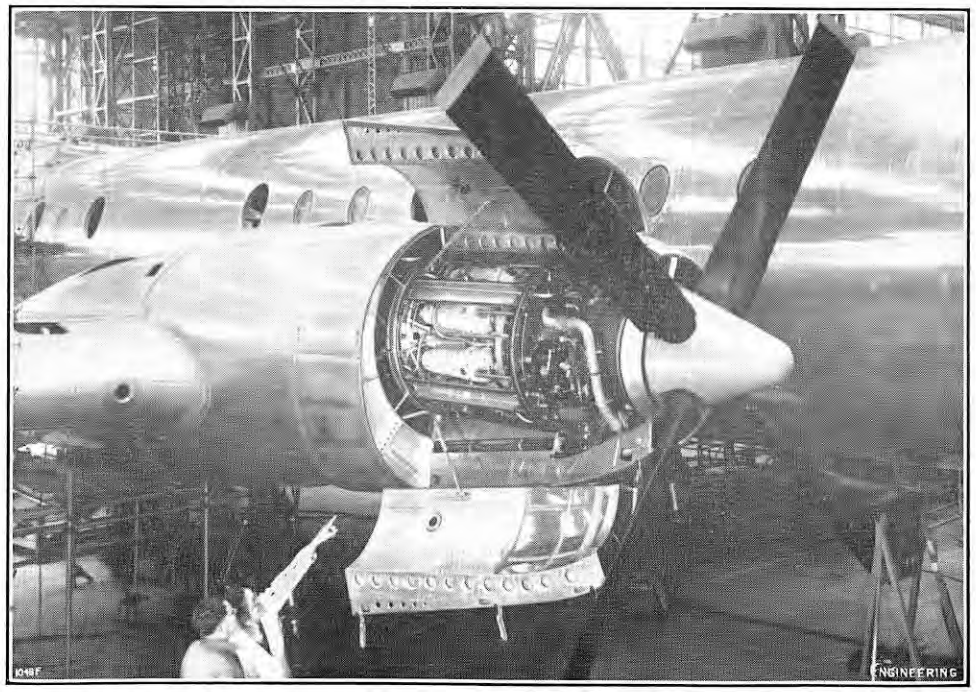


FIG. 19. "PROTEUS 625" WITH DE HAVILLAND HOLLOW-STEEL PROPELLER.

"BRITANNIA" PROPELLER-TURBINE AIR-LINER.

BRISTOL AEROPLANE COMPANY, LIMITED, FILTON, BRISTOL.

(*For Description, see Page* 257.)

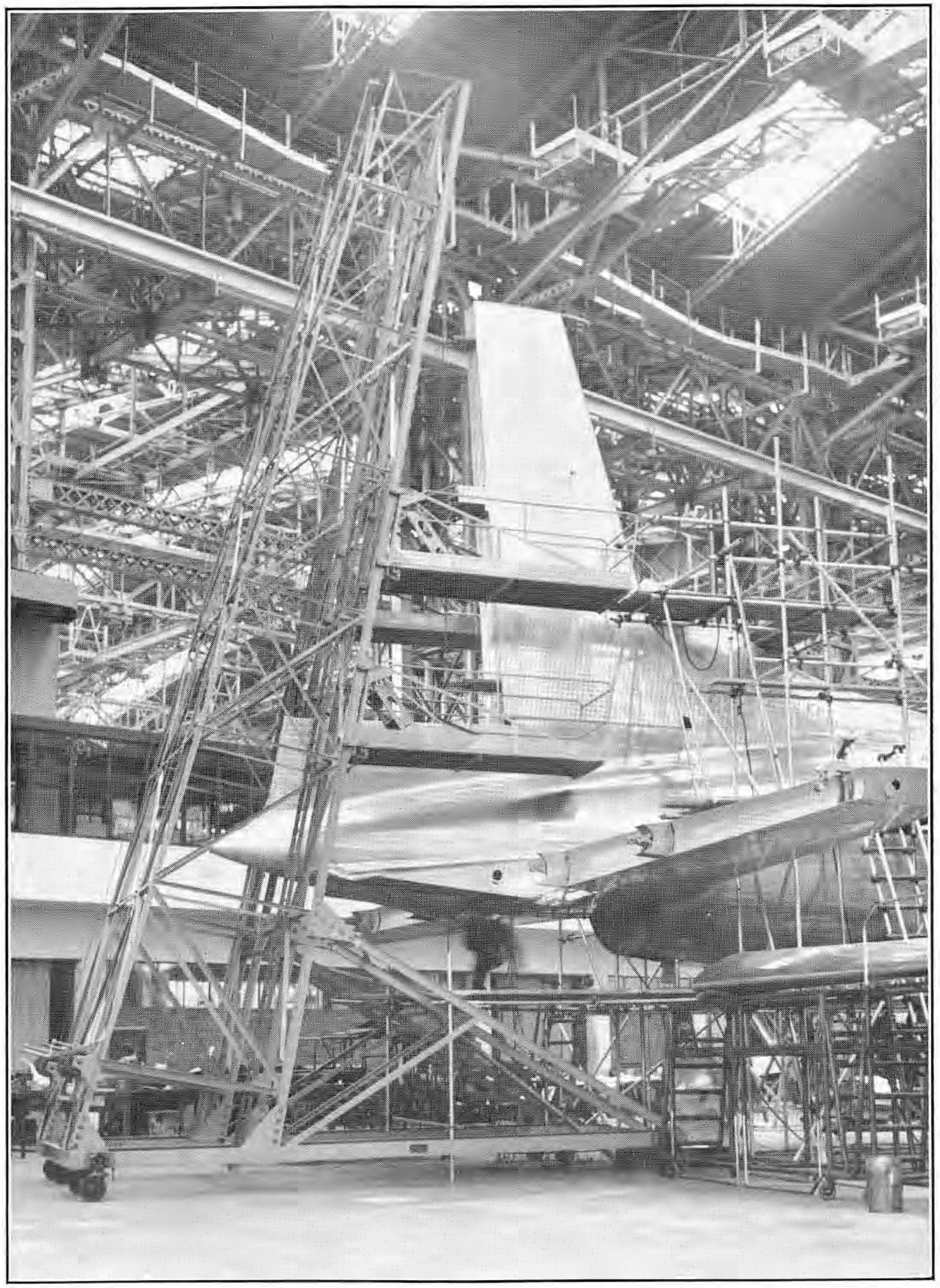


Fig. 20. Servicing Tower for Fin and Rudder.

Fig. 21. Double-Slotted Flap.

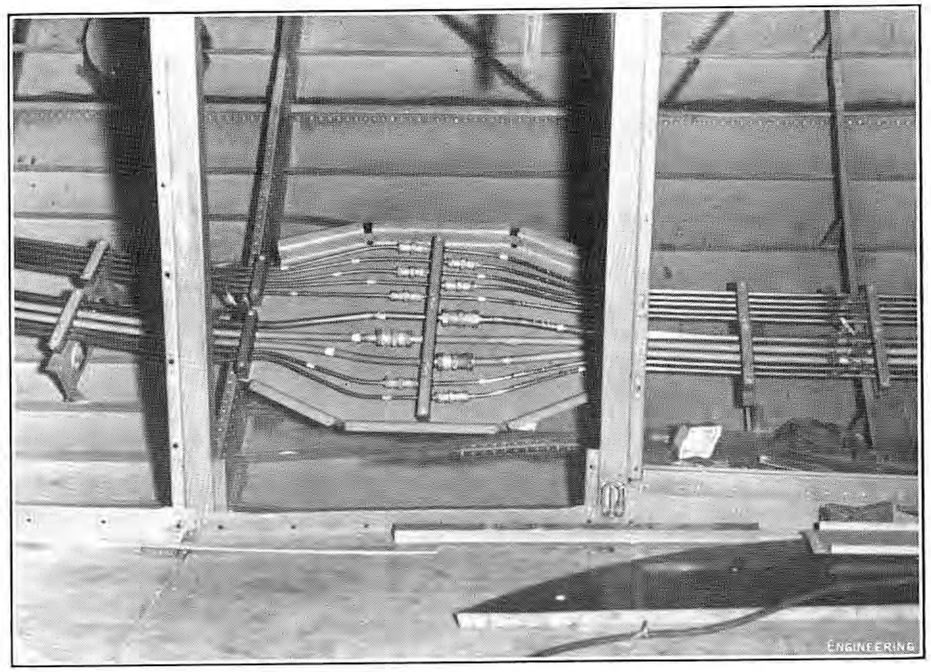


Fig. 22. Typical Group of Hydraulic Pipe Joints.

The ventilation outlets in the freight holds are equipped with smoke detectors operating warning lights on the flight deck; sampling tubes are also provided to enable the source of the fire to be located. Manually-operated portable water-glycol fire extinguishers are provided at several points along the cabin, and there is a carbon-dioxide bottle on the flight deck for extinguishing electrical fires in the radio installations or electrical control panels.

To guard against the effects of losing the cabin pressure, the crew are provided with high-pressure oxygen equipment and masks, with an oxygen bottle of 2,250 litres capacity. Five portable oxygen sets are stowed in the passenger cabin.

Model tests in a water tank have indicated that the Britannia should have good "ditching" characteristics, provided that the cabin-pressure discharge valves and the cabin-air inlet valves are clamped shut by manual controls provided on the flight deck. A roof escape hatch is provided for the crew, and the ten large cabin window hatches, which can be opened inwards, are well above the static water line. Stowages for four 20-seat RFD dinghies are provided in the wing trailing edges between the nacelles; in the high-density versions, additional valise dinghies will be stowed in the cabin.

LITERATURE.

Electricity Supply in Great Britain: Its Development and Organization.

By SIR HENRY SELF and ELIZABETH M. WATSON. George Allen and Unwin, Museum-street, London, W.C. [Price 20s. net.]

THIS book is one of a series which has been planned to cover those industries and services, such as coal, transport and electricity supply, which have recently been nationalised and are now carried on by quasi-Governmental authorities. It is intended for the general reader interested in administration and economics and the university student in the same subjects. It is, therefore, essentially non-technical, a point which must be borne in mind by electrical and other engineers if they would escape disappointment at certain gaps in the information given. As we are often reminded, criticism of the policy of these new bodies, and still more of their daily omissions and commissions, by the public, is rendered difficult owing to the position of immunity in which they have been placed, partly by the action of Parliament and partly by administrative decisions. However, it is well that their structure and working should be understood, if only because it will render constructive criticisms more pertinent and better timed.

It must be confessed, however, that this book is not ideally suited for educating the public along these lines. Of its 200 odd pages, rather over half are devoted to the history of electricity supply. Considering the object in view, some background information was, of course, necessary; but hardly so much space as has been devoted to it, seeing that the ground has been so well covered in other publications, both official and general, of which a satisfactorily complete list is given in the bibliography. The succeeding portion of the book, dealing with the transfer of electricity supply from municipal and private ownership to the present organisation and with the administrative structure under nationalisation, is the more valuable, since in a fairly short space it gives the reasons why it was desirable, if not essential, to invent a national body for that purpose, even though it need not necessarily have taken its present form. It is not without significance, perhaps, that, while labour conditions and relations receive ten pages of treatment, and education, training and recruitment eight pages, the consumer interest is dealt with in four pages. We can only hope that the relatively meagre attention which the consumer receives does not indicate a failure to recognise his paramount importance. There are already signs that he is not altogether satisfied, and an earnest effort to ensure that the machinery available for giving his views due weight is operated at full efficiency would be worth while in the common interest.

The chapters on the immediate tasks facing the British Electricity Authority and on the financial structure and economics of the industry are well worth study, even if they make rather hard reading. At least they show the magnitude of the task that has had to be, and is being, undertaken. The final chapter, on the status of the industry, contains a great deal of useful information and places such problems as the peak load and the need for increased efficiency in their proper perspective. The statistical information set out in the appendices is well worth inclusion. All this, however, will require revision in a few years' time, when it is possible to compare plans with performance and to give reasons why the two have not coincided.

A few misprints may be noted. Sylvanus, for Silvanus, Thompson is a common mistake, but need not be perpetuated; the leading engineering body is the Institution, not the Institute, of Civil Engineers; Sir John Kennedy is, fortunately, still with us; "Sir Johnston" should be Sir Johnstone Wright. Although the names of many pioneers are noted, Crompton and Ferranti are both omitted, which is strange, as are Sir Andrew Duncan and Sir Archibald Page among the moderns. These however, are eaily-corrected blemishes on a book that is well worth reading.

Technological Applications of Statistics.

By L. H. C. TIPPETT, M.Sc., Williams and Norgate, Limited, 36, Great Russell-street, London, W.C.1. [Price 18s. net.]; and John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, N.Y., U.S.A. [Price 3·50 dols.].

THE author of this excellent book is the head of the Mechanical Processing Division of the British Cotton Industry Research Association. In the course of his work at the Shirley Institute he has had much experience in applying statistical procedures to industrial research and manufacturing problems and, as the outcome of his specialised knowledge of these matters, was invited on two occasions, in 1938 and again ten years later, to deliver a course of lectures at the Massachusetts Institute of Technology. The substance of these lectures, delivered to an audience of widely varying attainments in statistical knowledge and practice, is now embodied, with a little amplification, in a book addressed to the whole body of production technologists.

Industrialists in general, and experimental engineers and physicists in particular, are mostly aware by now of the potential value of the statistical approach to many types of problems with which they are confronted. Far less commonly, however, are they sufficiently familiar with even that modicum of basic statistical theory which would enable them to decide the most appropriate technique, to apply it to an investigation entailing perhaps a considerable financial stake, and to feel complete confidence in the results indicated. It is to such readers as these that Mr. Tippett has designed his book to be especially helpful. He arranges his text in two main parts, of which the first presents what may be termed the logic of statistical methods applied to industrial procedures, attention being mainly directed to the measurement and control of quality in production, intimately associated with which are sampling and inspecting practices, and, eventually, the manipulation of data and the interpretation of records and results. Very reasonably, in an introductory book of this sort, the author has omitted anything approaching rigorous proofs of statistical propositions, urging his readers, instead, to get the "feel" of the subject, as well as practice in using it, by working through the arithmetic of typical examples based on actual industrial data.

The same principle of treatment underlies the succeeding and rather more difficult, yet essentially introductory, chapters on the statistical theory of errors, the analysis of variance and correlation, and the planning of statistical investigations, which comprise the second part of the book. Engineers, perhaps more than other applied scientists, will appreciate Mr. Tippett's emphasis on the economies made possible by the use, not only of statistics in appropriate circumstances, but also of the optimum methods of selecting and using statistical data. His guidance on such common practical difficulties as the nature of truly random sampling, and his insistence on the importance of technical knowledge as a foundation for statistical operations, exemplify a refreshingly practical attitude combined with clarity of expression that are characteristic of the book as a whole. The obvious fact that the author is intimately conversant with industrial practices as well as an authority on applied statistics is the best possible reason why technologists who study his book with the care it merits should be encouraged to experiment with statistics and to explore its potentialities more extensively.

Low-Temperature Physics.

By PROFESSOR F. E. SIMON, DR. N. KURTI, PROFESSOR J. F. ALLEN and DR. K. MENDELSSOHN. Permagon Press, Limited, 2, 3 and 5, Studio-place, Kinnerton-street, London, S.W.1. [Price 21s.]

IN February and March, 1950, a course of four lectures on "Low-Temperature Physics" was given in the Royal Institution by four leading authorities in this field. The present volume reproduces these lectures substantially as delivered, though the opportunity has been taken to include also some of the more recent developments. Professor Simon introduces the series with a general survey of low-temperature problems in which he stresses the impetus provided by the advent of the quantum theory, and the discovery and interpretation of low-temperature quantum effects such as zero point energy. Illustrations are afforded by superconductivity, and electronic and nuclear paramagnetism.

Dr. Kurti, in the second lecture, deals with the temperature range below 1 deg. absolute, which has only become accessible since 1933. The theoretical basis and experimental realisation of the magnetic cooling method, whereby this was achieved, are clearly presented, and other possible techniques are outlined.

The third lecture, by Professor Allen, is devoted to liquid helium, which exists in a more or less normal high-temperature form, called helium I and, below 2·19 deg. K, in a low-temperature form, called helium II, which exhibits many peculiar "superfluid" properties. The thermal conductivity of helium II is abnormally high and momentum transfer results in the spectacular "fountain effect." Its viscosity, on the other hand, is vanishingly small, so that it creeps in the formof a film over all solid surfaces above the bath level. Other remarkable properties are described and the progress made towards their interpretation is indicated.

The final lecture, on superconductivity, is by Dr. Mendelssohn, who points out that it is only exhibited by certain metals. Superconductive electrons appear to be in a state of complete order, i.e., energetically, at absolute zero. There are sections on superconductive electrodynamics and thermodynamics and mention is made of a practical application in which a superconductor serves as a sensitive bolometer. Attention is directed to aspects requiring further investigation. These lectures form an admirable survey of the present position in a fascinating and expanding branch of physics.

Die Hebezeuge: Band 2, Winden und Krane.

By PROFESSOR DR. ING. HELLMUT ERNST. Friedrich Vieweg & Sohn, Brunswick, Germany. [Price 38.80 DM. net.]

THIS book on winches and cranes is the second volume of a work on hoisting machinery; the first volume dealt with their elements, and the third volume will be devoted to cranes for special purposes. Engineers of the older generation who know the German work of the same title by Professor Adolf Ernst, which also extends to several volumes, should not be misled by the coincidence of the authors' names; the book under review is a new and independent work, which deserves to become a classic like its predecessor. The author's aim is to meet equally the requirements of the engineer in practice and of the student, and the various types of hoisting machinery are therefore more thoroughly treated than is usual in text-books. Mere basic calculations and constructional data are of little use to the designer, as they alone do not enable him to solve the problems encountered in practice; he needs as full a survey as possible of proved solutions of similar problems. The planning, purchasing, and works engineer likewise needs a deeper knowledge of the characteristics and of the specific fields of application of the various types of cranes. Of course, the student also benefits from such contact with practice.

The basic arrangement and the details of construction of winches, travelling and jib cranes occur also in all special cranes; to keep the work within reasonable limits, these groups of hoisting machinery are given preferential treatment, together with bridge cranes, telphers, and mobile cranes on rails or caterpillar tracks. Only designs which have been proved in practice have been selected, either as being typical of contemporary design or which appear important for the trend of development. The examples are mainly taken from German sources, but American and, to a small extent, British makes are also considered. As far as it is feasible, design data and weights are compiled in tabular and graphical form. Particular importance is attached to calculations, and some of the numerous worked examples occupy several pages. There are 463 illustrations, predominantly excellent line drawings. The many extracts from DIN standards contain information which is valuable also to non-German readers; and there are bibliographies at the end of most chapters, though these may give the impression that only German engineers have contributed to the literature on hoisting machinery.

Waterworks Byelaws and Fittings.

BY DELWYN G. DAVIES, B.SC. (ENG.), M.I.C.E., A.M.I.W.E., A.M.I.I.A. The Colliery Guardian Company, Limited, 30 and 31, Furnival-street, London, E.C. 4 [Price 30s. net.]

THIS handbook, compiled by the engineer and manager of the Harrogate municipal water-supply undertaking, is published under the auspices of *Water and Water Engineering* and is claimed to be the only work available on its subject. It opens with a brief, but adequate, historical survey, leading to a consideration of the legislative powers of water undertakings; from which the author proceeds to examine in detail, with ample commentary, the regulations of the present day. The second part of the book discusses the model byelaws and the reasons for the requirements specified therein. A great variety of typical fittings for the control and use of water supplies are described and illustrated. English plumbing regulations are sometimes criticised by foreigners, especially on the ground of their apparent failure to allow for the risk of damage by frost. This liability must be admitted, but a study of Mr. Davies' book will show that it has not been ignored so completely as might appear to be the case.

STRIP TENSION IN TANDEM MILLS.

Fig. 5. SECTION A A.

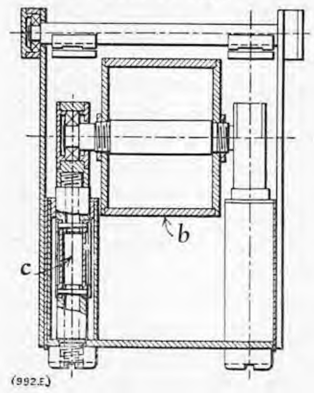
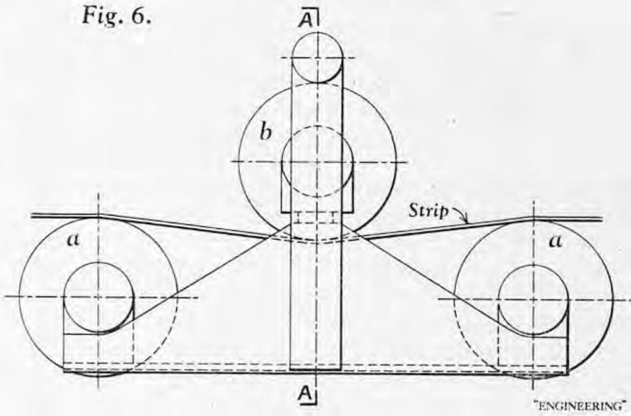


Fig. 6.



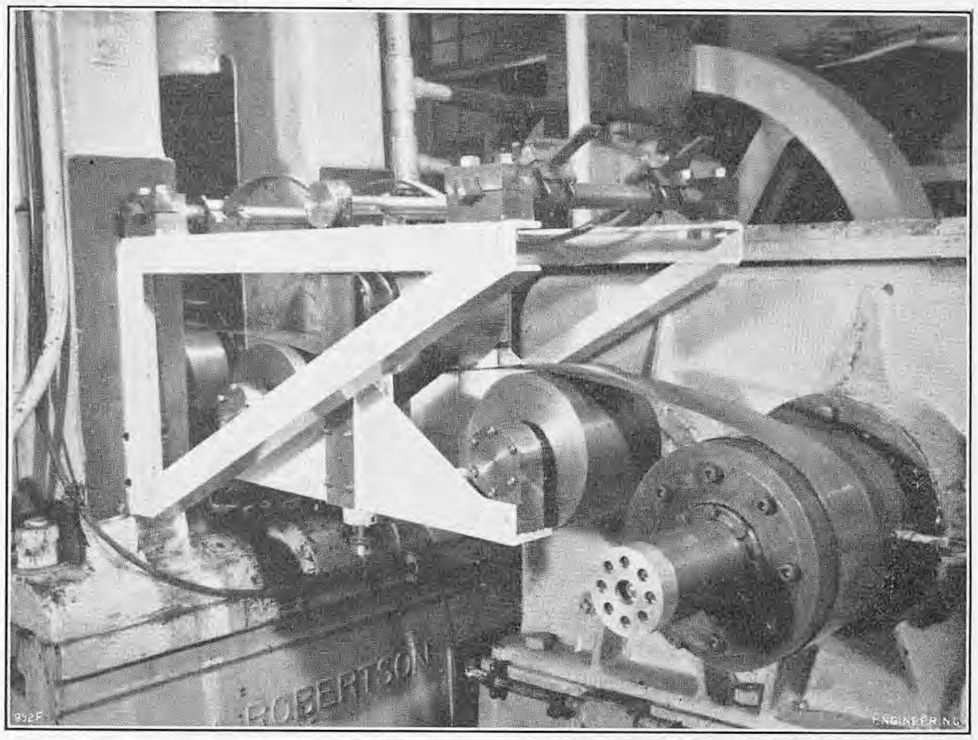


FIG. 7. PROTOTYPE TENSIOMETER.

THE MEASUREMENT OF STRIP TENSION IN TANDEM MILLS.

By R. B. SIMS, B.Sc., A.M.I.Mech.E., A.Inst.P.

(Concluded from page 233.)

GENERAL ARRANGEMENT OF THE INSTRUMENT.

THE thrust on the measuring roller will vary directly with the angles of contact α_1 and α_2. It is not possible to ensure that these angles remain constant in production mills when using the simple arrangement of a measuring roller shown in Fig. 1, on page 232 of last week's issue, since the shape of the pass-line varies with the diameter of the work rolls and the backing rolls in each mill.

The general arrangement of a prototype tensiometer is shown in Figs. 5 and 6. The actual apparatus is illustrated in Fig. 7, above, and Fig. 8, opposite. The angles of contact are equal and are maintained constant by the addition of two guide rollers, *a*, on each side of the measuring roller, *b*, which is supported by two thin-walled tubes, *c*. These tubes deform elastically by less than 0·001 in. at maximum load. The variation in the contact angles is less than 0·1 per cent. due to this strain displacement. All three rollers are 8 in. in diameter and are mounted axially parallel, to close tolerances. They are supported in self-aligning roller bearings. A measure of the load is obtained from two strain-sensitive temperature-compensated Wheatstone networks of electric resistance strain gauges, bonded directly on the tubes. The electrical load-measuring circuit is shown in Fig. 9, opposite. Both the input and output terminals of the two Wheatstone networks were connected in parallel, and the combined bridge was supplied with 30-volt alternating current at 500 cycles per second. The output was amplified, rectified, and presented on a direct-current milliammeter. The loadmeters were calibrated by deadweight loading on the measuring roller, and the output was related to strip tension by equation (13).

After the calibration of the loadmeters, the tensiometer was suspended from two sine springs in a frame attached to the housings of the experimental mill, and mild-steel strip, $3\frac{1}{2}$ in. wide, was passed through it from the back coiler of the mill to the front coiler. The tension indicated by the prototype tensiometer was then compared with the values given by the tensiometer built into the wind coiler drum of the experimental mill. This tensiometer, which has been described by Rankine, Bailey and Stanton,* had been calibrated prior to the experiments and indicated the true tension applied to the strip to an accuracy within ± 2 per cent. The comparison was made for strips of various thicknesses, first with the strips stationary, and then moving at a speed of 30 ft. per minute.

Each strip was allowed to coil up on the reel under constant tension in order to determine whether the prototype instrument was sensitive to changes in the shape of the pass-line. The results are shown in Fig. 10, and in Tables III and IV, on page 264. There is some scatter in the results, but

* "Resistance Strain Gauges for Measurement of Roll Force, Torque and Strip Tension," by J. Rankine, W. H. Bailey and F. P. Stanton. *Jl. I. and S. Inst.*, vol. 160, page 301 (1948).

MEASUREMENT OF STRIP TENSION IN TANDEM MILLS.

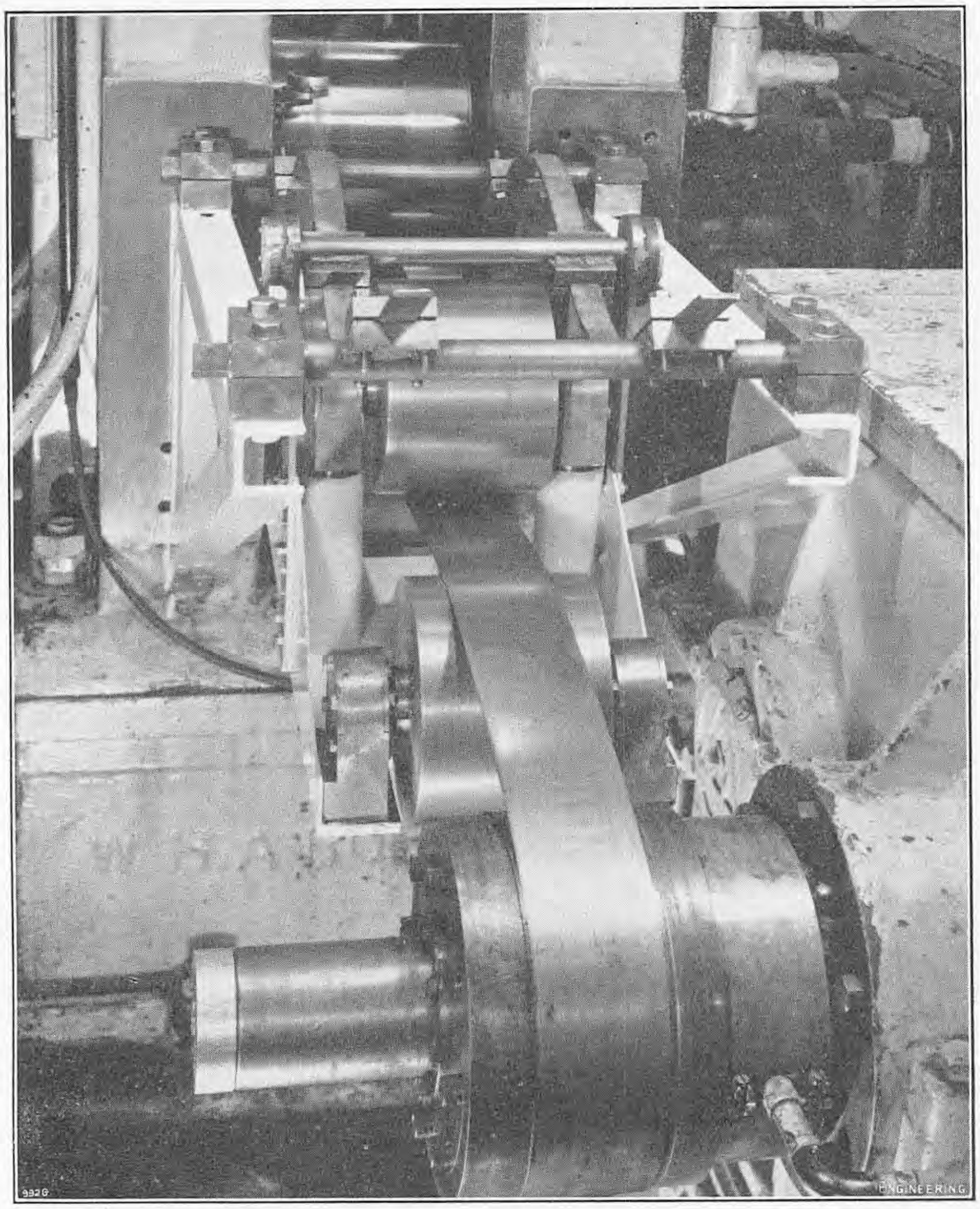


FIG. 8. END VIEW OF PROTOTYPE TENSIOMETER.

Fig. 9.

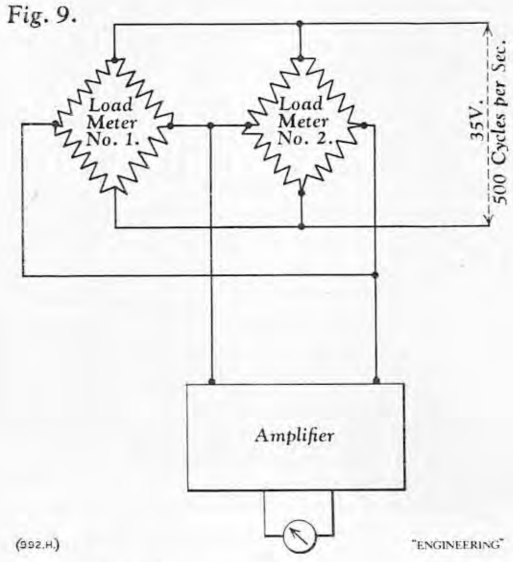


Fig. 10.

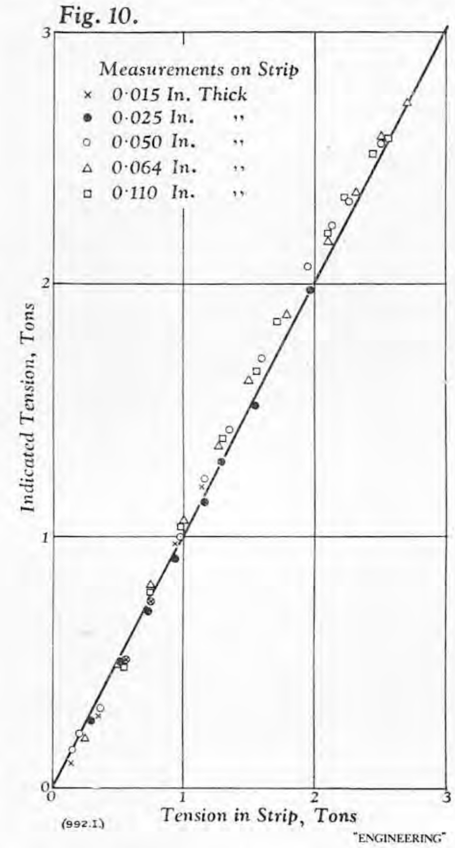


Fig. 11. SECTION AA.

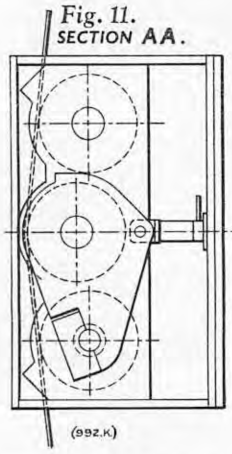
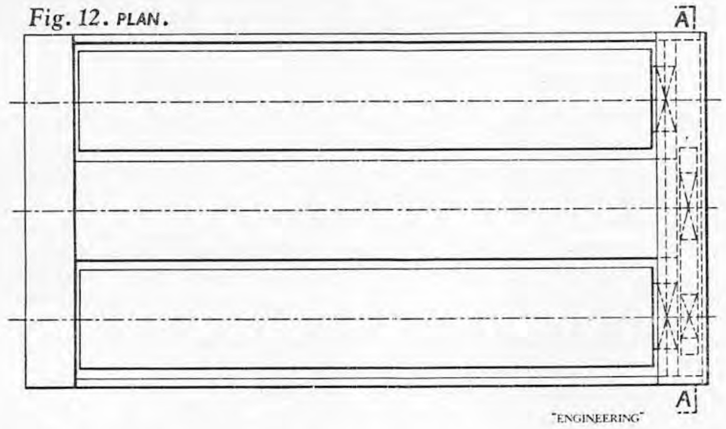


Fig. 12. PLAN.



most of this is due to the amplifier and milliammeter in the indicating circuit. The amplifier had not been designed for this application and was working at a gain in excess of its rated value. The milliammeter was not matched to the amplifier output stage, and was not of first quality. The experimental results also contain all the errors of the mill tensiometer. Nevertheless, it is clear that this rather rough prototype was capable of giving an indication of tension to an accuracy of ± 5 per cent. over most of its range and, with properly designed equipment, an accuracy of ± 3 per cent. should be possible.

INDUSTRIAL FORM OF INTERSTAND TENSIOMETER.

An interstand tensiometer based on the foregoing principles has been installed in a tandem mill capable of rolling strip up to 56 in. wide at 1,700 ft. per minute. Its general construction is shown in Figs. 11 and 12, herewith, and a photograph of it, taken in the rolling mill, is shown in Fig. 15, on page 264. It differs in operation from the prototype previously described in that the strip passes over all the rollers, and not under the measuring roller, an expedient introduced into the prototype because of restrictions imposed by the experimental mill. The tandem mill normally produces strip between 0·020 in. and 0·040 in. in thickness; hence, from equation (14), an accuracy within ± 3 per cent. should be possible with the 8-in. measuring and guide rollers with which the instrument is equipped. These rollers were fabricated from cold-drawn low-alloy molybdenum-steel tube with a wall thickness of 0·875 in., and are supported at each end on self-aligning roller bearings, fitted into cartridges for ease of withdrawal from the welded-steel main frame. The bearing cartridges of the measuring roller are held in links pivoted about the axis of one of the guide rollers, and supported in the vertical plane by the two load-measuring elements. Figs. 11 and 12 show this arrangement, and the construction of the load elements is shown in Figs. 13 and 14, on page 264. The load elements may be withdrawn without dismantling the tensiometer when it is installed in the pass-line.

Each loadmeter consists of a thin-walled measuring element of heat-treated EN.17 steel, held in end caps of stainless steel and protected from mechanical damage by an outer cover of stainless-steel tube. The indication of applied load is obtained from the strain in the EN.17 steel tube by means of four electric resistance strain gauges bonded to its surface and connected to form a Wheatstone network, and

MEASUREMENT OF STRIP TENSION IN TANDEM MILLS.

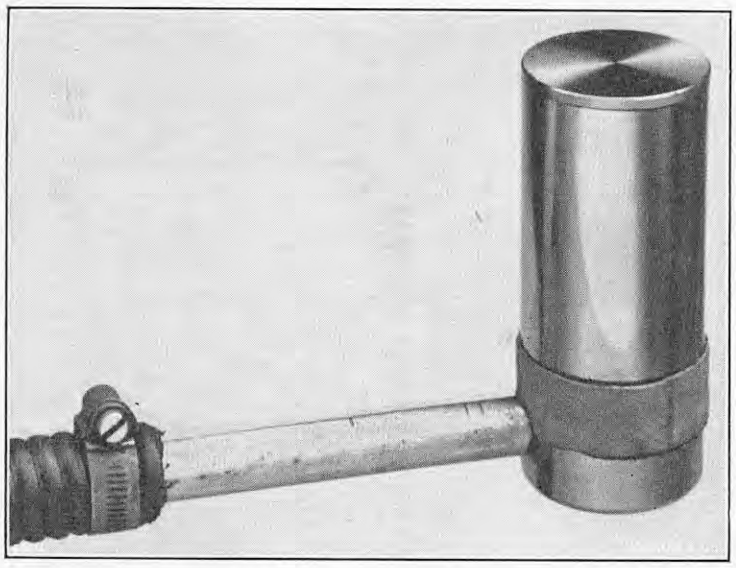


FIG. 13. COMPLETE LOAD ELEMENT.

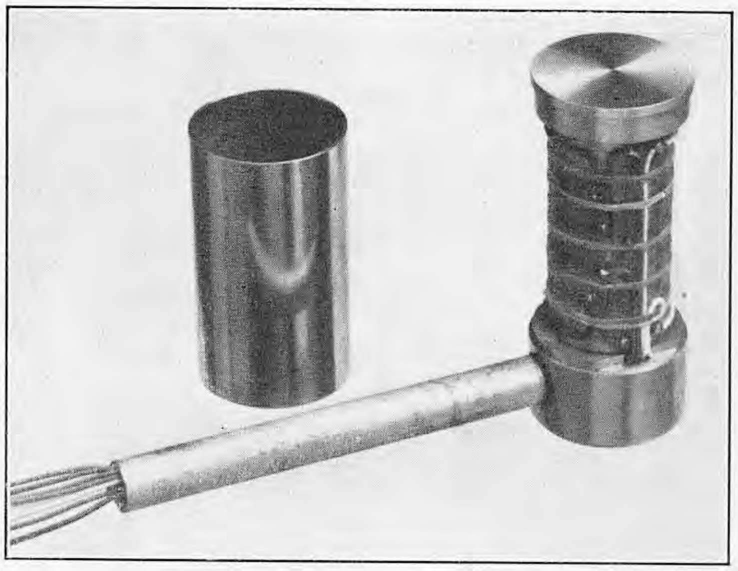


FIG. 14. LOAD ELEMENT, WITH COVER REMOVED.

the total load on the roller is measured by connecting in parallel the output and input terminals of the loadmeters under each bearing. The principles on which these loadmeters were designed have been discussed by Sims, Place and Morley.*

In all cold-reduction mills, there is a great deal of steam, oil and water near the pass-line, and care has been taken to protect the electrical parts of the loadmeters from damage by wetting. The loadmeters are sealed by a rubber proofing, bonded directly to the metal,† and this type of sealing is

TABLE III.—*Comparison of True and Indicated Tension; Strip 0·025 in. Thick.*

Applied Tension. (±2 per cent.)	Indicated Tension.	
	Strip Stationary.	Strip Moving, 30 ft. per min.
Tons per sq. in.	Tons per sq. in.	Tons per sq. in.
0·28	0·25	0·28
0·51	0·46	0·46
0·76	0·73	0·70
0·95	0·89	0·89
1·14	1·14	1·15
1·33	1·33	1·34
1·58	1·58	1·60
1·71	1·70	1·70

TABLE IV.—*Tests for Variation in Indicated Tension with Coil Build-up.*

Radius of Coil on Coiler.	Ratio, Indicated Tension: Applied Tension.
5 in.	1·00
5½ in.	0·97
6 in.	1·03
6½ in.	0·97
7 in.	1·00
7½ in.	1·02
8 in.	1·04

used between the bearing cartridges and the inner wall of the tensiometer in order to keep moisture out of the bearing compartments.

The pair of loadmeters were held in a specially-designed jig and calibrated to a maximum load of 8 tons in a universal testing machine of accuracy better than ± 0·2 per cent. The proportion of applied load carried by each loadmeter was varied by altering the loading point on the jig. The load was accurately indicated under all conditions of unequal loading likely to be experienced in production mills due to variations in the shape of the strip and its position in the pass-line. The angle made by the strip over the measuring roller (nominally 5 deg.) was measured accurately and equation (13) used to

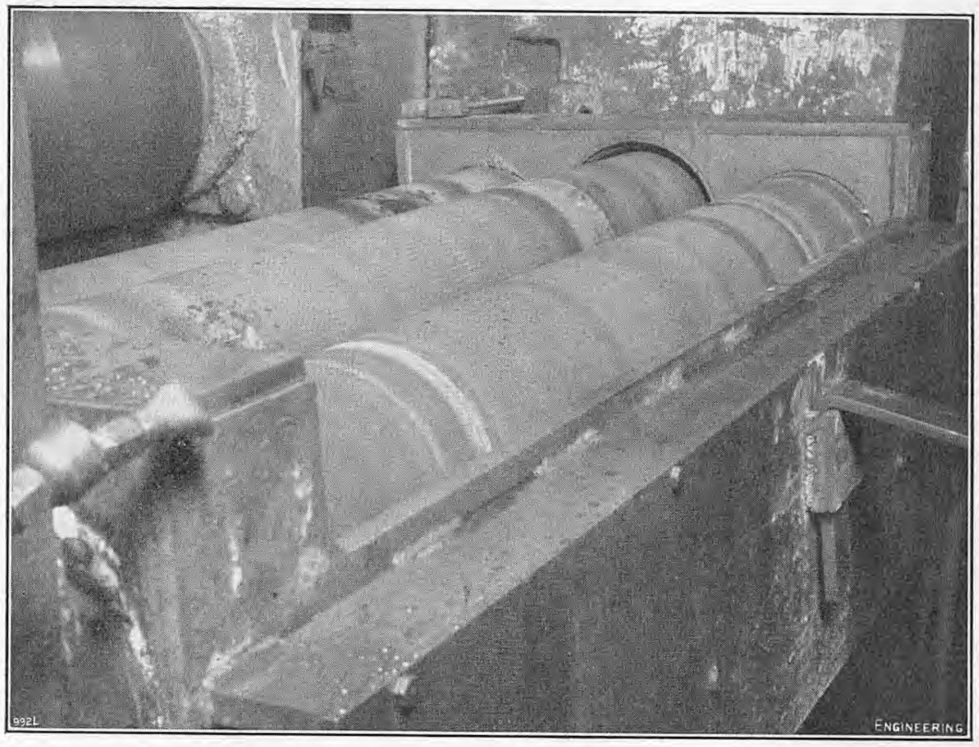


FIG. 15. INTERSTAND TENSIOMETER INSTALLED IN TANDEM MILL.

calibrate the instrument. The loadmeters were supplied with stabilised current at 30 volts and 500 cycles, and the output was amplified by a self-contained unit designed for the purpose by P. R. A. Briggs.* The maximum indicated strip tension is 40 tons. This tensiometer has operated successfully for over five months in the mill under normal conditions and may be considered a reliable production tool.

The author is indebted to Mr. R. F. Bowler for carrying out the experimental work on the prototype tensiometer, and especially to Mr. A. D. Morley, who undertook the majority of the design work on the industrial model and supervised its construction and installation.

* "Loadmeter for Industrial Mills," by R. B. Sims, J. A. Place and A. D. Morley. ENGINEERING, vol. 173, pages 116 and 137 (1952).

† "Torquemeter for Industrial Applications," by R. B. Sims and A. D. Morley. ENGINEERING, vol. 174, pages 20 and 36 (1952).

* ENGINEERING, vol. 173, page 116 (1952).

SOUTH-EAST LONDON TECHNICAL COLLEGE.—The prospectus of the Department of Electrical Engineering and Applied Physics of the South East London Technical College, Lewisham-way, S.E.4, has been published. The Department provides full-time, part-time day, and evening tuition in electrical, communications, radio and illuminating engineering and applied physics, to prepare students for the National Certificate, professional, and other examinations. In addition, special and post-graduate courses are available, consisting of one evening a week, in high-voltage engineering, vector analysis and the fundamentals of the electromagnetic theory, the theory and design of communication networks, the fundamental theory of electric machines, the electric-circuit theory, electric strain gauges and their application, power-factor improvement and capacitor design, electrical engineering economics, principles of logic for engineers, and other subjects. Full-time day classes will re-open on September 1 and part-time classes on September 22.

"VALVES FOR GAS MAINS": ERRATUM.—In the preparation of the article, on page 170, *ante*, describing the type of dust-excluding gas valve made by Messrs. Zimmermann and Jansen G.m.b.H., we were informed that their address was Bochum, Germany, and this was stated in the article. We now learn, however, that they are at Duren, Rheinland, Germany.

"AXIAL-FLOW MINE-VENTILATING FAN."—In our article on page 76, *ante*, on the 209-in. axial-flow fan which Walker Brothers (Wigan), Ltd., have built for the Zinc Corporation, Ltd., we referred to, and illustrated, the tensioning device which has been fitted to each of the blades. We are informed by Messrs. Walker Brothers that this device is the subject of Letters Patent No. 621963, in the name of the S.K.F. Company, Gothenburg, for whom the Skefko Ball Bearing Co., Ltd., Luton, are acting as the British agents.

DRILLING A DEEP HOLE IN ROCK.

A hole $7\frac{1}{2}$ ft. deep and 2 ft. in diameter was drilled recently with pneumatic tools in the rock of the Wolf Rock lighthouse jetty, Scilly Islands. Drilling was unavoidable, blasting not being permissible owing to the proximity of the lighthouse. It was therefore necessary to drill a series of holes, in stages, and break the rock between them with a road ripper. This procedure will be apparent from the accompanying illustration, which is reproduced by permission of the Elder Brethren of Trinity House; it shows the hole only a foot or so deep, after seven hours of drilling. The hole is intended for a new iron crane post, 26 ft. high and weighing $2\frac{1}{2}$ tons.

Messrs. Holman Brothers, Limited, Camborne, were consulted by Trinity House, and it was decided to use the following Holman equipment: a compressor, a "Silver Bullet Handrill" with a $4\frac{1}{4}$-in. shank, using "Holbits," and a road ripper with plugs and feathers. Messrs. Holman Brothers also produced two special tools for the job, a scoop for clearing the rubble from the bottom of the hole as the depth increased, and a tool for guiding the drill steel around the bottom of the hole after a depth of

3 ft. had been reached. Because of the extreme difficulty of carrying out this operation on the Wolf Rock, and to eliminate the possibility of mistakes, the operators spent four weeks at the Holman test mine, where they were given special training in the use of rock drills. A hole 6 ft. 6 in. deep was drilled in the solid granite of the test mine, and every forseeable feature of the forthcoming drilling operation was carefully rehearsed.

At Wolf Rock, the compressed-air supply for working the drills was supplied by pipeline from the compressor, which was housed in the hold of a fishing boat anchored some distance off the Rock. On May 5, the compressor, drilling equipment and stores were loaded on to the boat but adverse weather prevented a landing until May 23. Conditions became favourable for drilling to commence on May 26. The seas running off the Wolf Rock do not allow the lighthouse to be approached every day, and only a few hours work can be done at a time at low tide. The complete drilling operation took 60 working hours spread over a month. The work was successfully completed and the new mast was placed in position on July 14.

Dockyard Schools become Technical Colleges.—Founded more than a century ago, H.M. Dockyard Schools will in future be known as Dockyard Technical Colleges, to bring them into line with the system of classification used for other educational establishments, and their headmasters will be known as Principals. These schools, at Portsmouth, Devonport, Chatham, Sheerness and Rosyth, were instituted in 1843 "to enable apprentices to acquire a scientific knowledge of their profession." They are attended by Dockyard and Air Repair Yard apprentices, aged between 15 and 19 years, and a full course of four years at these schools is undertaken by about 10 per cent. of the entrants. The Dockyard School at Malta is also affected by the change of nomenclature.

APPLIED PSYCHOLOGY AND MACHINE DESIGN.

Research on applied psychology in relation to the design of machines is leading to a number of practical developments which will improve the co-ordination of the actions of operators and their machines. The Applied Psychology Research Unit of the Medical Research Council is working on problems of this nature, particularly in connection with the design of indicators (usually graduated in 0·001-in. steps) on machine tools, and on such questions as anticipation and forethought in human performance, the relation between "perceptual evidence" (i.e., what an operator perceives) and skilled action, the optimum characteristics of control levers, the actions of an operator in response to signals from, say, a conveyor belt, and ways and means of ensuring that as much as possible of the skill gained by a man in one job is transferred to his work in a new job.

One of the first branches of the work to reach the stage where a commercial firm can undertake to produce machine components thus developed is that dealing with machine-tool indicators. New instruments, described as universal direct-reading indicators, have been designed which will make it possible to set machines to accurate limits without hesitation or mental arithmetic, and to obtain substantial savings in setting times with almost complete elimination of human errors. English Numbering Machines, Limited, Queensway, Enfield, Middlesex, have co-operated with the Research Unit in this work and are now responsible for its commercial application. They have the exclusive rights to the instrument, for which patents are pending in Great Britain, Belgium, Canada, France, Germany, Italy, Sweden, Switzerland and the United States, and they state that they will soon be producing a range of models suitable for a variety of machines.

For many machine tools, such as lathes, jig-borers and milling machines, an indicator is needed which can be easily and accurately read, which is sensitive to changes of the order of 0·001 in. but has a range of several feet, and which requires no counting, mental arithmetic, or successive machine stoppages for resetting. Dial-type indicators, at present the most common, have often been found difficult to read accurately and at speed, especially when the principles of their design vary as widely as they do at present, and to overcome this difficulty workers in the Unit have produced the new numerical scale indicator. Tests with the prototype in a large machine shop showed a reduction of 40 per cent. in machine-tool setting time, and 17 out of every 18 "human errors" were eliminated. Further trials demonstrated a large saving in learning and machining time for new operators. The principles which it embodies are applicable to many problems of machine design outside the machine-tool industry.

In the design of control mechanisms so as to provide useful information, much has been learnt which is now ready for application, but most of the problems can receive radical solution only as a result of much more fundamental research; it must be known how—and how much—information coming to the operator from the complicated and obscure mass of sensations set up by his bodily movements can be used by him to direct his skill. However, the Research Unit has already been able to compare the usefulness of control levers with small movement range and heavy spring loading with that of those with light free-moving control. In many practical industrial situations, the former type appears to give much more information, and some applications have already been made in Service and industrial operations.

Once the information, or stimulus, has been received, the next stage in a skilled task is to make the appropriate response. This stage, too, has been investigated by workers of the Unit, particularly in tasks requiring continuous attention and activity. They have been able to show that the ease or difficulty of making the response depends largely on two factors, which they have called "load" and "speed." Speed is the rate at which decisions have to be made. Load is the complexity of the sources of information, due sometimes to the number of the sources, as when a cotton operative has to tend sixty spindles, at others to their arrangement in space or time, as when a pilot has to change height at the same moment as he is receiving a radio message. Load and speed are independent, in the sense that if either changes beyond definite limits it causes a disproportionate increase in error. In industrial practice, however, it is very rare for one to increase without the other, and their combined effect is demonstrably greater than the sum of their separate effects. Work is in progress to discover what changes in the one can be used to compensate for changes in the other, so as to avoid strain; in the past it has often been assumed that doubling the load can be compensated by halving the speed, but it is already clear that no such simple relation exists.

There is a special case of the relation between stimulus and response that is of outstanding interest. In many industrial skills appropriate actions have to follow signals which succeed one another rapidly on a conveyor belt. The normal operative soon comes to look ahead of his action point and to read signals to which he will not respond for several "moves." It is this anticipation that produces the smoothness, consistency, and freedom from forced effort that are characteristic of skill. The Unit has been able to distinguish three main forms of anticipation, each with a characteristic time span. The practical problem is to match rate of display signals to rate of control movements that will give the anticipation span best suited to the skill in question. There is strong evidence that the best timing rates are significantly different for different broad age groups, and this is obviously a matter of great importance at a time when industry must give greater consideration to the employment of older workers. Besides these studies of the intrinsic nature of skilled performance, work has also been done on the effect of very fast imposed speed and of great heat or cold or humidity.

Work is in progress on the transfer of skill from one situation to another, as already mentioned. The great natural danger of all human learning is that, unless special precautions are taken, the new skill is so tightly tied to the conditions in which it is acquired that it cannot be adapted to other conditions without delay and waste. In these days of rapid technological invention and change, this inability of workpeople to adjust themselves easily makes great demands on the industrialist who plans large-scale training schemes. Workers at the Research Unit, however, are beginning to be able to pick out the essential components in an industrial operation so as to reproduce them in a "synthetic" training scheme and omit what is irrelevant, though there is still much to find out about the details of transfer and about the bodily processes which underlie it.

Most of the above information is given in the *Report of the Medical Research Council for the Year* 1950-51. In the second World War, the report states, the Council devoted some attention to fatigue produced by the mental effort, accurate and often extremely speedy, which is needed to control machines. If the signals for action, and the means provided by the machine for dealing with them, are not designed with regard to normal capacities, the attempt to deal with them day after day sets up nervous strain, lowers efficiency and morale, causes unnecessary accidents, and in many cases leads to definite and continued ill-health. In all skilled operations, whether in work or in play, the first stage is the identification and interpretation by the operator of certain information. The information may come, as for instance in motor-driving, from the world outside, in which case its form, timing, and arrangement can be controlled only to a very slight extent. It may come from the machine itself, from objects moving on a conveyor belt, from gauges, or other "display" devices; or it may come from the operator's own bodily movements as he manipulates the control mechanism of the machine and notes its response or resistance to the movements of levers and switches. In both these last two cases, which are much more common than the first, the form and timing of the information depend almost entirely on the design of the machine. "Display" signals can be arranged so as to be most easily read and understood by a normal operator, while to a lesser extent "control" mechanisms can be so designed that, besides performing their primary function, they supply the maximum of useful information to their users. An example of improved "display" design is provided by the machine-tool indicator. Such work of the Applied Psychology Research Unit, of which Sir Frederic Bartlett, C.B.E., M.A., F.R.S., is director, and Dr. N. H. Mackworth, M.B., is assistant director, should benefit the engineering industry if the results and lessons are adequately published and applied.

AN IMPROVED STRAIN GAUGE.

A NEW type of resistance strain gauge, which offers higher sensitivity and greater reliability than the existing wire resistance strain gauge that is commonly used for experimental stress analysis, has been developed by the electronics department of Messrs. Saunders-Roe, Limited, East Cowes, Isle of Wight, and by Messrs. Technograph Printed Circuits, Limited, 32, Shaftesbury-avenue, London, W.1, in collaboration. The new gauge is constructed on a lacquer film base, on which is deposited a layer of metal foil. The latter is masked and etched to form a flat resistor, comprising a number of slender parallel conductors connected to form a continuous path by wider strips at their ends. Each end conductor broadens out to form a wide base to which the supply leads can be robustly attached.

It was, in fact, a requirement for a stronger connection between the gauge and the supply leads that led to the development of a foil gauge. During flight tests by the helicopter division of Saunders-Roe, Limited, in which a number of dependent variables such as rotor and transmission-shaft torques, forces in the rotor blades, and vibration in the control linkages, were being investigated by wire resistance strain gauges, the failures of a few gauges were found to invalidate the results of whole tests. The primary cause of failure of the gauges was the structural discontinuity of the small spot-welded junction of the fine resistance wire to the soldering tag, which was vulnerable both mechanically and also, in the presence of moisture, to electrolytic action. The possibility of adapting the printed-circuit technique to the production of strain gauges to replace the wire resistance type was therefore investigated, and Technograph Printed Circuits, Limited, were called in to assist in the development.

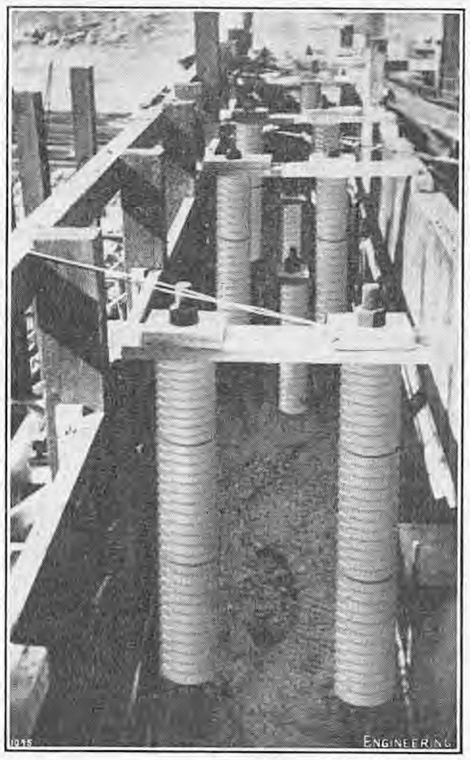
The first experimental gauges were highly successful. In addition to solving the problem of structural discontinuity, it was found that the new gauge had a much higher performance than the conventional type. The reasons for this are partly because, in the foil gauge, strain is transmitted more efficiently from the loaded specimen to the gauge, on account of the thinness of the lacquer-film base, which has excellent mechanical and electrical properties. The wider sections at the ends of the grid also assist in transmitting the strain efficiently. Principally, however, the high performance of the foil strain gauge is a result of the high ratio of the contact-surface area of the resistance element to its volume, which is much greater than that of a wire of circular cross-section. This makes it possible to use considerably higher working currents, and therefore the sensitivity of the gauge is greatly increased. Other advantages that are claimed for the foil gauge are its flexibility and ease of application, the simplicity of waterproofing techniques, and its lower susceptibility to accidental damage. It is also possible to produce gauges in shapes that would be impossible with wire construction and, moreover, quantity-production methods can be developed for their manufacture, whereas the making of a resistance-wire strain gauge requires a skilled operator.

STOCKS OF COAL.—The total distributed stocks of coal in Great Britain on August 16, 1952, were 17,336,000 tons, compared with 13,597,000 tons on August 18, 1951. The saleable output of deep-mined coal was less for the week ended August 23, 1952, than for the corresponding week of 1951.

CONCRETE BOXES FOR FOUNDATION BOLTS.

THE practical difficulties which have been experienced in making, placing and stripping the conventional timber boxes for foundation bolts have encouraged the consideration of other methods. The shortage and high cost of timber, together with the scarcity of carpenters on constructional sites, have added to the difficulties involved in this small but vital item in constructional procedure. Timber boxes have been constructed on various easy-strip principles, but this has added considerably to the initial cost and their use by no means ensures complete withdrawal of the timber. The advent of concrete bolt boxes overcomes these difficulties to a great extent.

Introduced by Messrs. Leeson, Limited, 2, Park-row, Leeds, 1, the concrete bolt boxes are pre-cast and cut at the manufacturer's works to the required lengths. They are at present available with internal diameters of 3 in., 4 in., 5 in. and 6 in., the



largest being suitable for $2\frac{1}{2}$-in. foundation bolts. It is not intended that the boxes should be stripped, and in order to procure a sound bonding with the concrete of the foundation block, the boxes are made with external grooves at 1-in. centres; a key with the final grout filling is obtained by an internal helical groove. An essential feature of the Leeson system is the locators: concrete end-pieces which keep the box accurately centred about the bolt during the placing of the foundation concrete. The top locator has the additional duty of keeping the grouting space clean until such time as the structural steelwork, or machinery, has been put into position. Although the top locator has no permanent function and should be removed to storage for future use after final grouting is complete, experience has shown that it is advisable to order two locators for each box to provide against expenditure through breakage and loss. For extra long foundation bolts it is sometimes necessary to use two or more boxes for each bolt; in these circumstances, cement grout is applied between the ends of the boxes to ensure that there is no side movement and to maintain alignment of the boxes. In the illustration above are shown some Leeson boxes in position in a foundation trench on a large steel-plant extension site at Scunthorpe where over 10,000 of the boxes have been successfully used.

CONFÉRENCE INTERNATIONALE DES GRANDS RESEAUX ELECTRIQUES.—It is announced that the fifteenth session of the Conférence Internationale des Grands Reseaux Electriques will be held in Paris, from Wednesday, May 12, to Saturday, May 22, 1954.

A CRANE ACCIDENT.

AN unusual accident occurred on August 12 to a tower crane of a type that is readily dismantled for transport. The crane was working on a building site at Caistor-road, Balham, London, and had been made by Messrs. Jules Weitz, of Lyons, France. It is of lattice construction and consists of a tower with a fixed cantilever at the top. The tower and cantilever can be rotated together through a full circle about the vertical axis of the tower, thus facilitating the placing of loads of bricks, cement, concrete, pre-fabricated parts, etc., wherever they are needed on the site. The driver's cab travels up and down inside the lattice tower to suit the driver's view of the work. For ease of removing the crane from one site to another, the tower is in several sections which are secured together by bolted fishplates. When the crane is dismantled, cross-bars at the joints are removed, and replaced on re-erection.

On the afternoon of August 12, the crane was turning when, without warning, the tower started to bend at mid-height, just above where the cab was at that time, and the upper part came down. Fortunately, there were only a few people on the site and the driver escaped with a shaking. The distributors for this type of crane in the United Kingdom, Machinery (Continental), Limited, 175, Brompton-road, London, S.W.3, communicated with the makers, whose chief engineer was flown from France, arriving at the scene of the accident on the morning of August 13.

An examination undertaken jointly with the engineer for the insurance company revealed that the cross-bar at the place where the tower had bent was missing. It was eventually found in the driver's cab, and after interrogation the driver admitted that, as the bright aluminium paint on the bar had dazzled him, he had procured a wrench, climbed on to the top of the cab, and unbolted the vital member. It was not clear why he did not simply raise the cab several inches rather than climb on the roof. In view of the doubts which the accident has raised—particularly among other contractors who operate such cranes in this country—it is, perhaps, expedient to state that both the engineer for the insurance company, and a consulting engineer who was instructed by the distributors to investigate the accident independently, have certified the cause of the accident, as summarised above, and have signed a statement which should settle beyond doubt any question as to the stability of these cranes.

SECOND INTERNATIONAL CONGRESS ON RHEOLOGY.

The British Society of Rheology, supported by the Joint Commission on Rheology of the International Council of Scientific Unions, are organising an international congress which is to be held from Sunday, July 26, to Friday, July 31, 1953, at St. Hilda's College, Oxford. This will be the second international congress on rheology. The first, it may be recalled, was held in Holland in 1948. Those wishing to submit papers, not exceeding 2,000 words, to the congress, should do so before December 1, 1952. Proofs of the papers will be circulated at the congress, and the proceedings will be published in book form. The congress will cover the whole field of the study of the deformation and flow of matter, other than those specialised subjects that have come to be regarded as branches of applied mechanics, e.g., the classical theory of elasticity, aerodynamics, etc. In addition to submitted papers, the programme will include a presidential address, a number of invited lectures, and a discussion on the international organisation of rheology. Excursions and visits to colleges will also be arranged, and delegates' wives will be welcome. Accommodation will be provided in Colleges, or in rooms in Oxford. The fee for the Congress, including reprints, and a copy of the final proceedings, is expected to be about 4*l*. Further particulars may be obtained from the honorary organising secretary, Dr. G. W. Scott Blair, The University, Reading.

PIPE-FABRICATION WORKS OF STEWARTS AND LLOYDS OF INDIA, LTD.

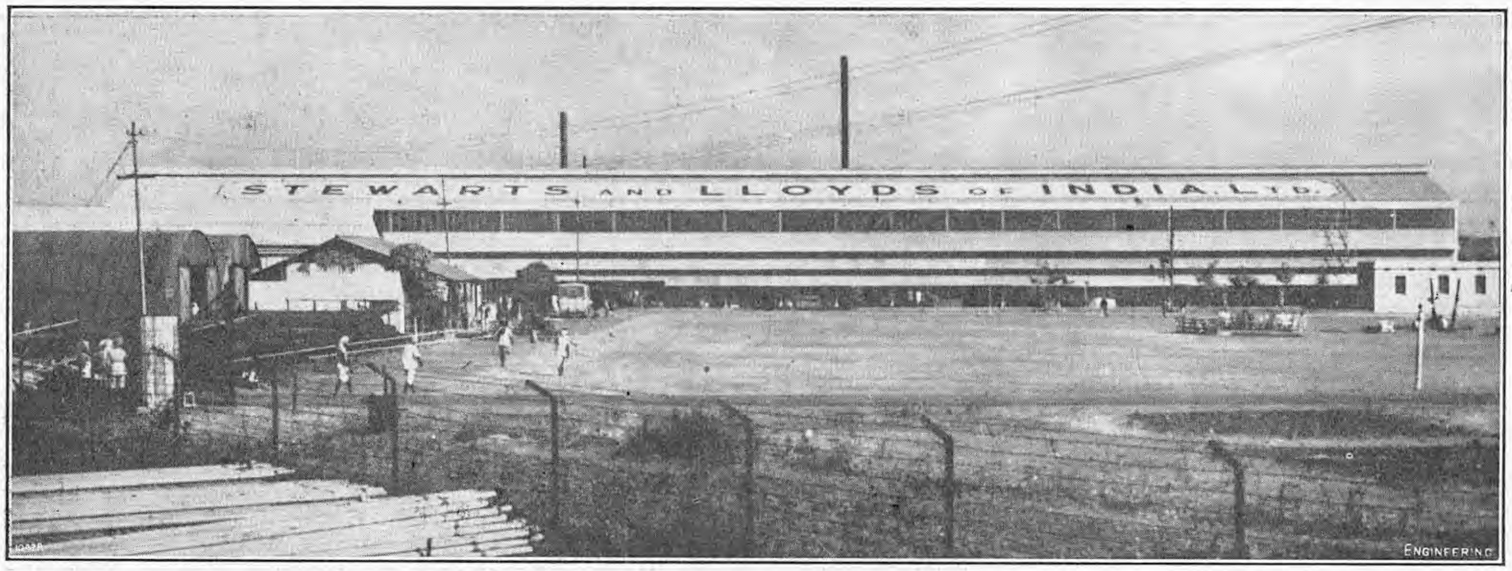
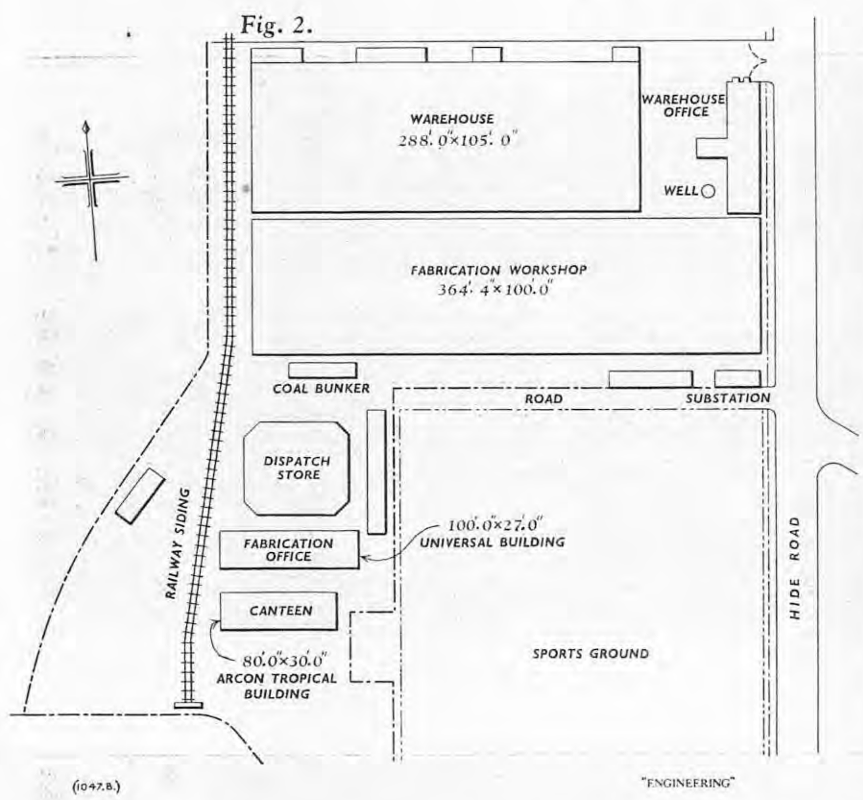


FIG. 1. VIEW OF WORKS FROM SOUTH.

Fig. 2.



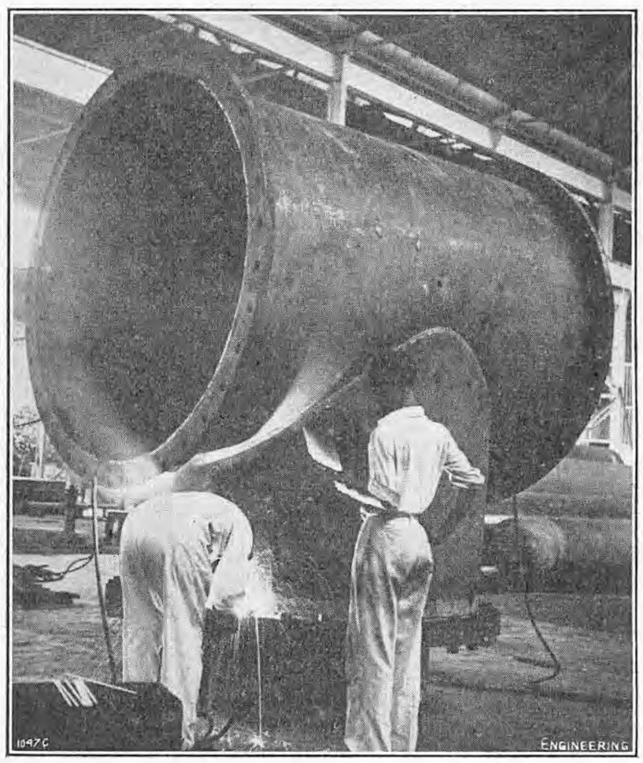


FIG. 3. WELDING FLANGE ON 72-IN. TEE FOR CIRCULATING WATER MAIN.

THE PIPE-FABRICATION WORKS OF STEWARTS AND LLOYDS OF INDIA, LTD.

IN ENGINEERING of March 7, 1952, we described and illustrated the artificial-fertiliser factory of Sindri Fertilizers and Chemicals, Limited, at Sindri, in Bihar, which was constructed at the instigation of the Government of India with the object of increasing the Indian production of nitrogenous fertilisers to 350,000 tons per annum. The construction of this factory involved the supply of about 80 miles of pipework, ranging in size from ⅛ in. to 72 in. bore and including a large proportion of "specials," the contract for which was placed with Stewarts and Lloyds of India, Limited, acting in association with their parent company, Stewarts and Lloyds, Limited. In the two years over which the order was spread, some 1,200 tons of piping were fabricated in the former company's works in Calcutta, then newly completed. As this factory represents a considerable addition to India's industrial resources, the particulars of it which are given below will, no doubt, be of interest.

The decision to establish the works was taken in 1947. As there was a growing demand in India for fabricated pipework, most of which had to be imported, it was decided that the projected works should be capable of handling all sizes normally produced by Stewarts and Lloyds, Limited —i.e., within the range indicated above as being required for Sindri; except that, as the main industrial demand for steam piping was for the low-pressure and medium-pressure types, supplies for this service should be limited initially to 450 lb. per square inch pressure and 800 deg. F. steam temperature. For working conditions outside these limits, the special pipework would be supplied directly by Stewarts and Lloyds, Limited, for the time being. It was estimated that the initial demand would be for about 1,000 to 1,500 tons per annum; but, in view of the extensive programme of industrialisation, upon which the Government of India were embarking, the plant was designed to deal with an annual production of 2,000 to 2,500 tons. At the outset, the tubes were to be supplied by Stewarts and Lloyds, Limited, but the flanges were to be made in the Calcutta shops.

A general view of the plant is reproduced in Fig. 1, on this page, and a diagrammatic layout is given in Fig. 2. Fig. 3, above, and Figs. 4 to 6, on page 268, show work in progress; and Figs. 7 to 9, on page 272, also show typical examples of the work undertaken and interior views of the workshops. Fig. 10, also on page 272, illustrates the erection on site of one of the large pipe-bends supplied to the Sindri fertiliser factory.

The layout of the warehouse is in three parallel bays. The northern bay is devoted to the storage of tube fittings and flanges; the central bay is a tube warehouse; and the southern bay provides tube stowage for fabrication. The fabrication workshop contains the machine shop and the bending, marking-off, welding, and expanding and testing departments. On the south side of the fabrication shop are buildings for the liquid-oxygen and acetylene plant, and a transformer house. The inspection, painting and despatch departments are in the south-west corner of the main building. These several departments are not enclosed, so that full advantage can be taken of the liberal floor area when large or awkwardly-shaped "specials" have to be handled. This feature can be appreciated in several of the accompanying illustrations.

In the construction of the works, a certain amount of equipment was ordered directly from suppliers in the United Kingdom, but the main building, illustrated in Fig. 1, was designed and constructed in Calcutta; it has a floor area of about 36,000 sq. ft. To accommodate the works staff and the draughtsmen, a "Universal" building, 100 ft. long and 27 ft. wide, with a tubular steel frame, was bought from Tubewrights, Limited; and an "Arcon tropical structure," 80 ft. by 30 ft., the frame of which was also made by Tubewrights, Limited, was purchased from Messrs. Taylor Woodrow (Building Exports), Limited, for use as a canteen. Their respective positions are shown on the site plan, Fig. 2. A railway connection was provided for bringing material into the works, and lines were also laid to the various shops, etc., for transferring materials and work from one bay to another. For handling work in the shops, there are also two 3-ton overhead gantry cranes, supplied by Messrs. Wellman-Smith-Owen, Limited. There are also four 2-ton jib cranes, with 30-ft. jibs, two 30-cwt. jib cranes and a 1-ton crane with a 10 ft. 4 in. jib, serving particular machines.

Tool Equipment.

The machine-tool equipment is extensive enough for a variety of general-engineering work to be undertaken if the occasion arises, as well as the pipe fabrication, bending and finishing for which the plant was primarily designed. There are, for example, two Lang hollow-spindle lathes, with taper-turning attachments, which can accommodate tubes up to $12\frac{3}{4}$ in. outside diameter; a Herbert 9B/30 combination turret lathe, with an electric chuck, and a Herbert No. 5 turret lathe with a 12-in. chuck; and a Willson gap-bed centre lathe to take work $8\frac{1}{2}$ in. diameter and up to 8 ft. long. For general work, there is also a Kearns No. 1 surfacing, boring and milling machine, which, of course, can be used also for drilling and tapping; a 28-in. Kitchen and Wade V10 pillar drilling machine with tapping attachment; a Corona pillar drilling machine, similarly equipped; a 42-in. Town radial drilling, tapping and studding machine; a Harihar No. 1 centre lathe—an Indian make—with 9-in. swing; and a Cooper shaping machine, with a stroke of 13 in.

The special tools provided for pipe and tube work include a Kendall and Gent bend-screwing machine with a rotating die-head and cutting-off attachment, to take tubes of 2 in. to 8 in. nominal bore; two Landis rotary-head screwing machines, for tubes $\frac{1}{4}$ in. to 2 in. bore, and a fixed-head machine of the same make, with cutting-off attachment, to take tubes from $2\frac{1}{2}$ in. to 6 in. bore; a branch-shaping machine, which cuts branches to profile by the use of templates and will accommodate tubes from 2 in. to 8 in. bore; a power-operated tube-expanding machine of similar pipe-size capacity; and a flange-facing machine, made in the works from a former lathe. There are also two hand-operated cold bending machines for tubes up to $1\frac{1}{2}$ in. bore, and a Kennedy No. 3A machine, hand-operated, which will bend cold tubes up to 2-in. bore, in addition to two large cast-iron bending tables, 12 ft. by 8 ft., surface tables, hydraulic-test pumps working to pressures up to 3,000 lb. per square inch; and a stemming platform, for filling tubes with sand before bending, which will accommodate tubes up to 30 ft. long. For bending the pipes on the large bending tables, there is an electrically-driven two-speed capstan, capable of exerting a pull of $1\frac{1}{2}$ tons at 40-ft. per minute, or 3 tons at 20 ft. a minute, supplemented by a 2-ton crab winch.

Miscellaneous general-purpose and special tool equipment includes a Churchill single-wheel grinder and a Turner double-ended grinder, both taking 20-in. wheels; a Turner chaser grinder; a "Rapidor" power hacksaw to cut tubes or bars up to 6 in. in diameter; a Cobra tube-sawing machine with a cutting capacity up to $2\frac{1}{2}$-in. tube; a universal saw-grinder; a Worcester double-headed grinding machine for tools and twist drills; and a bench drilling machine, to drill holes up to $\frac{3}{8}$ in. diameter in mild steel. For cutting the plates for

PIPE-FABRICATION WORKS AT CALCUTTA.

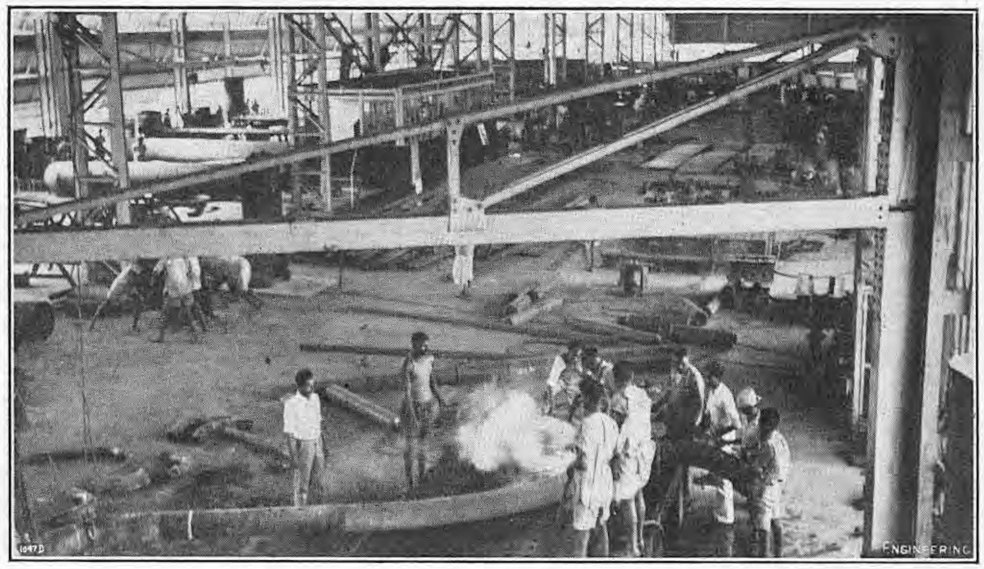


Fig. 4. Hot-Bending a 9-In. Special.

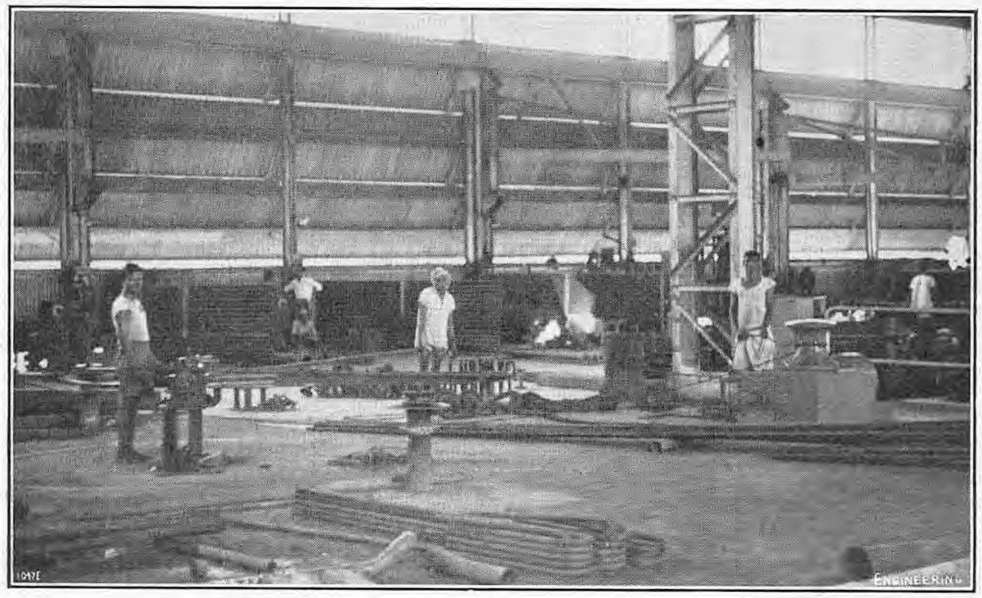


Fig. 5. Cold-Bending with 2-Ton Electric Capstan.

Fig. 6. 24-In. Special Pipe.

ALUMINIUM-ALLOY BARGES FOR THE CONGO.

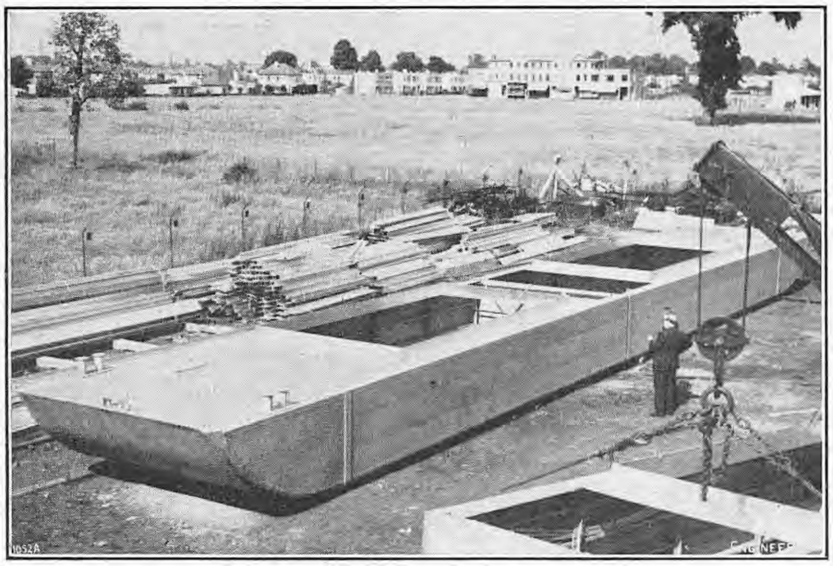


FIG. 1.

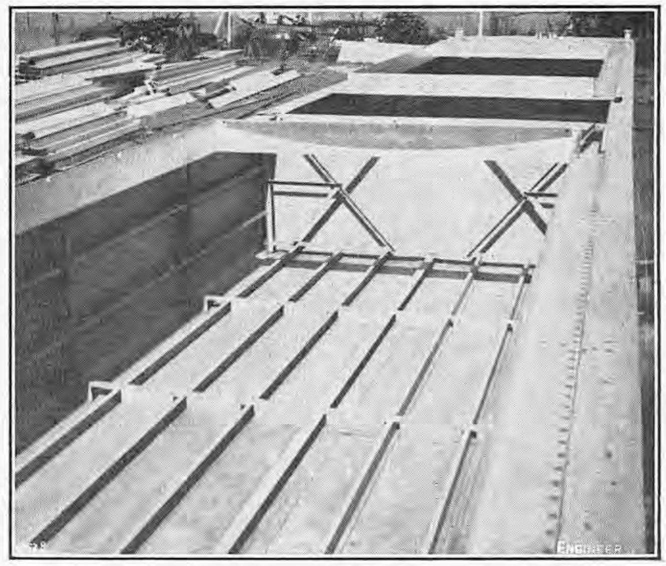


FIG. 2.

large pipe-flanges there is a 36-in. profile gas-cutting machine supplied by the British Oxygen Company and a portable Hancock oxy-acetylene pipe-cutting machine, to cut pipes up to 12-in. bore. These are supplied with gas from a liquid-oxygen and dissolved-acetylene plant. Three blacksmith's hearths are provided, with Keith Blackman blowing equipment; these are used mainly for expanding and reducing the ends of tubes. For welding the fabricated pipes, and for welding-on flanges, there are four Lincoln direct-current welding machines, three of 400-amperes capacity and one of 200 amperes. Long pipes are held in a "welding tower" for convenience in face-welding the flanges.

The Sindri contract was one of exceptional size, but many other large orders have also been undertaken; for example, about 250 tons of piping, up to 60 in. bore, for extensions to a steel works, a complete piping layout for a paper mill (about 21,000 ft. of piping, weighing 125 tons), and large quantities of 6-in., 8-in., 10-in. and 12-in. casing for tube wells, which are being extensively sunk for land irrigation.

INDIAN STEEL-TUBE WORKS.

A recent development which will have an important bearing on the provision of tubing to meet India's industrial expansion, and the supply of material to the works described above, is the decision of the Tata Iron and Steel Company, to construct, in association with Stewarts and Lloyds, Limited, a steel-tube works at Jamshedpur, which will draw its supplies of steel from a new strip mill to be installed by the Tata Company, also at Jamshedpur. The mill will be able to roll strip up to $12\frac{3}{4}$ in. wide and is expected to be in operation in about $3\frac{1}{2}$ years' time. Part of the capital for the tube works will be provided by Stewarts and Lloyds, but the controlling interest will be vested in the Tata Company. The scheme is being sponsored by the Government of India and will require an initial investment of about Rs.2.65 crores in the strip mill and Rs.3 crores in the tube works The Fretz-Moon continuous tube mill, which will be the first plant installed, will make welded tubes up to and including 3 in. nominal bore, and will have a capacity of about 80,000 tons of tube per annum. This is considerably greater than any likely Indian demand for some years to come, but will ensure that the future development of Indian industry will not be retarded by lack of these pipes. The scheme envisages the eventual production also of seamless and electrical resistance-welded tubes and is in line with the policy followed by Stewarts and Lloyds, Limited, in Australia and South Africa, where tube works have been put down to utilise steel supplied from the steelworks in those countries.

ALUMINIUM-ALLOY BARGES FOR THE CONGO.

AFTER a fairly long period of tentative experiment, both structural and metallurgical, aluminium alloys are now accepted materials for many marine applications. For seagoing vessels, their use is expanding steadily, but in smaller types of craft, it has definitely passed the experimental stage. Evidence of this is provided by the order for 60 barges of this material which Messrs. Thorpe Brothers (Bessborough Works), Limited, of West Molesey, Surrey, are now completing for service in the Belgian Congo, and one of which is illustrated in Figs. 1 and 2, on this page. They have an overall length of 77 ft., a moulded beam of 11 ft. 6 in., and a depth (excluding the hatch coamings) of 4 ft. 6 in. The two holds each measure 30 ft. in length, 10 ft. 6 in. in breadth and 4 ft. 6 in. in depth, giving a capacity of 66 tons at 40 cub. ft. to the ton. The draught, laden, is 3 ft. 9 in., which is 10 in. less than that of a steel barge of similar dimensions. This has the practical advantage that the barges can be used, in the area for which they are intended, for some eight months in the year instead of the five months to which a steel barge would be restricted by the reduced depth of water available in the dry season. In addition, of course, they are free from corrosion, immune against attack by the wood-boring worms, etc., which seriously limit the life of wooden barges in these tropical waters, and require a less expenditure of power when being towed, especially when they are empty.

The construction of these barges has been greatly simplified by the availability of aluminium-alloy plates of large size—up to 30 ft. long and $\frac{3}{16}$ in. thick. These, and the extruded sections, some of which have been produced specially for this contract, have been supplied by the British Aluminium Company, Limited. The side, bottom, deck and bulkhead plating is all of $\frac{3}{16}$-in. thickness, as also are the bulkhead and hatch-corner brackets. The transverse frames are 6 ft. apart. For convenience of shipment, each barge is constructed in two parts, joined by a wide T-section, specially extended, which is riveted to one half at the builders' yard, the other riveted joint being made on the final erection site. The midship deck plate is also left off until the final assembly; this is a fairly wide plate, giving considerable lap over both the adjacent plates, so that it acts as an effective butt strap. Special extrusions are used for the keelson, the bilge stringers (which are formed to a radius of 5 in.), the gunwales and the hatch coamings. The intercostals, which are $5\frac{1}{16}$ in. by $1\frac{1}{2}$ in. L bar, are attached to the bilge stringers by cast brackets. The bottom longitudinals (other than the centre keelson, which is of inverted T-section, with the flanges joggled to take the plating) are Z bars, measuring $3\frac{13}{16}$ in. by $1\frac{1}{2}$ in. by $1\frac{1}{2}$ in. and $\frac{1}{4}$ in. thick; they are spaced 18 in. apart. The bulkhead and side stiffeners, and the deck girders, also, are Z bars, of the same scantlings as the bottom longitudinals, and the bulkhead boundary is an extruded T-section, 6 in. by 2 in., and $\frac{1}{4}$ in. thick. The hatch openings measure 18 ft. in length by 9 ft. in width. The ends of the barges are of spoon shape, fitted with wood fenders attached to mild-steel brackets. These and the timber linings of the holds are being fitted on arrival in the Congo.

The barges are to be used to transport general cargoes from the upper reaches of the rivers down to the coastal ports. In this service they are certain to receive rough handling, but experience with aluminium-alloy craft has shown that they are well able to withstand arduous operating conditions. The size of the present order enabled the builders to organise the production methods to a high efficiency—for example, many of the plates are delivered to the yard ready cut to the required sizes, within close margins of tolerance; thus it has been possible to construct the vessels at a price which is stated to be "highly competitive."

CEYLON ROAD BRIDGE.—World-wide tenders will be called for shortly for the construction of a new bridge over the Kelani River. The bridge will be 900 ft. long and 80 ft. wide, with six traffic lanes and two footways.

ACCELERATION TEST RIG FOR PILOTS.—To study the effects of high-speed manœuvres on aircraft pilots, a 50-ft. whirling arm, designed and constructed by the McKiernan-Terry Corporation, has been installed in the Aviation Medical Acceleration Laboratory of the United States Naval Air Development Center, Johnsville, Pennsylvania. It is capable of imposing accelerations of the order of 40*g*. The subject sits in an airtight gondola, the attitude of which can be adjusted to simulate flight conditions, on the end of the arm. Medical instruments and recording cameras are carried in the gondola. The whirling arm is of braced-girder construction, comprising four sections of welded chromium-molybdenum steel tube, adjacent sections being attached together at each joint by eight 1-in. diameter alloy-steel bolts and self-locking anti-vibration elastic stop nuts. The highest tensile load on any joint is 225,000 lb. The gondola is made up from two half shells of aluminium-faced sandwich construction with a gear ring, 10 ft. in diameter, between them; the two halves are attached by 288 bolts of $\frac{1}{2}$-in. diameter secured with elastic stop nuts. The motions of the gondola are provided by two drive shafts, supported on outriggers from the whirling arm, coupled to the gondola gear ring and the gimbal in which it is suspended. The test rig is driven by a direct-current motor with an instantaneous rating of 16,000 h.p. and a standard rating of 4,000 h.p.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

Pig Iron and Steel Production.—Production of steel ingots and castings during July was at an annual rate of 1,502,500 tons in Scotland, which compared with 1,184,500 tons in July of last year. The output for the first six months of the present year was equivalent to 2,070,500 tons against 2,231,800 tons in the corresponding period of 1951. Pig-iron production was at a rate of 828,600 tons in July, contrasting with 674,900 tons a year ago, while the output for the first half of the year was at a rate of 888,800 tons against 765,400 tons in the first six months of 1951.

The Albion Marine Diesel Engine.—The first sea trials of a marine version of the Albion Diesel engine were carried out on August 14 over the measured mile in the Gareloch, when the 34-ton wreck-survey launch, Northern Kiwi, averaged eight knots over six runs. Known as the Albion Albatross, the engine is a four-cylinder overhead-valve unit of 65 h.p. It drives a propeller 28 in. in diameter through a 2 : 1 reduction gear. The unit has been developed at the Scotstoun works of Albion Motors, Ltd., the production, at present, being about 45 units a week. The engine in the Northern Kiwi was installed by the Scottish agents for the Albion Albatross, namely, Peters Motors (Bishopton), Ltd., Bishopton.

Kintyre Naval Air Station.—It was announced by the Admiralty on August 14 that the Royal Naval Air Station in Kintyre, H.M.S. Landrail, will close down temporarily next month. A naval spokesman said that it was not expected that flying operations would be resumed before the end of 1953. The airfield is not suitable for large aircraft, and, in order that it may take heavier and faster machines, the runways are to be enlarged. When they are reconstructed, transatlantic planes will be able to land in an emergency.

Cement Project in Cyprus.—The announcement was made on August 14 by the Tunnel Portland Cement Company and William Baird & Co., Glasgow, of a decision to become partners in a new cement project in Cyprus. For the purpose of building and operating a cement works, a local company has been formed in which the United Kingdom firms will be jointly interested. The Tunnel company have also announced plans for increasing their manufacturing capacity in this country, including the extension of the grinding plant at the Clydebank works of their subsidiary concern, the Clyde Portland Cement Company.

Industrial Developments at Prestonpans.—The Edinburgh district committee of the Scottish Board for Industry have approved the Haddingtonshire planning officer's suggestion that Prestonpans would be a suitable site for small industrial units. This was stated in Edinburgh on August 16, after development plans for the county had been discussed by the committee and referred to the county planning authority.

The Elgin to Lossiemouth Railway.—The oldest railway north of the Grampians, the five-miles Elgin to Lossiemouth line, which is still in use for goods and passenger traffic, is now 100 years old. The contractor responsible for the construction of the line, Mr. J. Samuel, also designed two locomotives for it. They were shipped to Lossiemouth from England, together with carriages and wagons. To advertise the venture the owners, the Morayshire Railway Company, allowed passengers to travel free between the two towns on the opening day, August 10, 1852.

The Late Mr. J. T. Guthrie.—Mr. James Taylor Guthrie, a former works manager with the Anglo-Iranian Oil Company, Ltd., at Abadan, died suddenly at his home in Edinburgh on August 20. He was formerly in charge of the electrical installations at Abadan. Mr. Guthrie was elected deputy chairman of the Scottish branch of the Institute of Petroleum in 1938, a position he held until his death.

The Late Mr. W. P. Weir, M.B.E.—Mr. Walter Pollock Weir, employed throughout his working life with Lithgows Ltd., shipbuilders, Port Glasgow, died last week at the age of 75. For many years head foreman plater in the Kingston shipyard, he was promoted manager of the firm's East Yard a year or two before the war, continuing in that capacity until his retirement in 1945. Mr. Weir was awarded the M.B.E. in 1943.

CLEVELAND AND THE NORTHERN COUNTIES.

Tyne Shipbuilding.—Three launches in September, making a total of about 32,000 gross tons, will bring the Tyne's output of shipping for the first nine months of the present year to just over 130,000 tons, which is about equal to the figure for the corresponding period of 1951. A 7,000-ton passenger ship for the Bergen Steamship Co., Ltd., will be launched on September 3 by Swan, Hunter and Wigham Richardson, Ltd. On September 16, the 32,500-ton tanker, World Enterprise, will be launched from the Walker-on-Tyne yard of Vickers-Armstrongs Ltd. Two larger tankers, each of 44,000 tons, are on order at Barrow-in-Furness. The Tyne's third launch in September will be the cargo ship Glenmoor, of 9,350 tons, which R. and W. Hawthorn, Leslie & Co., Ltd., are building for the Moor Line. At the beginning of September, the same firm will hand over the new tanker Tynefield, built for Hunting & Son, Ltd., Newcastle.

The Admiralty and the North-East Coast.—At the end of his tour of Tyne and Wear shipyards last week, Mr. S. W. Digby, Civil Lord of the Admiralty, stated that, in the last quarter of the present year, shipbuilding firms would receive 8 per cent. additional steel, instead of the 5 per cent. announced in July. Mr. Digby said that he had discussed various problems, including the steel shortage, with the shipbuilders, and he gave an assurance that the Government would do their best to increase supplies to the industry as more steel became available. Mr. Digby hoped that there would be a gradual improvement in the steel position.

Full-Time Working Resumed at North-East Steelworks.—The normal 17-shift week has been restored at the steelworks of the South Durham Steel and Iron Co. Ltd., West Hartlepool. This has been made possible by the putting into commission of a new steel furnace and the building up of stocks during the holiday period. Largely owing to ingot shortage, a 15-shift week had been operating for some months past. The Cargo Fleet Iron Works, Middlesbrough, which, last September, began working 12 shifts weekly instead of 17, owing to the shortage of scrap, have now also returned to full production. In May, a new blast furnace was blown in, thus increasing iron output by 1,000 tons a week, making the works less dependent upon scrap. Within the next few weeks a new tilting steel furnace, having a capacity of 220 tons, will be brought into operation, and work is also in hand on the rebuilding of a battery of 22 coke-ovens, which will increase the output of coke from 4,200 tons to 6,000 tons a week.

Closing of Small Drift Mine.—After being in operation for 200 years, Hareshaw Head pit, a small drift mine near Bellingham, Northumberland, has been closed down. The managing director of the firm, which operated under licence from the National Coal Board, is Mr. B. Armstrong, whose family have always worked the mine. The output during the 200 years of the mine's existence has amounted to about 200,000 tons and, in the best years, the annual output was 5,000 tons, produced with 30 employees on the books.

LANCASHIRE AND SOUTH YORKSHIRE.

Impending Cancellation of Re-armament Orders.—Sheffield manufacturers with re-armament orders on hand are not perturbed by the impending cancellations of Government defence orders. The impression is that there will be a gradual scaling down of defence work and no significant dislocation. It is felt that it would be easy to divert raw material bought for defence to other sections of manufacture, where short supply is a constant worry. Firms are to be compensated for work put in hand for the Government and not now needed.

Contraction in Demand for Motor-Car Components.—The numerous engineering firms which specialise in the manufacture of motor-car components, in Sheffield and district, are feeling the effects of a contraction of demand consequent upon the curtailment of production by leading motor-car manufacturers. At the Sheepbridge Equipment Works, which form part of Sheepbridge Engineering, Ltd., 25 men have been given notice, and, at the nearby Sheepbridge Stokes Works, 50 are to be given two weeks' notice to leave early in September. Efforts are being made to find the men alternative employment before the notices expire.

A Research Rolling Mill.—A new cold-strip reversing rolling mill, which has cost 60,000*l*., is being erected at the research station of the British Iron and Steel Research Association at Sheffield. It was planned some six years ago, when the committee of the Association decided that equipment different from the normal commercial rolling mill was needed, namely, plant in which various-sized rolls could be incorporated and driven at speeds covering a wide range.

A Result of "Holidays With Pay."—Sheffield industrial operatives are short of funds after their first holiday-with-pay fortnight. Some have taken the unusual course, for men fully employed, of applying for public assistance. To some, loans have been advanced, but, where there are children and real hardship, grants have been made. Other employees, through the welfare officers at their works, have asked for an advance on their wages.

Industrial Development in Lancashire.—The President of the Board of Trade, Mr. P. Thorneycroft, stated recently that agreements had lately been concluded for the development of engineering works in Lancashire, namely, the General Electric Co., Ltd., in Shaw, Burnley Aircraft Products, Ltd., in Burnley, and the British Thomson-Houston Co., Ltd., in Nelson. All three projects, he stated, would be housed in existing premises and they were expected to provide additional employment for about 2,000 persons.

Visit of Contractors' Employees to Power Station.—On Saturday, August 16, by courtesy of the British Electricity Authority (North Eastern Division), 64 members of the Rose Mount Engineering Society, employees of Robert Dempster & Sons, Ltd., Rose Mount Iron Works, Elland, Yorkshire, paid a visit to the North Tees power station. The members were conducted round the power station, and afterwards inspected the coal-handling, sorting and reclaiming plant which had been erected by their firm.

THE MIDLANDS.

Redundancy in the Motor Trade.—The Austin Motor Co., Ltd., Longbridge, have declared 800 men redundant, out of the total of 22,000 employed at the works. The reasons given by the company are the reduction of Australian imports, German competition, and a decreased demand for some of the larger and more expensive cars. The Austin A90 model is being withdrawn, but a new A40 coupé has been introduced, and the first models have already been shown in America. Dismissals have also been announced by the Standard Motor Co., Ltd., Coventry, where 80 men are affected. The company state that the discharges are necessary because of the increasing tendency for cars to be exported in the "fully knocked down" condition, for assembly abroad.

Power Station Re-Opened.—The electric power station at Wolverhampton, in the British Electricity Authority's Midlands Division, which was closed more than twelve months ago as a result of a serious breakdown, has now been completely overhauled, and was re-opened on August 12. Its return to service has enabled plant at Walsall power station, also in the Midlands Division, to be taken out of commission for routine overhaul.

Railway Derailment.—Three loaded wagons of a goods train, which was leaving a siding at Bushbury, Wolverhampton, on August 18, fouled the points and became derailed. The down line was damaged and blocked, but the up line remained in commission, and single-line traffic was worked for five hours until a breakdown gang from Bescot, Walsall, had cleared and restored the track. The line affected was the London Midland Region main line from Birmingham and Wolverhampton to Stafford, Crewe, and the north, and several trains were delayed.

Repair of an Old Beam Engine.—The beam engine driving a rolling mill at the works of the Hart's Hill Iron Co., Ltd., Brierley Hill, Staffordshire, which broke down at the end of June, is now at work again. The cast-iron beam, which broke in two at the trunnions, has been replaced by a steel one, the two sides of which were flame-cut from 3-in. thick slabs, rolled at the Abbey Steelworks, Margam. The work of repairing the engine, which included removing the broken beam, machining and fitting the new one, and replacing the wooden spring beams, was undertaken by the company's own maintenance staff, and was completed in five weeks. The engine, which has a cylinder 48 in. in diameter, and a stroke of 9 ft., is of unknown age, but it has been in its present position for over 100 years.

Scrap Iron and Steel Collection.—Several local authorities in the Midlands have now concluded their special scrap drives, with satisfactory results. Efforts in the rural areas of the Midlands, with the assistance of the local branches of the National Farmers' Union have produced a total of about 35,000 tons of scrap from Shropshire and Worcestershire, and about the same quantity has been collected in Staffordshire. Mr. P. G. Grigg, chairman of the Midland Scrap Drive Committee has, however, expressed the view that, though the figures for the area compare favourably with those for the rest of the country, there is scope for improvement.

A NEW USE FOR GRASS-DRYING PLANT.—An ordinary grass-drying plant has been used experimentally at Ashlow, near Kenilworth, Warwickshire, for drying plums. This experiment, the first of its kind to be carried out in the British Isles, was organised by the Horticultural Branch of the National Farmers' Union, to examine the possibility of using existing standard equipment for fruit-drying. The area has a record crop of plums, much of which is going to waste for the want of a market. The plums were placed on wooden trays with expanded aluminium bottoms, and dried for 15 hours.

SCALE MODEL GAS ENGINE.—A working scale model of a gas engine of a type which was once common, but is now becoming rare, has been placed on exhibition for an indefinite period at the Chance Technical College, Crockett's-lane, Smethwick, 40. The work of two Birmingham amateur model makers, Mr. A. J. Kent and Mr. F. H. Tapper, the model is of a Tangye engine of 1890. It is built to a scale of a quarter full size and represents an engine of 6 n.h.p., which developed 11·5 b.h.p. at 200 r.p.m.

SOUTH-WEST ENGLAND AND SOUTH WALES.

WELSH STEEL TRADE.—As a result of pre-holiday intensified production, the output of steel in South Wales, during the month of July, reached a record, according to details issued by the British Iron and Steel Federation. The average weekly output, during the month, was 72,570 tons, compared with 68,440 tons in June and an average of 68,670 tons for the first six months of 1952. The previous highest weekly average was reached in November, 1951, when it stood at 72,260 tons. The pig-iron output in the district was also a record, the weekly average being 31,210 tons, compared with 27,220 tons in June and an average of 26,680 tons in the first six months of 1952.

TRAFFIC AT SOUTH WALES PORTS.—During the first seven months of the present year the South Wales ports handled about 2,000,000 tons more traffic than was the case in the corresponding period of last year. Both imports and exports increased. On the import side, there was a substantial rise in arrivals of oil and spirits, destined chiefly for the enlarged Swansea refinery, while iron-ore imports rose from 1,127,199 tons in the first seven months of 1951 to 1,290,710 tons this year. Among exports, shipments of coal and coke to foreign countries increased from 1,647,841 to 2,193,058 tons, and tin-plate from 130,423 to 154,313 tons.

EMPLOYMENT AT MERTHYR.—The Merthyr factory of Hoover (Washing Machines) Ltd., which, in the middle of June went on to a shortened working week of four days, has now returned to a five-day working week. Building development at the factory, now nearing completion, will bring the total floor space up to 200,000 sq. ft., or three times the area available when the factory was opened in 1948. Plant costing some 500,000*l*. is being installed in the extensions.

FUTURE OF THE COAL EXPORT TRADE.—A gloomy picture of the coal export trade is given by Sir Herbert Merrett, the Cardiff industrialist, in the current issue of the *National Provincial Bank Review*. The trade will shrink rapidly from 1954, he expects, and will die out completely by 1956 unless measures are taken to save it. It hardly seems possible, he continues, to raise coal production by more than the 2,500,000 tons a year, which was hoped for in the National Coal Board's "Plan for Coal." It is likely, therefore, that it will become necessary to import coal and that this importation, side by side with the export of British coal, may become a permanent feature of the British economy. Even so, it seems certain that the export of British coal will be restricted to the very lowest level. The potential home demand, Sir Herbert estimates, will be from 240,000,000 to 243,000,000 tons by 1956, and from 255,000,000 to 260,000,000 tons by 1961. The probable output by 1956, he thinks, will be about 226,000,000 tons.

END OF MINERS' TRANSPORT FARES STRIKE.—The 1,600 colliers employed at the Tirherbert and Tower Collieries, Hirwaun, who had been on strike for a fortnight as a protest against the increased omnibus fares introduced by the Merthyr Corporation, returned to work during the past week. Work was resumed pending discussion between the National Union of Mineworkers and the National Coal Board on the question of subsidising miners' travel.

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.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Leeds Branch:* Monday, September 1, 7.30 p.m., The Great Northern Hotel, Leeds. "The Application of Aluminium in the Construction of Cables," by Mr. J. W. Fall and Mr. J. W. Robertshaw. *North-East London Branch:* Monday, September 1, 8 p.m., The Angel Hotel, Ilford. "The Work of the Association of Supervising Electrical Engineers," by Mr. G. Davidson. *West London Branch:* Tuesday, September 2, 7.30 p.m., Windsor Castle Hotel, 134, King-street, Hammersmith, W.6. "The Isolation of Vibration and Noise from Electrical and Mechanical Machinery," by Mr. R. B. Grey. *North London Branch:* Wednesday, September 3, 8.15 p.m., The Three Jolly Butchers Hotel, Wood Green, N.22. "Air Conditioning and Modern Methods of Insulating Buildings," by Mr. A. C. Mackadam. *South London Branch:* Thursday, September 4, 8 p.m., The Café Royal, North End, Croydon. "Oil Burners and Panel Heating," by Mr. E. H. Bailey. *Crewe Branch:* Friday, September 5, 7.30 p.m., The Crewe Arms Hotel, Crewe. "Ethical Implications of Science," by Mr. J. Levitt. *Liverpool Branch:* Friday, September 5, 7.30 p.m., Liverpool Engineering Society, 9, The Temple, 24, Dale-street, Liverpool, 2. Branch chairman's address, by Mr. L. Harper.

HELICOPTER ASSOCIATION OF GREAT BRITAIN.—Friday, September 5, 5.30 p.m., Institution of Civil Engineers, Great George-street, S.W.1. "Helicopter Operating Experiences," by Mr. A. V. J. Vernieuwe.

INCORPORATED PLANT ENGINEERS.—*East Lancashire Branch:* Tuesday, September 9, 7.15 p.m., Engineers' Club, Albert-square, Manchester. Open Discussion Meeting. *Newcastle-upon-Tyne Branch:* Thursday, September 11, 7.30 p.m., Roadway House, Oxford-street, Newcastle-upon-Tyne. "Liquid-Fuel Firing," by Mr. Alan Moore. *Liverpool and North Wales Branch:* Monday, September 15, 7.15 p.m., Radiant House, Bold-street, Liverpool. "Amenities in Industry," by Mr. H. S. Crump.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*Midlands Centre:* Tuesday, September 9, 7.30 p.m., Crown Inn, Broad-street, Birmingham. "Some Factors Influencing the Choice of a Crankcase Lubricating Oil," by Mr. A. Towle. *North-West Centre:* Wednesday, September 17, 7.30 p.m., Adelphi Hotel, Liverpool. "Heavy Haulage," by Mr. E. Skelton.

INSTITUTE OF METALS.—Monday, September 15, to Friday, September 19, 44th Annual Autumn Meeting. Monday, September 15, 8.30 p.m., Sheldonian Theatre, Broad-street, Oxford. Autumn Lecture: "On the Foothills of the Plastic Range," by Professor H. W. Swift. Tuesday, September 16, and Wednesday, September 17, 9.30 a.m., Clarendon Laboratory, Parks-road, Oxford, various papers for discussion. Thursday, September 18, 9.30 a.m., Clarendon Laboratory, informal discussion on "Grain Boundaries." Various visits and excursions will take place on the afternoons of Tuesday, Wednesday and Thursday, and all day on Friday. For further particulars, see page 223, *ante*.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, September 16, 5.30 p.m., 85, Minories, E.C.3. Presidential address by Lord Howard de Walden.

INDUSTRIAL TRANSLUCENT LIGHTING UNITS.—A new series of industrial translucent lighting units has been introduced by Holophane, Limited, Elverton-street, London, S.W.1. They have been designed for lofty interiors where it is desired to provide, by light control, a satisfactory degree of ceiling brightness without reducing the illumination on the working plane. The fittings embody prismatic reflectors and are made in both single and twin units. The former are designed for use with tungsten lamps and the latter for a mercury-discharge and filament lamp, so as to give illumination approaching that of daylight.

INDUSTRIAL DESIGN COMPETITION.—The prize for the best work in industrial design by a student of the Royal College of Art, awarded annually by the Federation of British Industries, has been won this year by Mr. James Williams, who has been studying furniture design and fittings for ships' cabins. The 100*l*. prize is awarded to enable the winning student to see something of the work done in his field by designers in overseas countries. Mr. Williams is now studying in Scandinavia. In conjunction with Professor R. D. Russell, Professor in the School of Engineering and Furniture Design at the Royal College of Art, he gained the second prize for the Royal College of Art in a national competition for ships' cabin design organised by the Scottish Committee of the Council for Industrial Design.

PERSONAL.

SIR CECIL WEIR, K.B.E., M.C., D.L., is to lead the British delegation to the High Authority of the European Steel and Coal Community, Luxembourg. He will be assisted by MR. JAMES MARJORIBANKS, of the Foreign Office; MISS ELIZABETH ACKROYD, under-secretary, Ministry of Supply; and MR. CHARLES DE PEYER, under-secretary, Ministry of Fuel and Power. Sir Cecil is leaving for Luxembourg early next month.

BRIGADIER THE HON. H. K. M. KINDERSLEY has been appointed deputy chairman of Rolls-Royce Ltd., Derby. The firm also announce that AIR MARSHAL SIR COLIN W. WEEDON, K.B.E., C.B., will join them in September on his retirement from the Royal Air Force. Sir Colin will be concerned with the export side of the aero-engine division.

MR. T. S. CHARLTON, J.P., production director of the South-Western Division of the National Coal Board, has been appointed deputy chairman of the West Midlands Division, Himley Hall, near Dudley, Worcestershire, in succession to ALDERMAN G. H. JONES, O.B.E., J.P., who is retiring at the end of September. MR. G. S. MORGAN, general manager, No. 4 area of the South-Western Division, at Aberaman, Aberdare, is to succeed Mr. Charlton as production director.

Among recent promotions in the Scientific Civil Service are those of MR. S. B. GATES, O.B.E., M.A., A.F.R.Ae.S., of the Royal Aircraft Establishment, Ministry of Supply, who has been made a chief scientific officer; SIR DONALD C. BAILEY, O.B.E., D.Eng., A.M.I.C.E., M.I.Struct.E., of the Military-Engineering Experimental Establishment, Ministry of Supply, who becomes a deputy chief scientific officer; and DR. F. E. JONES, M.B.E., B.Sc. (Eng.), A.M.I.E.E., of the Telecommunications Research Establishment, Ministry of Supply, who has also been promoted to deputy chief scientific officer.

MR. E. G. A. SINGLETON, M.I.Mech.E., engineer and deputy general manager, Wolverhampton Corporation Transport Department, has been appointed general manager and engineer, Burton-on-Trent Transport Undertaking. He will take up his new duties on October 1.

MR. J. FOSTER VEEVERS, M.I.E.E., M.I.P.E., M.I.I.A., formerly with the General Electric Co. Ltd., as manager of the Stockport Works of Salford Electrical Instruments Ltd., has been appointed general manager of the Swindon Works of the Plessey Co., Ltd., Ilford, Essex.

MR. ROBERT BUCHANAN, a director of the Lion Foundry Co., Ltd., Lion Foundry, Kirkintilloch, near Glasgow, has retired after 71 years of service with the firm. Latterly, Mr. Buchanan has represented the firm in the Midlands.

MR. H. H. CASH, M.I.E.E., hitherto personal assistant to the chairman and deputy chairman of the Yorkshire Electricity Board, has been appointed system operation liaison engineer to the Southern Division, British Electricity Authority.

MR. W. F. WHITE, M.I.C.E., M.I.W.E., formerly with the Water Department, Liverpool, has been appointed water engineer to Torquay Municipal Council, Town Hall, Torquay, Devonshire.

MR. C. D. BARBER, A.M.I.C.E., A.M.I.Mun.E., of Northampton, MR. C. H. GOWMAN, B.Sc., of Balham, S.W.17, and MR. R. S. HENDERSON, of Roehampton, S.W.15, have been appointed to the Colonial Engineering Service, Mr. Barber to Malaya, Mr. Gowman to Tanganyika, and Mr. Henderson to Nigeria.

MR. F. MARSHALL, B.Met., has joined the metallurgical staff of the Research and Development Division, British Steel Founders' Association, Broomgrove Lodge, 13, Broomgrove-road, Sheffield, 10.

MR. E. S. H. EALES, A.C.A., A.M.Inst.T., audit officer, London Transport Executive, 55, Broadway, London, S.W.1, has been appointed costs officer. MR. W. P. LAVENDER, A.A.C.C.A., traffic auditor, has been appointed audit officer.

The Minister of Transport has appointed MR. A. G. BLOWS to be registrar-general of shipping and seamen, with effect from September 9, in succession to MR. ALFRED SPENCE, M.B.E.

ALDERMAN N. GRATTON, who is a member of the Derbyshire County Council, has been appointed as a representative of local authorities on the Transport Users Consultative Committee for the East Midland Area, in place of ALDERMAN C. F. WHITE, who has resigned.

SABEN, HART AND PARTNERS LTD., design consultants, have moved from 3-4, Albemarle-street, to larger premises at 207-213, Oxford-street, London, W.1. (Telephone: GERrard 9622-5.)

THE CLIMAX ROCK DRILL AND ENGINEERING WORKS LTD., have opened a new branch office at High-road, Earlsheaton, Dewsbury, under the management of MR. R. SHEFFIELD (Telephone: Dewsbury 2190).

PIPE-FABRICATION WORKS OF STEWARTS AND LLOYDS OF INDIA, LTD.

(*For Description, see Page* 267.)

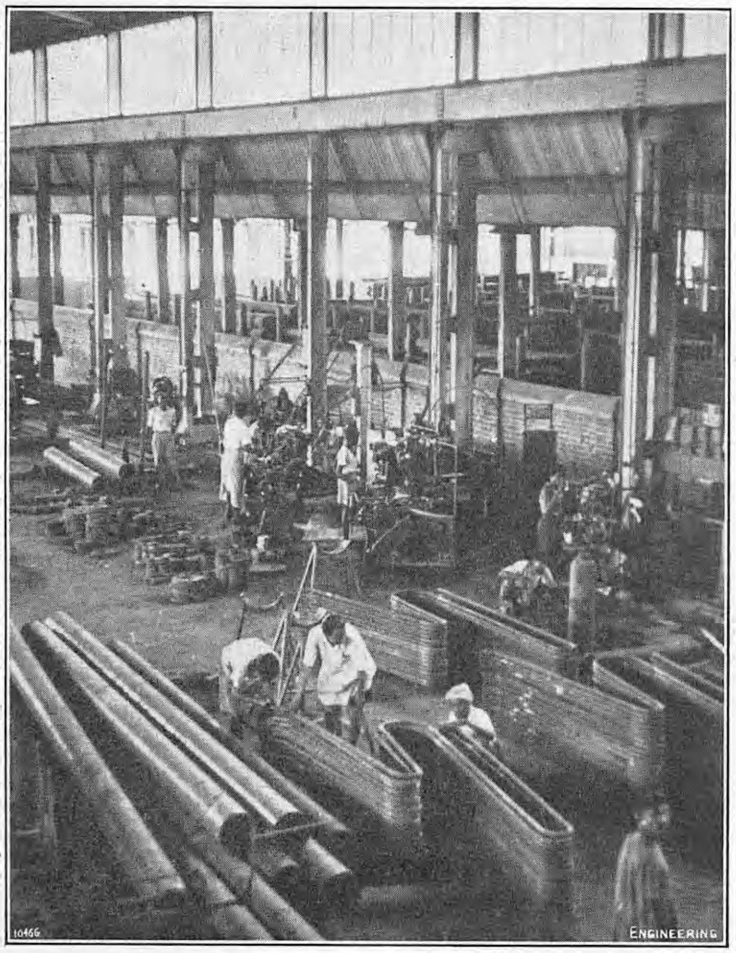


FIG. 7. SUPERHEATER ELEMENTS FOR WATER-TUBE BOILER.

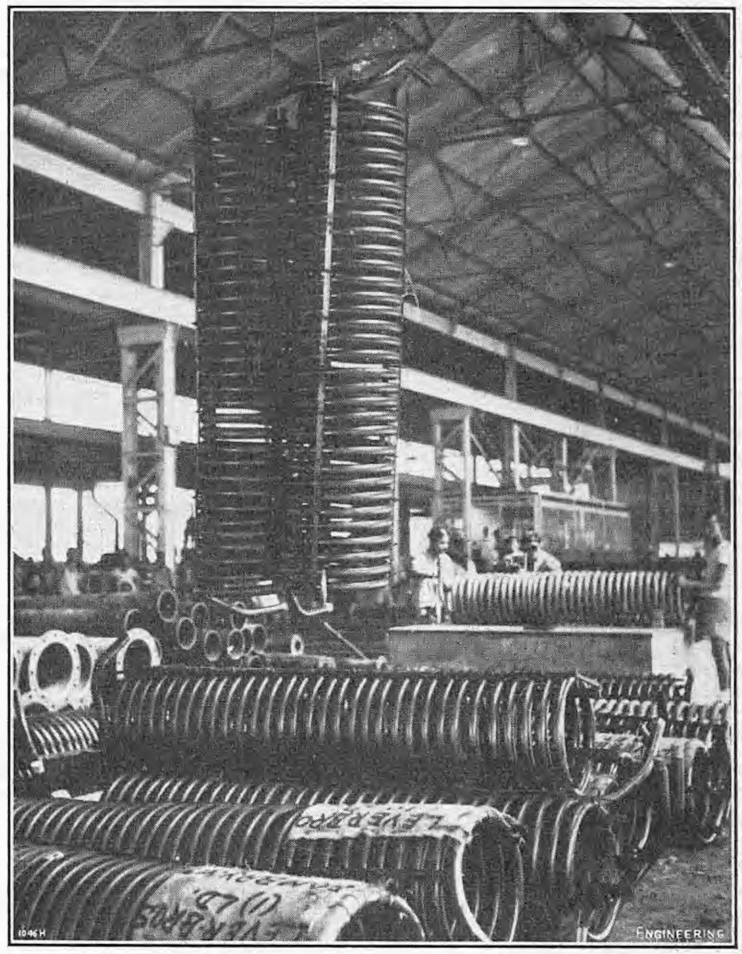


FIG. 8. $1\frac{1}{4}$-IN. STEAM HEATING COILS.

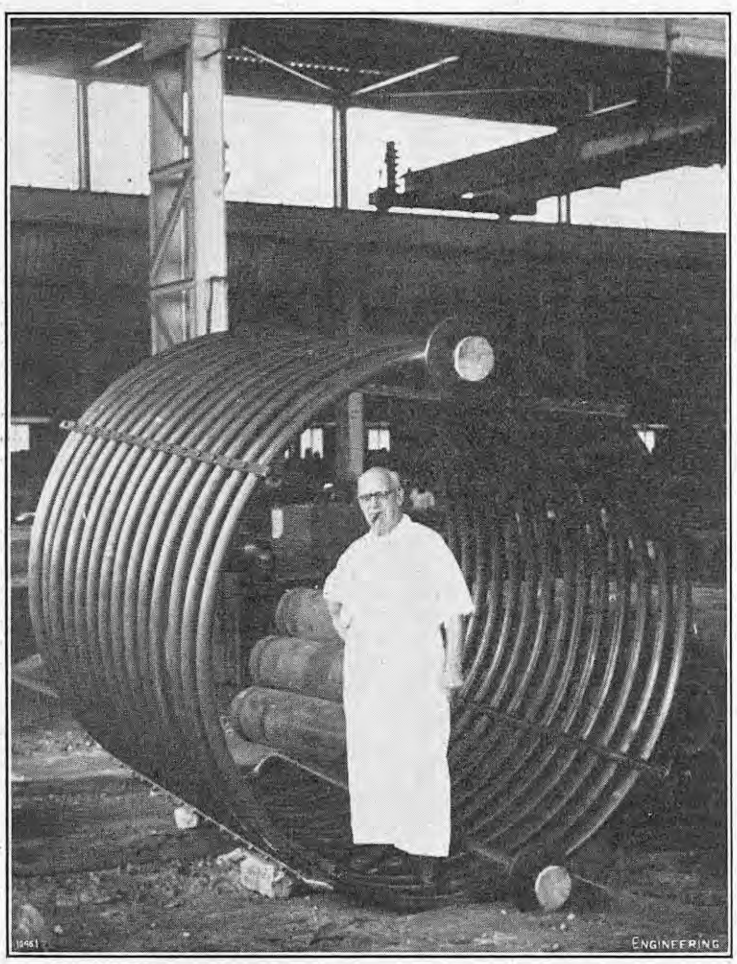


FIG. 9. 2-IN. BORE COOLING COIL.

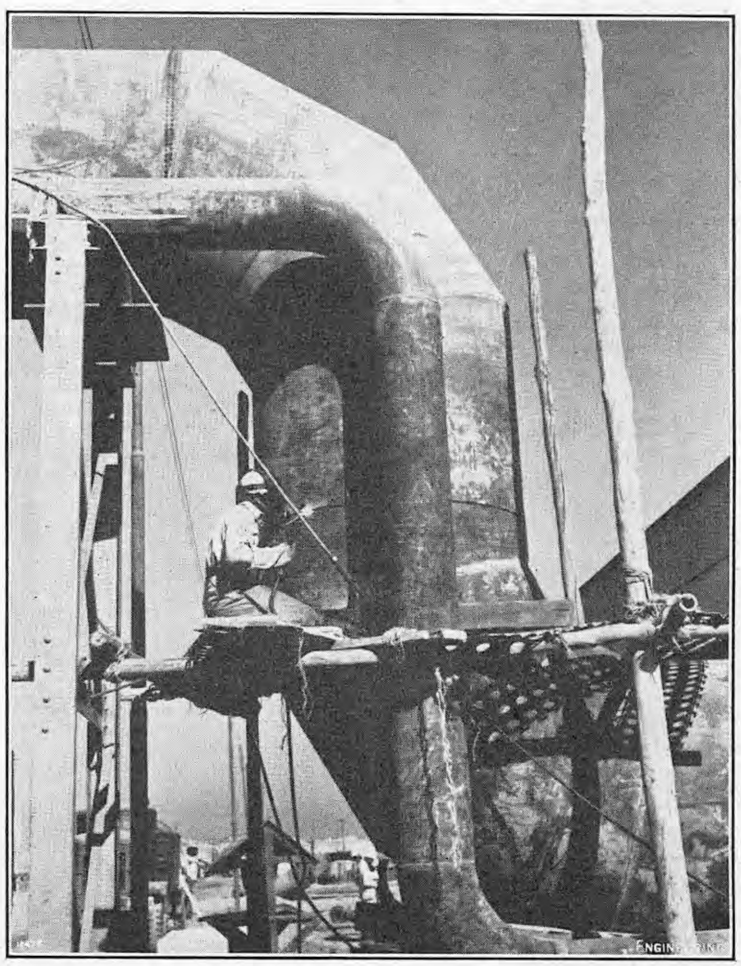


FIG. 10. OUTSIDE ERECTION AT SINDRI.

ENGINEERING

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CONTENTS.

ENGINEERING

FRIDAY, AUGUST 29, 1952.

VOL. 174. No. 4518.

DEVELOPMENTS IN IRON AND STEEL TECHNOLOGY.

IN one direction or another, the production of iron and steel—especially steel—has been figuring very prominently among the engineering topics claiming consideration during the month of August, though there is no particular reason to suppose that this is other than a mere coincidence. In our issue of August 1, on page 145, *ante*, we discussed the Government's proposals for the return of the nationalised iron and steel industry in this country to private ownership and its operation thereafter under the general supervision of a Board, responsible to the Government. Three weeks later, on page 241, *ante*, we reviewed the activities of the present Iron and Steel Corporation of Great Britain—the body which, under the terms of the Iron and Steel Act, 1949, directs the nationalised industry—for the period from February 15, 1951, when the Corporation acquired control of 298 undertakings, to September 30 in the same year. Hard upon the heels of that report, which was concerned with financial and administrative matters rather than with the technology of steel production, there has appeared another, issued by the United Nations Economic Commission for Europe, dealing with "Recent Developments and Trends in Iron and Steel Technology."*

This report is stated to be "the first of a series designed to assist business men, Government officials and professional economists to keep abreast of developments in basic iron and steel making processes"—"basic," in this connection, obviously connoting "fundamental" and not referring to any specific process. It is essentially a popular presentation of the developments that it covers, and consists of five short papers by leading authorities from five countries, introduced by a general summary by Professor Robert Durrer of the Zürich Polytechnic, who is also director of the Louis de Roll iron and steel works, Switzerland. The other contributors are Mr. P. E. Cavanagh, assistant director in the department of engineering and metallurgy, Ontario Research Foundation, Canada; Professor Bo Kalling, of Domnarvet, Sweden; Professor A. G. Lefebvre, of the Faculté Polytechnique de Mons, Belgium; Mr. H. Malcor, President of the Institut de Recherches de la Sidérurgie, France; and Professor Dr. Ing. H. Schenk, of the Verein Deutscher Eisenhüttenleute, Düsseldorf, Germany.

The future development of iron and steel production, Professor Dürrer points out, is becoming more and more a matter of raw materials and their location. The world production at the present time is about 200 million tons of steel and about 20 million tons of pig iron, to be used as such. The gross production of pig iron is about 150 million tons, but some 90 per cent. of this is converted into steel. The consumption of iron ore is about 250 million tons, which requires annually more than 100 million tons of coke to smelt. Rather more than half of the world's steel production is obtained from pig iron, the remainder being made up from scrap. The tendency is to increase the proportion of scrap, when it can be obtained. In Professor Durrer's opinion, the rapid exhaustion of the raw-material sources on which the industry has been relying in the past is likely to lead to considerable industrial changes and to radical alterations in production methods. "So far as concerns iron," he observes, "this transformation has already begun, although on very modest lines; it will assume substantial shape before long." The trend of development, as he foresees it, will be towards a gradual displacement of coke from its present position of pre-eminence; "the aim must be to use any fuel, particularly as the over-all fuel reserves also are not inexhaustible, although much larger than those of coking coal." He does not rule out entirely the possibility that some practicable process of direct reduction—i.e., the production of steel directly from the ore—may be perfected, though he regards this as "rather unlikely," and points out that further refining will still be necessary before the steel thus produced will be usable.

Mr. Cavanagh, who deals with "Developments in the Iron and Steel Industry in Canada, 1950." expects that the vast iron-ore deposits in Labrador will come into production in 1953. The ore will be transported 300 miles by rail to the St. Lawrence river and thence by ship either to the Great Lakes or to the Atlantic Ocean. The production initially planned is at a minimum rate of 10 million tons a year. Meanwhile, other developments also are in hand, notably the production of low-carbon iron from ilmenite ore in electric furnaces by the Quebec Iron and Titanium Company. A pilot investigation is also in hand of a tunnel-kiln process for making sponge iron, under the auspices of the Ontario Research Foundation; but the process is somewhat expensive and, as Professor Durrer observes in his summary, its commercial practicability depends on a number of other factors. He considers that it should be of special value in situations such as obtain in Venezuela, where rich ore is found in conjunction with natural gas. The process is, in effect, a means of providing a substitute for scrap.

The production of sponge iron is being developed in Sweden also, as is mentioned by Professor Kalling in his review of progress in that country. Considerable progress is reported in processes of

* Document E/ECE/147, issued in English and French by the Commission, from Geneva, Switzerland.

sintering, especially the method of pelletising; and, in Sweden at least, much is expected of the process for removing phosphorus from ores by leaching, developed at Grängesberg. In steelmaking, the basic Bessemer process is expected to attain to an increased importance as a result of various methods of reducing the nitrogen content of the steel; and "great savings" have been effected in the Swedish acid open-hearth process by the introduction of oxygen at an early stage of the heat. While the high-frequency electric furnace has come much to the fore, especially in Sweden, Professor Kalling considers that it will never compare in importance with the arc furnace, so long as the big furnaces have to be acid-lined.

In Belgium, according to Professor Lefebvre, recent research has been directed mainly towards the improvement of Thomas steels, especially by the use of oxygen enrichment of the blast in the converter. By this means, in conjunction with a limestone flux, sodium carbonate and water vapour, it has been possible to produce Thomas steels with phosphorus and nitrogen contents as low as those of open-hearth steels, better physical characteristics, and a reduced liability to ageing. Three large Belgian iron and steel works, he adds, have decided to construct large oxygen-producing plants, with capacities of 100 to 150 tons of O_2 per day. The research work reviewed by Professor Lefebvre is carried out jointly by the Centre National de Recherches Métallurgiques, the Institut de Recherches, Sciences, Industrie et Agriculture, and the Institut de Recherches de la Sidérurgie (in France), and is undertaken collectively on behalf of all the Belgian and Luxembourg steelworks.

The industry in France is conditioned by the facts that good coking coal is scarce, and that practically all of the ore mined comes from Lorraine; about two-thirds of the steel, therefore, is produced in Thomas plants, the phosphorus content of the Lorraine ore favouring the use of the converter process. Scrap is scarce, however, thus restricting the adoption of open-hearth furnaces; so particular attention has been devoted to improving the quality of Thomas steel by eliminating the phosphorus, oxygen and nitrogen. Mr. Mancor states that considerable progress has been made in the coking (the report calls it "cokefaction") of Lorraine-Sarre coals, especially by the Carling and Sovaco processes, so that it is now possible to produce, from a charge containing at least 60 per cent. of Lorraine-Sarre coals, including a high proportion of high-volatile medium-caking coals, a coke possessing the necessary strength for use in blast furnaces. In some of the tests, it has been found possible to use Lorraine-Sarre coals only, or, alternatively, to increase the proportion of high-volatile non-caking coals. The latter coals will be used mainly in the form of semi-coke, which will be employed either for blending in the Marienau process, for sintering, or in low-shaft furnaces. An extensive programme for the construction of coke ovens is now in hand; and the use of oil, tar, natural gas and coke-oven gas in firing open-hearth furnaces is attracting attention.

Professor Schenk's review of developments in Germany emphasises particularly the effects of fuel shortage (especially of metallurgical coke, because so much of it is being exported) and the need to reduce the production costs of steel. Sintering practice has improved notably. An exhaustive study has been made of the manufacture of pig iron in low-shaft furnaces, with and without oxygen enrichment of the blast; and research designed to raise the quality of Thomas steel to approximately that of Siemens-Martin open-hearth steel, which was begun during the war, is being intensified. The use of oxygen in Siemens-Martin steelworks practice has produced excellent results; and the pre-melting of scrap in hot-blast cupolas is another development which has been tried, to improve the performance of Siemens-Martin furnaces.

RIVER POLLUTION PROBLEMS.

THE ultimate end of most of the activities of the Water Pollution Research Laboratory is improvement in the cleanliness of the streams and rivers of the country. An allied activity is investigation of problems connected with the treatment of water for domestic and industrial supply. The difficulty of these problems is accentuated by river pollution, the amelioration of which is, as suggested, one of the main purposes of the Laboratory. As three-quarters of the population of England and Wales is supplied with water obtained directly from rivers, any work destined to improve the quality of the rivers is of direct value in facilitating the provision of pure water supply. If the River Thames were a bubbling mountain stream, the activities of the Metropolitan Water Board would be much simplified.

The latest* report of the Water Pollution Research Board confirms these remarks. It contains sections dealing with various aspects of sewage treatment; methods of treating waste water from the manufacture of penicillin and paper, and water containing cyanide; the effect of polluted waters on fish; and an account, in considerable detail, of the progress made in the extensive survey of the Thames Estuary. The only matters bearing on the quality of water as supplied to users which are dealt with in the present report are an investigation concerned with the electrical treatment of boiler feed-water and the development of apparatus for giving a continuous indication of the conductivity of water. The former of these two matters is of direct mechanical engineering interest.

The survey of the Thames Estuary is being carried out for a committee appointed by the Ministry of Housing and Local Government at the instigation of the Port of London Authority and the London County Council. Its purpose is to "consider the effects of heated and other effluents and discharges on the condition of the tidal reaches" of the river and to determine the causes which lead to the deposition of silt in the central reaches. In much of the tidal portion of the Thames, especially during the drier and warmer months, the water is almost entirely devoid of dissolved oxygen, and there have been many complaints about the evolution of hydrogen sulphide. There is no doubt that the unsatisfactory state of the river is due to the sewage, industrial effluent and hot water discharged into it. To assess the influence of these various factors, extensive sampling and analysis are necessary, and the report contains a number of tables and curves which form contributions to the mass of data which must be accumulated before final conclusions can be drawn.

The report does not say so, but the main source of pollution may be taken to be in the effluents from the Northern Outfall at Barking, and the Southern Outfall some three miles further down the river. The discharge of sewage to the sea is common in seaboard towns. It is a relatively inexpensive practice, but may be fairly described as somewhat crude. Discharge to a river, as in London and Liverpool, is perhaps even cruder. The Mersey at Liverpool is a mile wide and the sewage is largely dispersed and carried away by the tides. The Thames at Barking is not much more than a quarter of a mile and the mass of tidal water is not sufficiently large to absorb and disperse the sewage rapidly. No surprise will be felt at the information given in the report that the section of the river with very low oxygen content is shortened when the flow over Teddington Weir is high.

In view of the more general interest now being taken in the whole question of river pollution, it may be that further treatment of London sewage will be undertaken eventually. It has been estimated that an adequate sewage works would cost 10*l*. million, but that is not an impossibly large sum for the County of London; the Maple Lodge sewage works, referred to on page 222, *ante*, cost 6,250,000*l*. In the meantime, the possibility of treating London sewage has not been overlooked and the partial chlorination of settled sewage was carried out at the Northern Outfall Works from July 5 to October 30, 1951. Between one-quarter and one-third of the sewage was treated. Particulars of the effect of the results obtained are given in the report. They were not promising, but it is pointed out that the quantity of chlorine actually applied to the sewage was not so large as had been intended, and that the rate of dosing was not consistent.

The effect of radioactive substances in sewage forms an illustration of the growing difficulties with which sewage works have to cope. Radioactive isotopes are becoming one of the tools not only of medicine but of some branches of industry, and they may be encountered in almost any part of the country. An investigation has been carried out at the Laboratory by a member of the Physics Department of the Royal Cancer Hospital to determine the fate of radioactive isotopes of sodium, phosphorus, cobalt, bromine and iodine during sewage treatment. It was found that, during primary sedimentation of sewage, the adsorption on sludge of each of the five isotopes was small when present in the form of an inorganic salt. In secondary treatment on percolating filters, or by the activated-sludge process, adsorption of sodium, bromine and iodine was small and most of the applied activity appeared in the effluent. For such isotopes it was therefore concluded that concentration in the sewage should be limited to the concentration permissible in the effluent. Phosphorus was strongly adsorbed in percolating filters and on activated sludge and might appear largely in humus sludge or surplus activated sludge. As, however, the phosphorus isotope has a half-life of only 14·3 days, it was considered that there would be no serious hazard in dealing with sludge containing it. Cobalt was strongly adsorbed during secondary treatment and, as it has a half-life of 5·3 years, a high level of activity might be built up in dry humus or activated sludge.

The experimental work on the treatment of boiler feed-water, referred to earlier, was undertaken in conjunction with the Fuel Research Station, where the investigation was carried out. Briefly, water, before being fed to a boiler, is treated by passing an electric current through it, between electrodes. Both direct-current and alternating-current are used. It is claimed that after this treatment any scale deposited in a boiler takes the form of a sludge and does not adhere firmly to the surface of the metal. Work was carried out with four small experimental boilers at the Fuel Research Station, and also on two full-scale boilers at Bovingdon Air Port. From the information given in the report, the results appear to have been inconclusive. It is stated that "in view of the large differences in the nature of the deposits in boilers operated under conditions which were made as similar as possible and the fact that the causes of these differences are not known . . . a very long investigation would be required to estimate quantitatively any effects . . . due to electrical treatment of feed-water."

* *Report of the Water Pollution Research Board with the Report of the Director of Water Pollution Research for the Year* 1951. H.M. Stationery Office. [Price 2*s*. 6*d*. net.]

THE LATE MR. C. B. COLLETT, O.B.E.

WE record with regret the death on August 23 of Mr. C. B. Collett, O.B.E., chief mechanical engineer of the Great Western Railway from 1921 to 1941. He joined the company in 1893, after a pupilage with Maudslay, Sons and Field, Limited. We hope to publish a memoir in our next issue.

NOTES.

INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING.

THE fourth Congress of the International Association for Bridge and Structural Engineering opened at Cambridge on Monday, August 25. The members registered for the Congress throughout Monday, while the Executive and Permanent Committees met to promote the business of the Association. The Congress was preceded by the University of Cambridge conferring the honorary degrees of Doctor of Law on the Rt. Hon. Lord Woolton, C.H., Lord President of the Council and President of the Congress, on Professor F. Stüssi (Zurich), President of the Association, and on Professor F. Campus (Liége), vice-president of the Association. Lord Woolton opened the Congress by sending loyal greetings to H.M. the Queen, and read a reply from Her Majesty wishing the Association success in their deliberations. Lord Woolton continued, on a personal note, by thanking the University for the honour that they had done him, and noting that in his official capacity he was responsible for the research done both at the Universities and at Government establishments. He then proceeded to welcome the 700 delegates, who represented some 22 nations, and emphasised the need for the better use of scientific knowledge in order that the losses and ravages of the wars of this century might be replaced. He ended by remarking briefly how readily the familiar terms of engineering—building, bridging—could be used, not only in their operative sense, but also in a speculative manner. The Vice-Chancellor of the University, Sir Lionel Whitby, C.V.O., M.C., M.D., who had conducted the ceremony of conferring the degrees, welcomed the Association to the University and was supported by the Mayor of Cambridge, Councillor S. T. Bull. The President, Professor Stüssi, and vice-presidents, Professor Campus, Mr. L. Cambournac (Paris) and Mr. Ewart S. Andrews (London) replied on behalf of the Association. In the evening, the members and their ladies were invited by Professor J. F. Baker and his staff to a conversazione at the Engineering Laboratory. The business of the Congress, divided into six working sessions, has been spread over the remainder of the week, during which arrangements have been made for visits to places of interest and instruction. Of the working sessions, two are concerned with general theoretical questions, two with steel structures and two with the properties and outstanding problems in the use of reinforced and prestressed concrete.

BRITISH ELECTRICITY CONSUMPTION.

On page 201, *ante*, we published the first of a series of tables which are to be issued monthly by the British Electricity Authority to show the amounts of electricity sold by them to the Area Boards and sent out by the Boards to their consumers. These tables set out, *inter alia*, the sales in each year between April 1, 1948, and March 31, 1952, the sales in each month from April, 1951, to June, 1952, and the sales in the twelve months ended each month during the same period. They also showed the electricity sent out by the individual Area Boards in June, 1951, and June, 1952, as well as the totals in the first three months of those two years and for the two periods of twelve months ended June 30, 1951, and June 30, 1952, respectively. The second series of tables, which was issued this week, again shows the yearly totals since April 1, 1948. It also shows that 3,737 million kWh were generated during July, 1952, compared with 3,669 million kWh during July, 1951, an actual increase of 1·9 per cent. During the year ending July 31, 1952, 55,042 million kWh were generated, compared with 53,660 million kWh in the corresponding period of 1950-51, an actual increase of 2·6 per cent. When these figures are adjusted for normal weather and standard working days, however, they become 1·3 per cent. and 4·3 per cent., respectively. The total electricity sold in the "mainly industrial" areas was the same within 1 kWh during both July, 1951, and July, 1952. In the "mainly non-industrial" areas, however, it increased from 1,366 million to 1,430 million kWh, or by 4·7 per cent. Comparing the first four months of the financial year 1951-52 with the corresponding period of 1952-53, the amount sent out decreased from 16,355 million to 16,056 million kWh, or by 1·8 per cent., although it increased from 53,660 million in the twelve months ended July 31, 1951, to 55,042 million in those ended July 31, 1952, or by 2·6 per cent. During the same period the output in the "mainly industrial" areas was 31,999 million kWh, an increase of 2·9 per cent. and in the "mainly non-industrial" areas 22,328 million kWh, an increase of 2·1 per cent.

DOUBLE ATLANTIC CROSSING IN EIGHT HOURS.

On Tuesday, August 26, a production Canberra B Mark 5 jet bomber aircraft, constructed by the English Electric Company, Limited, Warton, Lytham, Lancashire, and piloted by the company's test pilots, Mr. R. P. Beamont and Mr. P. Hillwood, flew from Aldergrove, Northern Ireland, to Gander, Newfoundland, and back in a total flying time of 7 hours 59 minutes. This is the first occasion on which the two-way crossing—a total distance of 4,145 miles—has been accomplished in a day and, subject to confirmation by the Fédération Aéronautique Internationale, it constitutes an international record. On the outward journey, 116-m.p.h. headwinds were encountered, and the journey time was 4 hours 34 minutes, giving an average speed of 455 m.p.h. It may be recalled that on August 31, 1951, another Canberra aircraft made the east-to-west crossing in 4 hours 18 minutes. The return journey, however, which was made after a two-hour stop at Gander for refuelling, was carried out with the advantage of following winds, in 3 hours 25 minutes, at an average speed of 606 m.p.h. The Canberra B Mark 5 is powered by two Rolls-Royce Avon jet engines.

WELSH INDUSTRIES FAIR.

The National Industrial Development Council of Wales and Monmouthshire have announced that the annual Welsh Industries Fair is to be held at the Pavilion, Sophia Gardens, Cardiff, from Wednesday, September 10, till Saturday, September 20. It will be open daily, excepting Sunday, from 12 a.m. till 8 p.m. The fair was first held in 1934, and since then it has taken place every year, forming a display ground for all types of products manufactured in Wales. This year, the principal theme will be housing and the building and allied trades. For the first time in Wales, the Ministry of Housing and Local Government will be showing models of the "people's house." Some 30 industrial organisations will be taking part in the fair, which is to be formally opened on Wednesday, September 10, by the Rt. Hon. Sir David Maxwell Fyfe, Q.C., M.P., Home Secretary and Minister for Welsh Affairs. The proceedings will be broadcast from the Welsh regional station of the British Broadcasting Corporation.

THE NATIONAL RADIO EXHIBITION.

The 19th National Radio and Television Exhibition was formally opened at Earls Court, London, by the Rt. Hon. Lord Burghley, on Wednesday, August 27, and will remain open until Saturday, September 6. There are 108 exhibitors, of whom 32 are manufacturers of radio and television receivers. There are good displays by the Services and other Government departments, which show that both methods of conveying intelligence are being employed for other than purely recreational purposes. The emphasis throughout the exhibition is on television, as is only natural when, according to the makers, the number of receiving sets produced rose from 6,500 in 1946 to 388,300 in the first six months of the present year, although at the present time high purchase tax and restrictions on hire purchase are both exerting a baleful influence. An interesting historical feature is a Baird "museum" which comprises examples of the early television receivers used by him and his first colour vision transmitter. The Royal Electrical and Mechanical Engineers are exhibiting one of the new electronically-guided missiles, which, although not strictly radio, is likely to attract a good deal of interest. The Royal Navy are illustrating the many and varied uses they are making of electronics both on board ship and in the air, the exhibits including a computer of the type used in gunnery, which enables two numbers to be multiplied by servomechanisms. The television camera and equipment that has been designed to enable the ocean bed to be examined is installed in a tank with glass panels to demonstrate an important new development which has taken place since H.M. submarine Affray was identified by this means. The large number of receivers on view do not indicate any revolutionary change in design, although there is a tendency towards the greater use of large direct-viewing screens, which has been made possible by the manufacture of rectangular 17-in. tubes. Examples of television receivers which project the picture on to a wall can also be seen. One manufacturer has produced a five-channel set for the export market, which projects a 4 ft. by 3 ft. picture. In this, either 525 or 625-line systems can be used with negative modulation and frequency-modulated sound reproduction. On the sound side, apart from changes which make improved production possible, an interesting feature is the improved portable sets, which can be operated either from the mains or from a battery. There are also a number of very elaborate radio-gramophones.

LETTERS TO THE EDITOR.

IMPROVED HEAT TRANSFER IN WASTE-HEAT BOILERS.

TO THE EDITOR OF ENGINEERING.

SIR,—As Dr. Richard Doležal says on page 103 of your issue for July 25, the efficiency of his boiler would have been increased by more than 7 per cent. if the economiser had not been covered with scale, but the feed-water temperature leaving the economiser would also have been higher.

Analysis of the figures in Table I shows that scale had reduced the overall heat-transfer coefficient in the economiser by about 14 per cent. With a descaled economiser and a feed-water inlet temperature of 62 deg. C., the outlet temperature would be about 151 deg. C., and, due to the reduction in the required heat input to the boiler for a steam output of 2·5 tons per hour, the quantity of exhaust gases would be further reduced by 1·3 per cent. Thus, with descaled economiser tubes and a constant water temperature at inlet to the economiser, fitting the insert tubes in the boiler would reduce the feed-water temperature by 14 deg. C., increase the steam output by 5 per cent., and the overall efficiency by about 8·5 per cent.

These figures are comparable with those given by Dr. Doležal and the stated increase in efficiency takes no account of the higher-grade steam obtained after fitting the inserts.

Yours faithfully,
C. GODFREY, A.M.I.Mech.E.

The Cottage,
Kerridge,
Macclesfield.
August 25, 1952.

COMMEMORATION OF THOMAS NEWCOMEN.

TO THE EDITOR OF ENGINEERING.

SIR,—There are two slight corrections to be made to your account, on page 244, *ante*, of our proceedings on August 16. Thomas Newcomen was baptised on February 28, 1663, at Dartmouth and died on August 5, 1729, at the house of his friend, Edward Wallin, in London.

The settlement of Kittery, in Maine, which you attribute to the Eighteenth Century, was actually made by Francis Champernowne in 1636. Kittery is the oldest township in the State of Maine, and the settlement is one of the many links between the port of Dartmouth and New England.

Yours faithfully,
PERCY RUSSELL,
Hon. Sec., Dartmouth Newcomen Association.

Waterside,
South Town,
Dartmouth, Devon.
August 25, 1952.

INELASTIC DEFORMATION OF REINFORCED CONCRETE.

STRESS-STRAIN DIAGRAMS FOR MILD STEEL.

Fig. 1. ACTUAL.

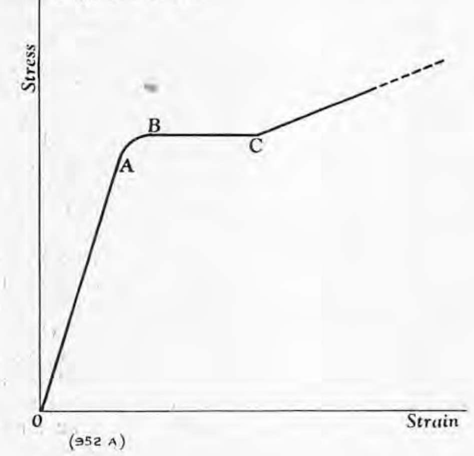


Fig. 2. IDEALISED.

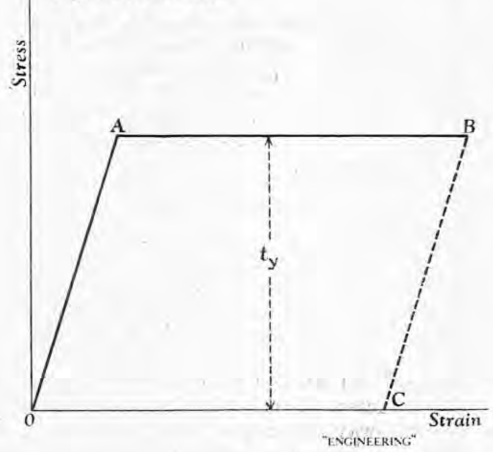


Fig. 3. RHEOLOGICAL MODEL OF THE DEFORMATION OF MILD STEEL.

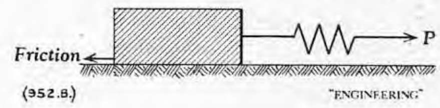
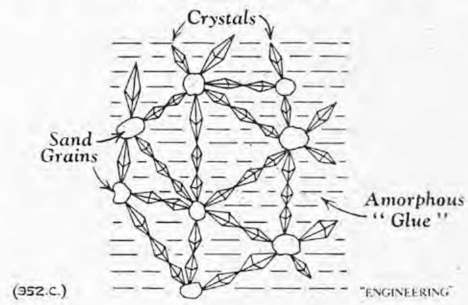


Fig. 4. STRUCTURE OF SAND-CEMENT MORTAR (AFTER FREUDENTHAL).



INELASTIC DEFORMATION OF REINFORCED CONCRETE IN RELATION TO ULTIMATE STRENGTH.

By Dr. Henry J. Cowan.

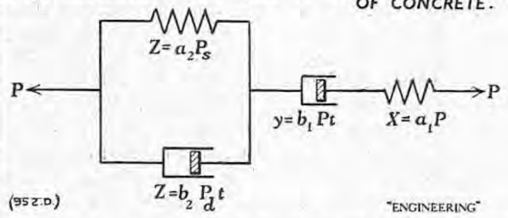
The recent successful application of the plastic theory to the design of steel structures has given fresh prominence to the problem of the ultimate strength of reinforced-concrete structures. Concrete shows considerable inelastic deformation immediately prior to failure, and experiments have shown that the collapse load of a simply-supported beam can be computed on the basis of a near-plastic stress distribution on the compression face. It is sometimes assumed that the pronounced non-linearity of the stress-strain diagram of concrete at high loads is a viscous phenomenon of the same character as the creep experienced at low loads. It would then appear reasonable to apply plastic design methods to reinforced concrete with only minor modifications.

There is reason to believe, however, that the greater part of the inelastic deformation of concrete can be attributed to damage of its micro-structure, which can only be repaired by chemical action over long periods. This leads to a falling off of the resistance moment of the section with increasing deformation, and the basic assumption of the simple plastic theory is thus invalidated. Before considering the ultimate strength of reinforced concrete it is important, therefore, to gain a clear conception of the nature of the inelastic deformation of concrete, as far as the present state of knowledge permits.

The deformation of a material is called elastic if it is produced instantaneously under the action of a force and is recovered instantaneously when the force is removed. This definition of elasticity implies the existence of a single-valued relation between stress and strain which is independent of time. In most engineering materials, including steel and concrete,[1] the elastic stress/strain relation is linear in accordance with Hooke's Law.

If a mild-steel bar of the type used in reinforced concrete is subjected to direct tension, its deformation (Fig. 1) is elastic up to the elastic limit (OA). At a slightly higher load, the yield point, the bar deforms plastically, i.e., the deformation increases without a further increase in the load (BC). The plastic strain following yield is generally much greater than the total elastic deformation. With increasing deformation, the yield point of the

Fig. 5. RHEOLOGICAL MODEL OF THE DEFORMATION OF CONCRETE.



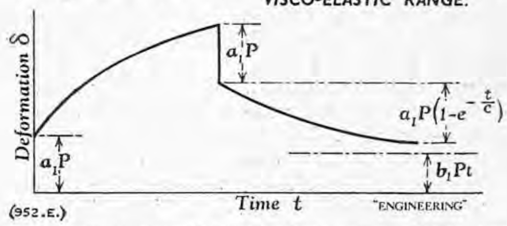
material is raised; due to this effect, known as strain hardening, the load must be further increased when the point C is reached. The total deformation of the reinforcement in concrete beams is generally too small to produce strain hardening, and the stress/strain curve can therefore be idealised into a perfectly elastic portion OA and a perfectly plastic portion AB, as shown in Fig. 2. On unloading, the whole of the elastic deformation BC is recovered, while the plastic deformation CO remains.

In rheological literature, the deformation of materials is frequently illustrated by mechanical models. Elasticity is represented by a spring, and plasticity by a body resting on a rough horizontal surface. The behaviour of mild steel then corresponds to the model shown in Fig. 3. Below the yield point the movement of the force P is determined by the extension of the spring; when P becomes sufficiently large to overcome the frictional resistance, the deformation proceeds without a further increase in P.

The inelastic deformation of concrete is more complicated than that of steel. Concrete is a composite material consisting of an aggregation of loose particles, the sand and the coarse aggregate, held together by a highly viscous liquid, the cement paste. In time, progressive crystallisation reduces the viscosity of the cement, until a complete crystalline network blocks all viscous deformation (Fig. 4, after Freudenthal). Creep in concrete was first described by Faber[2] who called it "plastic yield." In modern terminology, however, plasticity is usually associated with inelastic deformation of the type found in metals above the yield point or proof stress. Glanville[1] observed that the creep of concrete "can be considered for practical purposes as proportional to the stress." It occurs at the lowest load, though its effect then may not be appreciable. Its character is therefore different from the plasticity of steel, and is more akin to the viscous flow of a liquid.

The amorphous cement acts as a restraint on the elastic deformation of the skeleton formed by the aggregate and the cement crystals. Concrete may

Fig. 6. DEFORMATION OF CONCRETE IN THE VISCO-ELASTIC RANGE.



be expected, therefore, to show some of the properties of Kelvin's[3] "perfectly elastic vesicular solid (or sponge) . . . its pores and interstices filled with a viscous fluid, such as oil," which delays the elastic deformation of the skeleton on loading and its elastic recovery on unloading. It is generally difficult to distinguish between the effect of the viscous deformation proper and of the delayed elasticity, since recovery may proceed for years, and they are generally classed together as the creep of the concrete.

The deformation of concrete may be represented by a mechanical model proposed by Burgers[4] and reproduced in Fig. 5. Elastic deformation is represented by a spring, as in the previous model; viscous deformation is represented by a dash-pot consisting of a perforated piston moving in a cylinder containing a viscous liquid. The instantaneous elastic and the irrecoverable viscous deformation are then represented by the spring and the dash-pot in series, while the delayed elasticity or recoverable creep, corresponding to Kelvin's sponge, is represented by the spring and the dash-pot in parallel. At low loads the deformation is mainly elastic, but with increase in time and load the inelastic deformation becomes more and more important. When the load is removed, the spring in series contracts without hindrance, corresponding to instantaneous elastic recovery, while the other spring compresses the dash-pot, corresponding to the creep recovery with time.

For the spring element in series, the displacement x is directly proportional to the load P, $x = a_1 P$.

For the dash-pot in series, the rate of displacement is directly proportional to the load P, and the displacement y in a time t,

$$y = b_1 \int_0^t P\, dt = b_1 P t.$$

Similar relations hold for the spring and the dash-pot in parallel. Since the force on the spring P_s,

[1] W. H. Glanville, *Build. Res. Tech. Paper* No. 12, London 1930.

[2] O. Faber, *Proc. Inst. C.E.*, vol. 225, pages 27-130 (1927-28)

[3] N. Thomson, Article "Elasticity," *Ency. Brit.*, 9th ed., vol. 7, pages 796-825 (1877).

[4] M. Reiner, *Deformation and Flow*, H. K. Lewis, London 1949

INELASTIC DEFORMATION OF REINFORCED CONCRETE.

Fig. 7. COMPRESSION TEST TO DESTRUCTION ON A 6IN. × 12IN. CYLINDER OF LOW STRENGTH CONCRETE AT A CONSTANT RATE OF STRAIN.

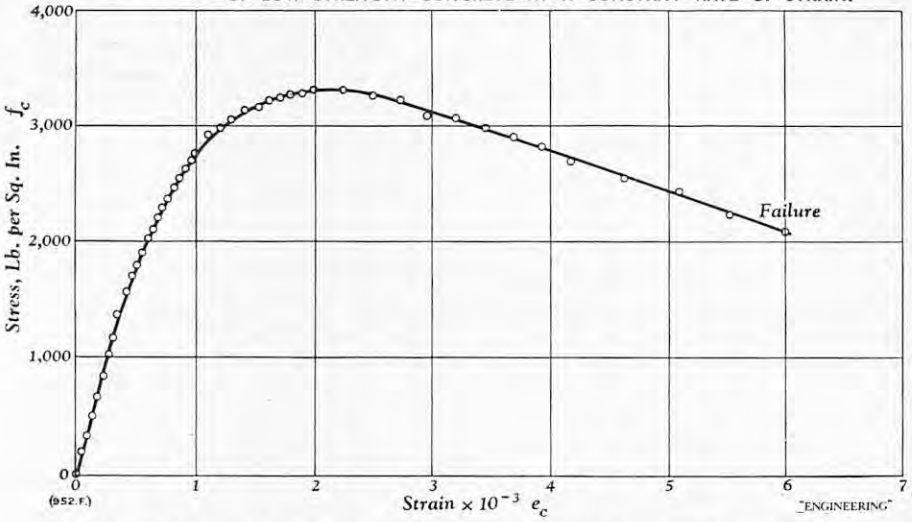


Fig. 8. COMPRESSION TEST TO DESTRUCTION ON A 6IN. × 12IN. CYLINDER OF HIGH STRENGTH CONCRETE AT A CONSTANT RATE OF STRAIN.

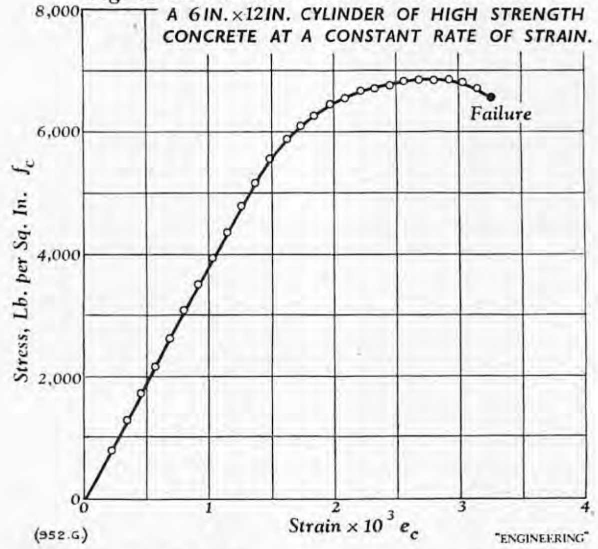
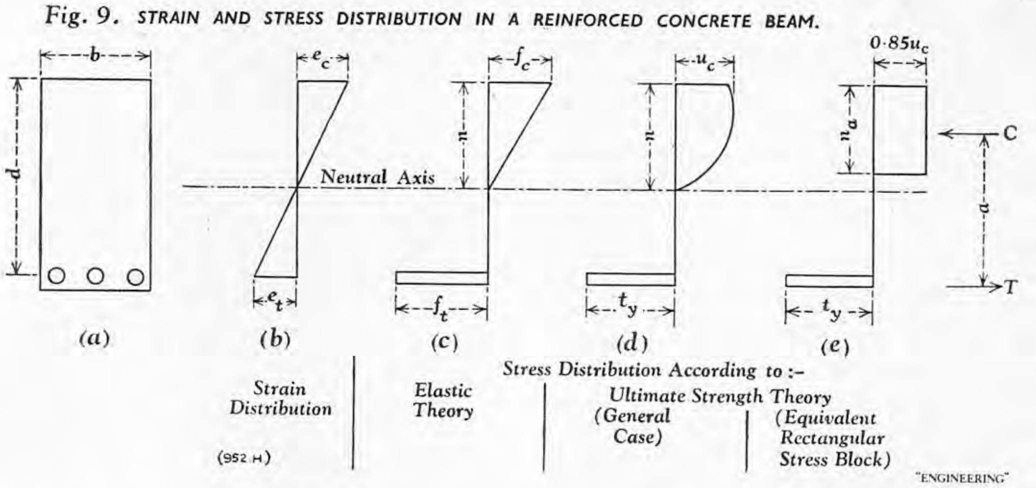


Fig. 9. STRAIN AND STRESS DISTRIBUTION IN A REINFORCED CONCRETE BEAM.



and the force on the dash-pot P_d, must equal the total load P,

$$P = P_s + P_d = \frac{z}{a_2} + \frac{1}{b_2} \cdot \frac{dz}{dt}.$$

Substituting $c = \frac{a_2}{b_2}$

$$(z - a_2 P)\, dt = - c . dz.$$

If the deformation increases by z during a time interval t,

$$\int_0^t - \frac{dt}{c} = \int_0^z \frac{dz}{(z - a_2 P)}.$$

The solution of this equation is

$$e^{-\frac{t}{c}} = \frac{z - a_2 P}{- a_2 P}$$

where e is the base of the natural logarithm.

The total deformation of the system

$$x + y + z = P \left[a_1 + b_1 t + a_2 \left(1 - e^{-\frac{t}{c}} \right) \right]$$

The first part of this expression represents the elastic deformation, the second part the permanent creep, and the third part the recoverable creep (Fig. 6).

Burgers' model represents the deformation of concrete in the visco-elastic range, i.e., the range corresponding to the elastic state in steel below the yield point. Above the visco-elastic limit, frequently referred to as the elastic limit of concrete, the stress-strain curve departs from the relation of the last equation, and shows a more rapid rate of increase in deformation. This is probably due to the breakdown of the adhesion between the aggregate and the cement paste and the formation of minute cracks. As the internal destruction in the concrete proceeds, it resembles more and more a granular mass relying on internal friction for its strength In an entirely incoherent granular material, the stress at which deformation occurs and proceeds remains constant, as in a plastic material.

There is, however, a fundamental difference between the plasticity of a metal and the apparent plasticity of a granular material. Freudenthal[5] considers "that this difference is not so much in the type of motion, but in the forces acting between the particles involved in it. Whereas, in plastic slip in metals, the interacting cohesive forces are strong enough to reform continually the cohesive bonds during the motion, the apparent cohesion between the particles of the aggregate, resulting in fact only from the adhesion between the particles and the cement medium, is not re-established if it has been destroyed once in the course of the relative motion of particles under the action of external forces. Hence, the effect of plasticity of a metal and of the apparent plasticity of concrete containing a relatively large volume of aggregates is of a basically different type : metal plasticity produces relief of elastic peak stresses by non-linear behaviour due to transcrystalline slip, without damage to cohesion during the process, whereas the relief of the elastic peak stresses produced by the "plasticity" of the concrete is accompanied by a certain amount of local destruction of cohesion, and is therefore the expression of a process of internal damage. Therefore the observation of considerable non-linearity of the stress distribution of a concrete section in bending which is not solely due to the non-linearity of the creep tacitly implies that under the applied load considerable local destruction is produced within the material ; otherwise, the concrete would remain a visco-elastic material with an essentially linear or slightly non-linear stress distribution."

[5] A. M. Freudenthal, *The Inelastic Behaviour of Engineering Materials and Structures*, Wiley, New York, 1950.

Under the action of slowly applied or repeated loads, the chemical reaction within the cement, which, in the presence of warmth and moisture, proceeds for many years, reduces much of this local destruction. This process of autogenous healing has been demonstrated even in the case of serious structural damage, but it can have no effect under rapid loading.

With the aid of a microscope, Berg[6] detected fissures at loads corresponding to between 55 and 60 per cent. of the cylinder crushing strength of the concrete. These micro-fissures were ½ in. to 1 in. long and approximately 5 in. by 10^{-4} in. wide. At the moment the micro-fissures were discovered, the lateral strain of the concrete was on the average 1 by 10^{-4}, which coincided with the ultimate tensile strain of the concrete. (Similar results have recently been obtained by Dr. R. Jones at the Road Research Laboratory.[7]) Berg concluded that the beginning of disintegration of concrete depended only on its ultimate tensile strain, and was independent of the type of test and the shape of the test piece.

Griffith[8] computed the strain energy necessary to break an elastic solid containing a crack by assuming the crack to be in the form of a narrow elliptical hole in a homogeneously stressed field. He found that the overall stress required for the propagation of the crack was inversely proportional to the square root of its length. The body may be considered to consist of a number of volume elements, each containing one crack. It is assumed that there is no inter-relation between the individual processes of crack propagation ; each volume element has a strength dependent on the size of its crack. The strength of the entire specimen is determined by the strength of its weakest volume element.

As the volume of the specimen increases, the total number of cracks increases equally, and there is thus a greater probability of encountering a severe crack.[9] The strength of concrete therefore decreases with increase in the volume of the test specimen.

From Griffith's theory of rupture it follows that fracture starts locally by sub-microscopic crack propagation in the direction normal to the principal

[6] O. Y. Berg, *Doklady Akademii Nauk S.S.R.*, vol. 7, pages 617-620 (1950) ; translated as Road Research Library Communication No. 165, London, 1951.

[7] R. Jones, *Brit. J. Appl. Phys.* (awaiting publication).

[8] A. A. Griffith, *Phil. Trans. Roy. Soc.*, London, vol. A 221, pages 163-198 (1921).

[9] J. Tucker, *Proc. A.S.T.M.*, vol. 41, pages 1072-1088 (1941), and vol. 46, pages 952-984 (1946).

tensile stress, since parallel cracks will show a tendency to close up. The initial short clean crack perpendicular to the principal tension may change into an oblique rough crack in the general direction of the principal shear. This change in the character of the fracture depends essentially on the state of stress and on the inelastic deformation preceding fracture.

Thus both cubes and cylinders of concrete tested in compression may show either a cleavage or a shear fracture, depending on the composition of the concrete. Low-grade concretes are more compressible than those of high strength, and the lateral strains are therefore more likely to be of the magnitude required to produce a cleavage fracture.

Fig. 7, on page 277, shows the stress-strain diagram of a low-strength concrete cylinder tested in compression. At low stresses the deformation is visco-elastic, i.e., the diagram shows a slight curvature due to creep. As the load increases, micro-fissures are formed, the cohesive strength of the cement paste is gradually destroyed, and the curvature increases more rapidly. After the maximum load is reached, the strength of the concrete is largely dependent on the friction of the aggregate, and the strength declines due to further breakdown of the internal cohesion.

The pseudo-plastic phase is less marked in a high strength concrete (Fig. 8), in which the rate of creep is lower and the cohesive strength higher. The contribution to the strength of the cylinder made by the internal friction of the aggregate is relatively much less, and the breakdown of the cohesive strength of the cement paste therefore results in abrupt failure.

The stress-strain relation for concrete in compression due to flexure is essentially similar to that obtained in direct compression. Herr and Vandegrift[10] have attempted to determine it by passing polarised light through a glass insert and photographing the photo-elastic fringes. Baker[11] has simulated bending on a short concrete specimen by means of a series of hydraulic rams.

It is generally assumed that the stress-strain diagram of a cylinder with a height/diameter ratio of 2 is a better guide to the behaviour of the concrete in a beam than the British Standard cube.[12] Theories based on this assumption have shown mainly good agreement with experimental data.

The principal theories for the ultimate strength of rectangular reinforced-concrete beams have been discussed elsewhere.[13,14] For a section with tension reinforcement only, the resistance moment is formed by a resultant tensile force T in the steel and a resultant compressive force C in the concrete (Fig. 9). Due to the inelastic deformation of concrete, the compressive-stress block shows a pronounced curvature at high loads. It is sufficient to know the magnitude of the force C, given by the area of the compressive-stress block, and its line of action, given by the depth of its centroid; the precise stress-strain relationship is not required. The simplest method of design, therefore, consists of replacing the curved stress block by an equivalent rectangular stress block, which has the same area and has its centroid at the same depth.

The equivalent rectangular stress block bears a superficial resemblance to the plastic stress distribution encountered in steel structures, and some of the problems in the design of reinforced-concrete structures for ultimate strength can be handled by methods originally developed for the plastic design of steel structures. It is, however, important to bear in mind that there are basic differences between the behaviour of reinforced concrete and steel beyond the elastic range. The substitution of the equivalent rectangular stress block for the curved stress block is merely a device to simplify the mathematical work; concrete does not exhibit a truly rectangular stress distribution immediately prior to failure.

The very large inelastic deformation of concrete near the ultimate load, unlike that of steel, is largely the result of structural damage. In an over-reinforced section this leads to a reduction in the resistance moment after failure on the compression face; in the case of high strength concrete, the moment falls off very rapidly. In an under-reinforced section, the yielding of the steel produces a plastic phase which continues until the rise of the neutral axis leads to failure of the concrete on the compression face. In both cases, however, the resistance moment of the section must be considered in relation to the deformation of the structure.

This is of particular importance in predicting the ultimate load of a statically indeterminate structure. Discounting the possibility of complete rupture, the structure cannot collapse until a sufficient number of hinges have formed to turn it into a mechanism. More than one hinge is required for the collapse of a redundant structure. The plastic theory for the ultimate strength of structures is based on the assumption that the hinge moment, once attained, remains constant until all hinges have formed. The validity of this assumption has been demonstrated for metal structures.[15]

The plastic design method, however, can be applied only to a limited range of redundant reinforced-concrete structures. If the section at which the first hinge forms is under-reinforced, the hinge moment is controlled by the plastic yield of the steel in the early stages of the inelastic range. Furthermore, if a low-strength concrete is used, the hinge moment is maintained almost constant for quite large deformations even in over-reinforced sections, due to the high ultimate strain of this type of concrete. In either case, full moment re-distribution may be attained if the number of redundancies is small. It is noteworthy that the experiments reported by Kazinczy[16], Glanville and Thomas,[17] and Cowan and Kanjanavanit,[18] in which full moment redistribution was observed, were all carried out on frames which were either under-reinforced or made of a low-strength concrete; all the test specimens were continuous beams or portal frames with only one redundancy.

On the other hand, recent experiments at the University of Sheffield on an over-reinforced portal frame of high-strength concrete failed to show any appreciable moment redistribution. The same result may be expected from reinforced-concrete structures with a large number of redundancies, on which experimental data are so far lacking.

THE BRITISH RAILWAYS AND WINTER TRAFFIC.—In announcing details of the winter train services that will operate from September 15, the Railway Executive state that the railways will start the winter passenger and freight movements with three weeks' stocks of coal in hand, which is one week's supply more than last winter. The track is in better condition. Arrears of maintenance are being overtaken and the number of speed restrictions is about 160, compared with 230 last autumn. The timings of a number of trains are being improved.

[10] L. A. Herr and L. E. Vandegrift, *Ohio State Univ. Eng. Exp. Sta. Bull. No.* 144, 1951.

[11] A. L. L. Baker, *J. Inst. C.E.*, vol. 35, pages 262-329 (1951).

[12] R. L'Hermite, Cement and Concrete Association Library Translation No. 24, London, 1951.

[13] H. J. Cowan, *Civ. Eng. and P.W. Rev.*, vol. 45, pages 376-378, 576-578, and 723-725 (1950); and vol. 46, pages 595-598 and 680 (1950)

[14] H. J. Cowan, *Mag. Conc. Res.*, vol. 3, pages 19-22 1951).

[15] J. F. Baker, *J. Inst. C.E.*, vol. 31, pages 188-224 (1949).

[16] G. v. Kazinczy, *Beton und Eisen*, vol. 32, pages 74-80 (1933).

[17] W. H. Glanville and F. G. Thomas, *Build. Res. Tech. Paper No.* 22, London, 1939.

[18] H. J. Cowan and R. Kanajanavanit, *J. Inst. C.E.*, vol. 36, pages xli-xliii (1951).

THE WORK OF PAMETRADA IN 1951.

THE Parsons and Marine Engineering Turbine Research and Development Association—which, by now, is probably much better known all over the world by its short name of "Pametrada" than by its full title—has gradually developed such a varied and extensive programme of research that it would be difficult to decide where to start in summarising the report of its activities during 1951, recently issued, were it not for the outstanding technical interest of the work on the 3,500-h.p. marine gas turbine which has been under test at the Association's research station at Wallsend-on-Tyne. This set and its performance, however, easily establish a claim to prior consideration, especially as the report, which covers the twelve months to December 31, 1951, has been supplemented by some particulars of the successful 100-hours continuous full-power test, carried out subsequently to the period covered by the report.

During 1951, the set was run for a total of 242 hours, in the course of which the low-pressure turbine was delivering power for 190 hours. The maximum sustained output was 3,650 h.p. for 25 hours. Three attempts were made to complete a continuous run of 100 hours at full power, but various operational troubles developed, which prevented its accomplishment in each case. The first attempt failed after 16 hours because the dynamic-brake rotor was rubbing against the pole pieces; the second, because it was found, after 48½ hours, that there was a fracture in the welding of an inlet duct on the high-pressure turbine; and the third was stopped after 25 hours because of a short circuit in the brake field coils, which caused an instantaneous removal of the load. In the eventual successful run, the subjoined performance figures were obtained; they are given verbatim, with the accompanying notes, as presented in the supplement to the report.

100-HOURS TEST OF GAS TURBINE.

S.h.p. (corrected to 14·7 lb. per square inch and 60 deg. F.) ...	3,532 h.p.
H.p. turbine inlet temperature (corrected to 60 deg. F.)	1,242 deg. F.
L.p. turbine inlet temperature (corrected to 60 deg. F.)	1,284 deg. F.
H.p. turbine speed (corrected to 60 deg. F.)	4,650 r.p.m.
Thermal efficiency	27·9 per cent.
Fuel consumption (corrected to 60 deg. F.)	0·505 lb. per b.h.p. per hr.

After the 100-hours continuous run at full power had been concluded, a complete opening up took place and an inspection was carried out by Lloyd's, who subsequently produced a very satisfactory report.

Modifications.—During the period of opening up, opportunity was taken to carry out modifications as follows: (*a*) new glands were fitted to the high-pressure turbine to reduce sealing-air consumption; (*b*) a water eliminator was fitted in the discharge side of the intercooler in order to prevent the admission of water to the high-pressure compressor, where it caused deposits to adhere to the blading; (*c*) an additional row of blading was added to the low-pressure compressor to raise the compression ratio to the designed figure; (*d*) modifications were made to the mixer following the two reheat combustion chambers, to reduce temperature variations over the gas stream.

Low Fuel Consumption.—The designed consumption for the gas turbine as originally conceived was 0·54 lb. per s.h.p. per hour. The best figure obtained so far is 0·49 lb. per s.h.p. per hour. As a result of the modifications carried out, it is hoped to improve on this figure. The running to date has been carried out on distillate fuel. As soon as the turbine has been proved after reassembly, running on residual fuels will commence, which should take place shortly. Progress has been slower than expected due to unforeseen demands on the Research Station's resources by the Admiralty. These demands have now been reduced and the tempo of the gas-turbine programme is being speeded up again.

PREVIOUS MODIFICATIONS.

In the low-pressure compressor, the annular area was reduced by 20 per cent. by reducing the length of the rotor blades and fitting bands round the cylinder between the blade rows, the spaces between adjacent blades, up to the height of the bands, being filled with lead. The effect was to reduce the mass flow at which surging started. Corner cascades were fitted in the low-pressure compressor outlet and high-pressure compressor inlet ducts, and the internal stay-tubes in the ducting were removed, which reduced the pressure loss between the compressors. The fitting of pre-inlet guide vanes to the high-pressure compressor was completed, and the compressor was cleaned and painted internally; the guide vanes slightly improved the efficiency. An orifice was fitted to measure the dummy leak-off, and drains were fitted to the intercooler tube-plate to reduce (which they did) the amount of water passing into the high-pressure compressor. Experiments showed that washing the blades with a 1 per cent. solution of Lissapol in water, followed by washing with warm water, effectively loosened the dirt on the blades; so apparatus was constructed to enable the solution and the warm water to be injected at several points while running. It is hoped that this will prevent the accumulation of dirt on the blades. The apparatus was found to work very satisfactorily when it was tried during a full-power run.

The heat exchanger between the high-pressure compressor and the high-pressure turbine was pressure-tested in search of suspected air leaks, which were found to be occurring from the flanges and staybolts on the high-pressure air side. There was some corrosion of the aluminium-bronze tubes in the first pass of the heat exchanger as a result of sulphuric-acid condensation, thought to occur in starting the engine. Until this problem could be solved, it was decided to start and to close down on fuels of less sulphur content than those used when running.

As the combustion-chamber air casings were found to be running at too high a temperature for the aluminised mild steel of which they were made, radiation shields were fitted between the flame tubes and the air casings, and these proved effective. The combustion efficiency was about 98 per cent. with gas oil. In the high-pressure turbine, corner cascades were fitted in the exhaust duct to improve the gas distribution to the reheat combustion chambers; a Venturi was fitted to measure the air flow to the glands; and arrangements were made to measure the relative movement between the casing and the pedestals. This was also done on the low-pressure turbine.

As in the case of the high-pressure turbine, corner cascades were fitted to the low-pressure turbine exhaust ducts to the heat-exchanger, and an orifice was provided to measure the gland air flow. As the torsional joints on the inlet ducts leaked badly when the set was running on load, and the sliding exhaust ducts, in expanding when hot, put a side load on the turbine, flexible bellows were fitted between the ducts and the heat exchanger; these allowed the exhaust ducts to be bolted firmly at both flanges. These modifications reduced the movements of the turbine casing to within the working limits at the maximum inlet temperature of 1,250 deg. F. An insulating plate in the coupling between the dynamometer and the turbine cured the trouble, mentioned above, due to stray electric currents from the brake, which had caused pitting of the turbine bearings during the first attempt to run for 100 hours at full power.

The whole of the lubricating-oil system was dismantled, shot-blasted and thoroughly cleaned; and no further trouble was experienced with dirty oil. All the manometers and pressure guages were re-arranged on a single large panel near the control desk; and a Honeywell-Brown 36-point automatic temperature indicator was fitted. This was subsequently doubled in size to accommodate the large number of new thermocouples which had been introduced.

THE DESIGN DEPARTMENT.

Among the other activities of Pametrada, one of the most important is that of providing designs for machinery to be constructed by member firms. During 1951, the number of preliminary designs prepared as the basis for estimates and quotations by firms, continued to decline; not because of any lack of new contracts, but because designs previously prepared, and proved to be satisfactory in service, tended to be repeated for other installations. The modification of previous designs, however, actually provided the design department with more work than previously, and the extension of the Association's field to include auxiliary machinery—on the principle that a machinery installation should be considered as a whole—led to increased activity. A promising development was the use of specially-designed mixed-pressure turbines for the generation of electric power. An investigation was made of the saving in fuel consumption obtainable by generating power by low-pressure steam, bled from the main turbines at 30 to 60 lb. per square inch absolute; and of means whereby the generator might be kept on load when manœuvring or when the main turbines were shut down. The auxiliary turbine could be used also to drive the main boiler feed-pump.

One of the most important designs prepared during the year was for an installation of 7,500 shaft horse-power for a single-screw tanker for this Anglo-Saxon Petroleum Company; a design of particular importance, because it is to be used in a large number of ships. It consisted of a high-pressure turbine of all-impulse type, with a high-pressure astern stage in a separate casing; and a low-pressure turbine of disc-and-diaphragm construction, with the rotor "gashed" from a solid forging. A double-casing construction is used, with a cast cylinder supported within a fabricated outer shell. A number of designs for naval machinery were also prepared for the Admiralty.

A detailed investigation was carried out, in conjunction with the Research Department, of torsional vibration in a twin-screw passenger liner in which severe gearing wear had occurred. Each shaft was driven by three turbines, the high-pressure turbine driving through double-reduction gearing and the other turbines through single-reduction gearing. The damage was confined to the main gearwheel and pinions, and showed no sign of periodic distribution of the wear. Low-frequency vibration excited by the propeller appearing to be out of the question, a Sperry high-frequency torsional pick-up was fitted to one of the main pinions. Observations made during a 36-hours trial showed that a very heavy torsional vibration was present at about 90 per cent. of the full-power revolutions—sufficiently heavy to cause the pinion to oscillate through the full extent of the backlash. It had a frequency of 1,700 cycles per minute and occurred once per revolution of the main pinions; yet it could not be detected by touch or sound. The amount of pinion eccentricity necessary to produce the observed vibration was calculated to vary between 0·0015 in. and 0·0005 in., according to whether the eccentricity occurred in the high-pressure, intermediate or low-pressure pinion. The pinions were checked by measurements at the tooth roots, and in two of them small eccentricities were found, the combination of which gave, by calculation, almost exactly the observed vibration. This instance showed that the oil films in bearings, and between gear teeth, were not sufficient in themselves to absorb high-frequency vibrations, and that the inclusion of a flexible element in the drive was necessary, even with single-reduction gearing.

The report contains a large number of progress reports on researches in hand, but, in many cases, the particular researches were neither begun nor concluded in the year under review. This makes the references a little hard to follow in places, and suggests that, in such instances, a sentence or two, outlining the work leading up to the report, might be useful to enhance the continuity.

COURSE IN SPECIAL LIBRARY ORGANISATION.—The Department of Librarianship of the North-Western Polytechnic, Prince of Wales-road, Kentish Town, London, N.W.5, are organising a year's course in special library organisation and administration. The course will commence on September 25, and enrolment will take place from September 15 to 19 between 6 and 8 p.m. Further particulars may be obtained from Mr. P. H. Sewell, Head of the Department of Librarianship, at the above address.

FORTHCOMING EXHIBITIONS AND CONFERENCES.

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

FRANKFURT AUTUMN FAIR.—Sunday, August 31, to Thursday, September 4, at Frankfurt-on-Main. *Agents:* LEP Transport Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. (Telephone: CENtral 5050.)

SUMMER SCHOOL ON PHOTO-ELASTICITY.—Monday, September 1, to Thursday, September 11, at University College, London. Apply to the secretary, University College, Gower-street, London, W.C.1. (Telephone: EUSton 4400.) See also our issue of June 20, 1952, page 795.

59TH ROYAL NETHERLANDS INDUSTRIES FAIR.—Tuesday, September 2, to Thursday, September 11, at Utrecht, Holland. *Agent:* Mr. W. Friedhoff, 10, Grosvenor-place, London, W.1. (Telephone: WELbeck 9971.)

FLYING DISPLAY AND EXHIBITION.—Tuesday, September 2, to Sunday, September 7, at Farnborough. Open to the public on September 5, 6 and 7, only. Organised by the Society of British Aircraft Constructors, Ltd., 32, Savile-row, London, W.1. (Telephone: REGent 5215.) See also our issue of June 13, 1952, page 745.

FOURTH ELECTRONICS SYMPOSIUM AND EXHIBITION.—Tuesday, September 2, to Friday, September 5, at the Examination Hall, Queen-square, London, W.C.1. Organised by the Electrical and Electronics Section of the Scientific Instrument Manufacturers' Association of Great Britain, Ltd., 20, Queen Anne-street, London, W.1. (Telephone: LANgham 4251.) See also our issue of June 27, 1952, page 815.

ASSOCIATION OF GERMAN ENGINEERS: GENERAL ASSEMBLY.—Thursday, September 4, to Sunday, September 7, at Stuttgart. Organised by the Verein Deutsche Ingenieure, Prinz-Georg-strasse, Düsseldorf, Germany.

19TH INTERNATIONAL GEOLOGICAL CONFERENCE.—Monday, September 8, to Monday, September 15, at Algiers. Convened by the Comité Algérien d'Organisation du XIX Congrès Géologique International. Apply to Professor R. Lafitte, Faculté des Sciences, Algiers.

WELSH INDUSTRIES FAIR.—Wednesday, September 10, to Saturday, September 20, at the New Pavilion, Sophia-gardens, Cardiff. Particulars from the offices of the Fair, 17, Windsor-place, Cardiff. (Telephone: Cardiff 23049.)

SWISS FAIR, LAUSANNE.—Saturday, September 13, to Sunday, September 28, at Lausanne. For further information, apply to Comptoir Suisse, Place de la Riponne 5, Lausanne, Switzerland.

CHEMISTRY OF CEMENT: INTERNATIONAL SYMPOSIUM.—Monday, September 15, to Saturday, September 20. At the Royal Institution, 21, Albemarle-street, London, W.1, on the first day, and thereafter at the Royal Society of Arts, John Adam-street, London, W.C.2. Organised by the Building Research Station and the Cement and Concrete Association. Apply to the organising secretary at the offices of the Association, 52, Grosvenor-gardens, London, S.W.1. (Telephone: SLOane 5255.) See also page 243, *ante*.

ASSOCIATION OF PUBLIC LIGHTING ENGINEERS, ANNUAL CONFERENCE AND EXHIBITION OF STREET LIGHTING APPARATUS AND EQUIPMENT.—Tuesday, September 16, to Friday, September 19, at the Royal Hall, Harrogate. Communications to be addressed to the secretary, Association of Public Lighting Engineers, 22, Surrey-street, Strand, London, W.C.2. (Telephone: TEMple Bar 9607). See also page 71, *ante*.

INTERNATIONAL MACHINE TOOL EXHIBITION.—Wednesday, September 17, to Saturday, October 4, at Olympia, London, W.14. Organised by the Machine Tool Trades Association, Victoria House, Southampton-row, London, W.C.1. (Telephone: HOLborn 4667.) See also our issue of July 13, 1951, page 51.

SUSSEX INDUSTRIES EXHIBITION AND TRADES FAIR.—Wednesday, September 17, to Saturday, September 27, at the Corn Exchange, Church-street, Brighton. Promoted by the Federation of Sussex Industries, Duke-street, Brighton, 1. (Telephone: Brighton 26189.) See also page 233, *ante*.

MODERN BUILDING PLANT EXHIBITION.—Thursday, September 18, to Wednesday, September 24, at the Sophia Gardens Field, Cardiff. For further information, apply to the Ministry of Works Lambeth Bridge House, London, S.E.1. (Telephone: RELiance 7611.)

ASLIB (ASSOCIATION OF SPECIAL LIBRARIES AND INFORMATION BUREAUX).—Friday, September 19, to Monday, September 22, Annual Conference at The Hayes, Swanwick, Derbyshire. Apply to the secretary of the Association, 4, Palace-gate, Kensington, London, W.8. (Telephone: WEStern 6321.)

NORTH-WESTERN BUSINESS EFFICIENCY EXHIBITION.—Monday, September 22, to Saturday, September 27, at St. George's Hall, Liverpool. Organised by the Office Appliance and Business Equipment Trades Association, 11-13, Dowgate-hill, Cannon-street, London, E.C.4. (Telephone: CENtral 7771.)

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS: SPECIAL CENTENARY MEETING.—Monday and Tuesday, September 22 and 23, at Neville Hall, Newcastle-upon-Tyne, 1. There will also be held, concurrently, an exhibition of mining in the Durham University School of Mines, at King's College, Newcastle-upon-Tyne. Further details may be obtained from the honorary secretary of the Institute, Neville Hall, Newcastle-upon-Tyne, 1. See also page 243, *ante*.

SYMPOSIUM OF MINERAL DRESSING.—Tuesday and Wednesday, September 23 and 24, at the Imperial College of Science and Technology, Prince Consort-road, South Kensington, London, S.W.7. Organised by the Institution of Mining and Metallurgy, Salisbury House, Finsbury-circus, London, E.C.2. (Telephone: MONarch 2096.) See also our issue of February 15, 1952, page 211.

COMMERCIAL MOTOR SHOW.—Friday, September 26, to Saturday, October 4, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148, Piccadilly, London, W.1. (Telephone: GROsvenor 4040.)

FOURTH INTERNATIONAL CONGRESS ON INDUSTRIAL HEAT AND APPLIED THERMODYNAMICS.—Saturday, September 27, to Saturday, October 4, in Paris. Apply to the general secretary of the Congress, 2, Rue des Tanneries, Paris, 13e.

18TH INTERNATIONAL NAUTICAL EXHIBITION.—Saturday, September 27, to Sunday, October 12, in Paris. *Agents:* Home and Overseas Trade Fairs, 40, Gerrard-street, London, W.1. (Telephone: GERrard 5947.)

IRON AND STEEL EXPOSITION.—Tuesday, September 30, to Friday, October 3, at the Public Auditorium, Cleveland, Ohio, U.S.A. Organised by the Association of Iron and Steel Engineers. Apply to Mr. Albert W. Erickson, Junr., at the Association's offices, 1010, Empire Building, Pittsburgh 22, U.S.A. See also our issue of April 18, 1952, page 486.

PLASTICS EXHIBITION.—Saturday, October 11, to Sunday, October 19, at Düsseldorf. Organised by the Nordwestdeutsche Ausstellungs G.m.b.H. (Nowea), Ehrenhof 4, Düsseldorf, Germany. *Agents:* John E. Buck & Co., 47, Brewer-street, Piccadilly, London, W.1. (Telephone: GERard 7576.)

ENGINEERING INDUSTRIES ASSOCIATION, LONDON REGIONAL DISPLAY.—Tuesday and Wednesday, October 14 and 15, at the Horticultural Hall, Vincent-square, London, S.W.1. Apply to the secretary of the Association, 9, Seymour-street, Portman-square, London, W.1. (Telephone: WELbeck 2241.)

EXHIBITION OF MACHINERY AND APPARATUS FOR FOOD-PROCESSING, CHEMICAL AND PHARMACEUTICAL INDUSTRIES.—Tuesday, October 21, to Wednesday, October 29, at Rotterdam. Organised by the Royal Netherlands Industries Fair, Rotterdam, Holland. *Agent:* Mr. W. Friedhoff, 10, Grosvenor-place, London, W.1. (Telephone: WELbeck 9971.)

MOTOR SHOW.—Wednesday, October 22, to Saturday, November 1, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148, Piccadilly, London, W.1. (Telephone: GROsvenor 4040.)

PUBLIC WORKS AND MUNICIPAL SERVICES CONGRESS AND EXHIBITION.—Monday, November 3, to Saturday, November 8, at Olympia, London, W.14. Organised jointly by the Municipal Agency, Ltd. and the Congress Organising Council. Applications to the Municipal Agency, Ltd., 68, Victoria-street, London, S.W.1. (Telephone: VICtoria 9132.) See also page 143, *ante*.

BUSINESS EFFICIENCY EXHIBITION, GLASGOW.—Tuesday, November 4, to Friday, November 14, at Kelvin Hall, Glasgow. Organised by the Office Appliance and Business Equipment Trades Association, 11-13, Dowgate-hill, Cannon-street, London, E.C.4.

27TH INTERNATIONAL CYCLE AND MOTOR-CYCLE SHOW.—Saturday, November 15, to Saturday, November 22, at Earl's Court, London, S.W.5. Organisers: British Cycle and Motor Cycle Manufacturers' and Traders' Union, Ltd., The Towers, Warwick-road, Coventry. (Telephone: Coventry 62511.)

BREWERS' EXHIBITION.—Monday, November 24, to Friday, November 28, at Olympia, London, W.14. Particulars obtainable from the organisers, Trades, Markets and Exhibitions, Ltd., 623, Grand Buildings, Trafalgar-square, London, W.C.2. (Telephone: WHItehall 1371.)

SMITHFIELD SHOW AND AGRICULTURAL MACHINERY EXHIBITION.—Monday, December 8, to Friday, December 12, at Earl's Court, London, S.W.5. Details obtainable from the Smithfield Show Joint Committee, 148, Piccadilly, London, W.1. (Telephone: GROsvenor 4040.)

LABOUR NOTES.

THE meeting between representatives of the Engineering and Allied Employers' National Federation and leaders of the Confederation of Shipbuilding and Engineering Unions, held last Friday, August 22, resulted in the final and unequivocal rejection of the wage claim for a weekly increase of 2*l*. The meeting lasted for two hours and the Confederation's case was put to the meeting by Mr. Jack Tanner; Sir Alexander Ramsay, director of the Federation voiced the employers' reply. After the meeting the employers issued a statement, which set forth that the unions had been told that the employers' negotiating committee had maintained its view that the claim was unjustified. The reasons for rejection were that the claim was against the national interests, as any increase must increase costs. These costs could only be passed on to the consumer, meaning an increase in the cost of living and of exports. The claim was unwarranted by the rise in the cost of living, which had been substantially met by compensations such as relief of income-tax and the increase in family allowances. The committee saw no reason to give any different reply, but undertook to report the unions' representations to the management board of the Federation, and to let the Confederation have their official answer in a week's time.

The Federation's management board met yesterday, Thursday, August 28, and it is understood that a reply is being sent to-day to the representatives of the unions who are in Margate for the meetings of the Trades Union Congress. A special meeting of the Confederation is to be held in Margate on Sunday, August 31, to consider the employers' reply. The nature of this is a matter for conjecture but it appears that some of the Confederation leaders expect a reply which will leave the way open for further negotiations. Others, on the contrary, believe that the reply will contain a continued refusal to entertain even a small increase.

In view of the claims put forward, or pending, for increased wages, an announcement made by the Ministry of Labour on August 21 is of some importance. The announcement was to the effect that the index of retail prices on July 15 was 138, this figure being identical with that for June 17. It is of interest to recall that between May and June the index rose by three points but that from April to May there was no increase. Since January this year the index has gone up by six points, whereas the rise for the period January to July last year was nine points. It is only fair to add, however, that the possibility of further increases in food prices, in the autumn, has been foreshadowed by H.M. Treasury.

A strike among members of the National Association of Colliery Overmen, Deputies and Shotfirers which started at two pits in the Rhondda Valley spread by the middle of last week to involve 750 officials at 40 South Wales mines. As a result of the strike of these key employees, some 24,000 miners were unable to work—about a quarter of the total labour strength of the coalfield. Following a conference which unanimously recommended the strikers to return to work, the last of them resumed duty on the night shift of Friday, August 22. The men came out on strike on account of dissatisfaction with a wage offer made by the Divisional Coal Board. As a result of a national agreement the men, who had previously been paid on a day basis, were granted wages ranging from 14*l*. to 16*l*. 10*s*. a week, the actual amount to be fixed on divisional level. It was reported that the South-Western offer was nearer the 14*l*. than the 16*l*. 10*s*. level and the men complained that they were able to earn more on the old basis, plus week-end overtime. It was stated, after the conference, that some members had been earning up to 18*l*. a week.

From time to time news is received from the Midlands, South Wales, and other parts of the country that employees have been rendered idle for a period or have been thrown out of work owing to a dearth of orders, the cancellation of contracts, difficulties in obtaining adequate supplies of raw materials and other causes. The closure, or partial closure, of factories or the decision to diminish outputs although usually on a small and local scale, have naturally caused hardship among the employees affected. The sufferers are usually semi-skilled or unskilled persons and while, in many industrial areas, women and girl operatives and male labourers are relatively plentiful, the skilled engineer is often, to use a well-worn modern phrase, in "short supply."

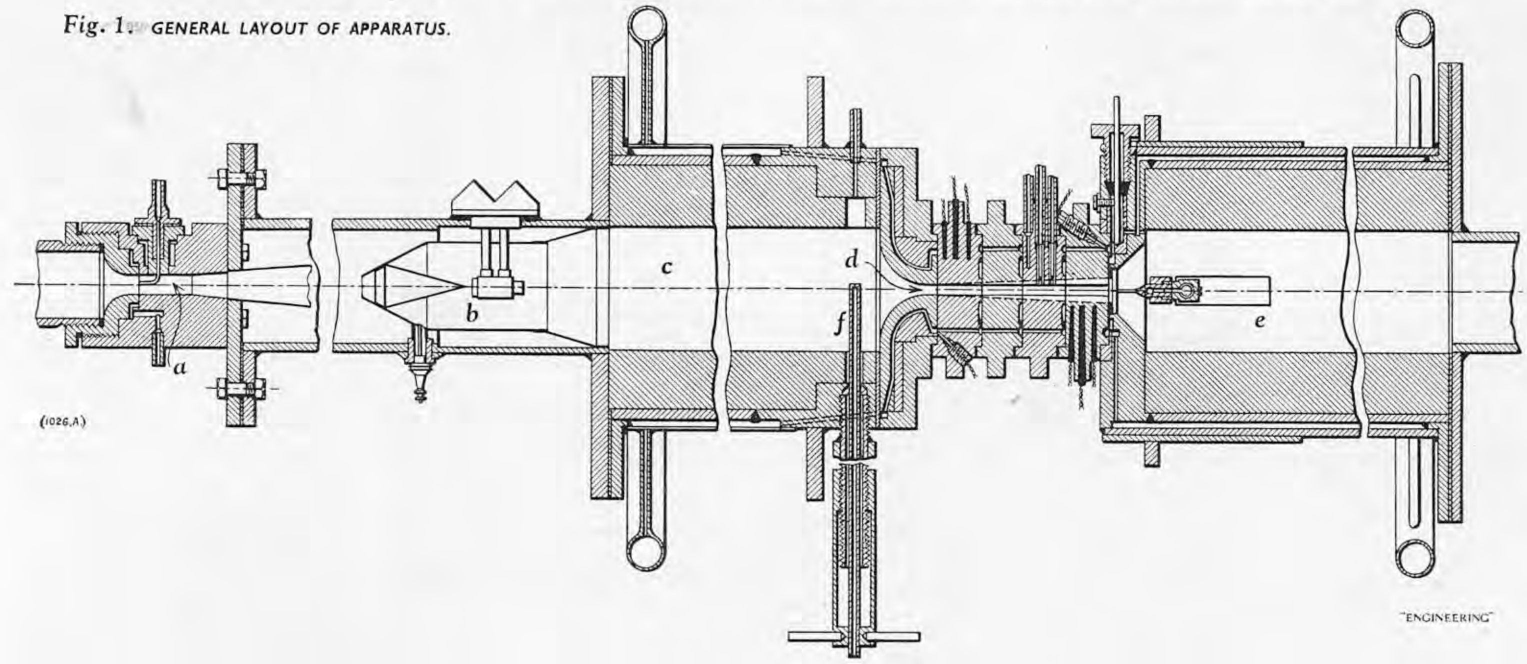
Thus, some of the heavy-engineering firms, in possession of order books filled with export and other urgent orders, are assiduously seeking to increase the numbers of fitters, erectors and other highly skilled men in their employ. These additional men are needed not only to maintain the quality of the firms' products but also to enable them to fulfil their contract obligations and deliver the finished machinery or plant in the stipulated time. Many firms are looking ahead and have either reorganised their apprentice-training methods or have instituted completely new and carefully thought-out schemes designed to attract a good type of boy leaving school and to encourage him to take up training in a skilled trade. Some of these schemes are bearing fruit as our columns have borne witness, while much is expected of others. It does seem that we are witnessing the passing of the unsettled days of the war and post-war years when boys, on leaving school, took up often highly-lucrative but "dead-end" repetition jobs in factories, in preference to undergoing the less spectacular, and less well-paid, long period of training necessary to become a skilled tradesman. The sense of security which an apprenticeship confers upon a young man and its value to him in his life's career are now being increasingly recognised and appreciated, and that is all to the good for the future well-being of this country and of its engineering industry.

Extracts from an address delivered to a meeting of foremen at a recent week-end school by a speaker described as the manager of a well-known tin-plate works, are given in the current issue of *Man and Metal*, the journal of the Iron and Steel Trades Confederation. The speaker stated that the operation of not one department but of the whole of a works must be the overriding factor and the first concern of all employees. The finished product was made by all and it was on this production and its quality and cost that the existence of all operatives depended, from the general manager down to the newest boy. This outlook was not easy to achieve, mainly because most people were parochial in their outlook, and attached far too much importance to their own needs and far too little thought to the needs of others. To attain a broad outlook was perhaps one of the most difficult of all things, and it was an attitude of mind which took a long time to develop. This outlook would not be achieved unless there was a willingness on the part of individuals to become united in a team and for that team as a whole to have confidence that the directives of higher management were for the good of all. If that faith were lacking, the prospects of building up a really good works were poor.

In his concluding remarks, the speaker referred to an outlook which, in the present difficult days, he considered seemed to be on the increase where those who exercised authority were concerned. He had heard many such people complain, especially when they felt tired and irritated and suffered from a sense of frustration, that it seemed of little use to strive to get things right; that nobody seemed to bother; and that it appeared that it paid to swim with the tide. Such an outlook was fanned by the bad world-wide affairs of these hard days, but it was pure defeatism, and a very dangerous line of thought. Any man who exercised authority and fostered such a thought had no right to hold authority. When, however, the thought did come, as might frequently be the case, it must be replaced by the conviction that: "The healing of the world will be brought about by those who lead, and I am in that category."

HEAT TRANSFER IN A NOZZLE AT SUPERSONIC SPEEDS.

Fig. 1. GENERAL LAYOUT OF APPARATUS.



HEAT TRANSFER IN A NOZZLE AT SUPERSONIC SPEEDS.*

By PROFESSOR O. A. SAUNDERS, D.Sc.(Eng.), M.I.Mech.E., and P. H. CALDER, Ph.D., B.Sc.(Eng.).

IN most practical cases of flow through a pipe at normal speeds under turbulent conditions, the "entrance length," in which the flow is settling down to equilibrium distribution of velocity over the cross-section, occupies only a small proportion of the whole pipe length. Over the remainder of the length the cross-sectional velocity distribution is the same; and when there is heat transfer between the fluid and the walls the temperature distribution also reaches its equilibrium form. In consequence, the local heat-transfer coefficient varies along the entrance length, but reaches a constant value after the flow has settled down and continues constant for the remainder of the pipe.

At higher speeds of flow, especially as the sonic velocity is approached, the process of heat transfer becomes more complicated because changes in the flow take place along the pipe as a result of the addition or removal of heat from the walls, or of friction at the walls, and these changes may affect the flow substantially before it has settled down. In a straight pipe, the growth of the velocity and temperature boundary layers may affect the flow in the core by reducing its cross-section for flow and thus cause choking to occur before equilibrium is established. In other cases, equilibrium may be reached and the exchange of heat continue along the pipe. On the other hand, in the divergent section of a convergent-divergent nozzle of the type, for example, used in rocket motors, the angle of divergence is frequently great enough to outweigh the narrowing of the central core of gas due to boundary layer growth; equilibrium over the cross-section can never be reached, and the central core of gas is therefore unaffected by heat exchange at the walls, or by wall friction effects, except for the indirect effect of reduction in the core area by the boundary layer growth.

In any case, there is considerable deviation from the assumptions, made in one-dimensional theory of the effects of heat and friction, that the velocity and temperature are uniformly distributed over the section. In attempting an experimental investigation of heat transfer to a gas flowing in a duct at high subsonic or supersonic speeds, therefore, it is essential to define precisely the conditions of both velocity and temperature distribution at the beginning of the measuring section; otherwise, the results may have little meaning and be difficult to interpret.

Two previous investigations of supersonic heat transfer have been made, by Kaye, Keenan and McAdams* and by Johnson and Monaghan.† The former used a straight heated pipe into which air was led by a convergent-divergent nozzle terminating in a parallel section, with as smooth a joint as possible between the nozzle and the pipe. In such an arrangement, the early history of the boundary layer in the nozzle is uncertain and the flow condition at the entrance to the heated measuring section is unknown. The results for the average heat transfer over the heated section showed very wide scatter, some of which was attributed by the authors to transition effects in the boundary layer and to difficulties in getting a completely smooth joint between the nozzle and the tube.

The second investigation, by Johnson and Monaghan, is open to less criticism. They started with the ideal arrangement of a very thin sharp-edged plate in a supersonic wind tunnel, but found this impracticable owing to difficulty in constructing a thin enough heater inside the plate, and finally used a heated flat plate which formed part of the wall of the tunnel. To define the flow precisely, they endeavoured to start a new velocity boundary layer at the upstream edge of the plate by means of a suction slot just ahead. This arrangement was fairly successful, though the exact setting of the leading edge was found to have some influence on the results. Their results showed transition taking place at length Reynolds numbers between 4×10^5 and 8×10^5. Their heat transfer values agreed with values deduced from turbulent flow theory, using the Prandtl-Kármán analogy between heat transfer and skin friction.

When the present experiments were started in 1948, it was decided to attempt two separate series of experiments. In the first series the aim was to measure the local heat-transfer coefficient at positions along the divergent section of a convergent-divergent nozzle. It was thought that these experiments would give a well-defined condition of flow at the throat, where the thickness of the boundary layer would be assumed to be very small indeed. The results are described in the present paper. In the second series of experiments, which is not yet completed, straight and conical heated pipes have been used, fed with air from a sufficient length of inlet nozzle to establish an equilibrium velocity-distribution at the entrance to the heated section.

In the present experiments, it was decided to use hot combustion gases at some 865 deg. C. (1,589 deg. F.) and to water-cool the nozzle; thus, moisture condensation troubles are avoided and a much simpler method of supplying and removing the heat is provided than when the experiment is done by electrically heating a tube through which cold air is passed. The use of fairly large temperature differences between the gas and the walls also permits more accurate measurement of the temperature difference.

DESCRIPTION OF APPARATUS.

Fig. 1, herewith, shows the general layout of the apparatus. Air from a compressor was passed through a Venturi *a* for flow measurement and entered a combustion chamber *b* in which kerosine was burnt to raise the final temperature to about 865 deg. C. The gases then passed through an approach duct *c* and finally entered the nozzle *d*, from which they passed into an exhaust duct *e*. The temperature of the gases was measured just before entering the nozzle, by means of the suction thermo-couple *f*. The static pressure was measured in the approach duct.

The divergent section of the nozzle was built up in four parts, bolted together through the flanges, with one flange on each section and the bolts staggered so as to pull together each pair of adjacent flanges. The nozzle could be operated with one, two, three, or four sections in position, and with the exhaust section, which was water-cooled and refractory-lined in a similar way to the approach duct, arranged to slide axially to accommodate different lengths of nozzle. The exhaust section also carried a traversing thermo-couple and Pitot tube, by which distributions of temperature and velocity at the nozzle exit could be determined.

The heat transfer to each nozzle section was deduced by measuring the temperature in the metal at two different depths, $\frac{1}{2}$ in. apart radially, the thermal conductivity of the metal having been specially measured. Lengthwise transfer of heat between different sections was prevented by an air gap 0·075 in. wide, narrowing to 0·006 in. at the bore of the nozzle. The nozzle was kept cool by narrow axial water-passages drilled in each section. It was not found practicable to measure the heat transfer by means of the rise of temperature of the cooling water through each section, owing to the possibility that the water in one section might pick

* Paper presented to the Institution of Mechanical Engineers for written discussion. Abridged.

* "Measurements of Friction Coefficients, Recovery Factors, and Heat Transfer Coefficients for Supersonic Flow of Air in a Pipe," by J. Kaye, J. H. Keenan and W. H. McAdams. *Report of the Heat Transfer and Fluid Mechanics Institute, Berkeley, California*, page 147. Published by the Amer. Soc. of Mech. Engrs., New York, (1949).

† "Measurement of Heat Transfer and Skin Friction at Supersonic Speeds," by J. E. Johnson and R. J. Monaghan. *R.A.E. Tech. Note No.* 1994, (1949).

up heat by conduction through the metal from the next section. To obtain a reasonable water-temperature rise, low velocities of the order of 4 ft. per second would also be necessary and the flow would thus be laminar and tend to cause errors in temperature measurement owing to lack of mixing. It was possible, however, to make an overall check of the heat transfer to the whole nozzle. This check confirmed the accuracy of the heat-transfer measurements; in particular, the absence of error due to the disturbance of the heat flow by the presence of the thermo-couple holes.

The Combustion System.—The combustion system, Figs. 2 and 3, consisted of an upstream-injection swirling conical spray, by which the fuel was thrown into an annular vortex generated by the air entering through inclined holes into the flame tube. Spill-control burners were used for good atomisation, and extra water-cooling over the rear end of the burner head was found to be necessary. Since the air flow was only from 0·01 to 0·15 lb. per sec., the combustion chamber was much smaller than in conventional designs and had to be specially developed.

The Nozzle.—The four sections of the nozzle were each bored out to a taper hole, with the throat of the nozzle approximately half-way along the first section. The last section was spigoted into a Sindanyo bush which was sealed into the exhaust section. Similarly, the approach entry-piece was insulated from the wall by a disc of Sindanyo, and water was prevented from coming into contact with the mounting by a split piece of Sindanyo, the inside of which had the same shape as the nozzle entry. The nozzle was provided with 12 static-pressure holes and each section had six thermo-couples, three at each depth. All the pressure and thermo-couple connections were brought out through the ring of water-cooling holes by means of radial drillings at points where three of the 60 equally-spaced water holes had been left undrilled. To overcome the difficulty of drilling the 0·031-in. diameter static pressure holes to such a great depth from the outside, inserts were used so that the holes could be drilled from the inside ends of the inserts, to break into the 0·0625-in. diameter holes drilled from the other end. To obtain a flush fit, the inserts were fitted before the main gas passage was bored.

The water seals between the nozzle sections, which prevented the cooling water from leaking either into the air gaps between the sections or to the outside of the nozzle, were arranged so that metal-to-metal contact was always obtained between adjacent nozzle sections. Sealing rings of outsize thickness were fitted initially, and were reduced to size by successive bakings in a furnace and reassemblies before the final reaming was carried out. The material used was Silastic, a rubber-like substance which retains its resilience at high temperatures.

Thermo-couples.—The final design of thermo-couple for measurement of nozzle metal temperature is shown in Fig. 4, opposite. The two ends of the 0·013-in. nickel-chrome and constantan wires were pressed separately into contact with the flat bottom of the hole drilled in the nozzle by means of a thin metal disc and a spring-loaded Sindanyo cylinder. In this way, good contact was obtained and the thermo-junction was located precisely at the bottom of the hole. The thermo-couple for measuring exhaust-gas temperature consisted of a stainless-steel hypodermic tube, tip-welded to alumel wire, 0·004 in. in diameter, passing down the tube and insulated by small quartz tubes. A suction thermo-couple was also used as a check test for absolute gas-temperature measurement.

The heat transfer to each section was obtained directly from the measured temperature gradient in the nozzle wall and the normal logarithmic conduction formula, and was based on the internal surface area of the hole in each section.

It has now been fairly well established, experimentally by Humble, Lowdermilk and Grele,* and theoretically by Cope†, that the heat transfer for

HEAT TRANSFER IN A NOZZLE.

COMBUSTION SYSTEM.

Fig. 2.

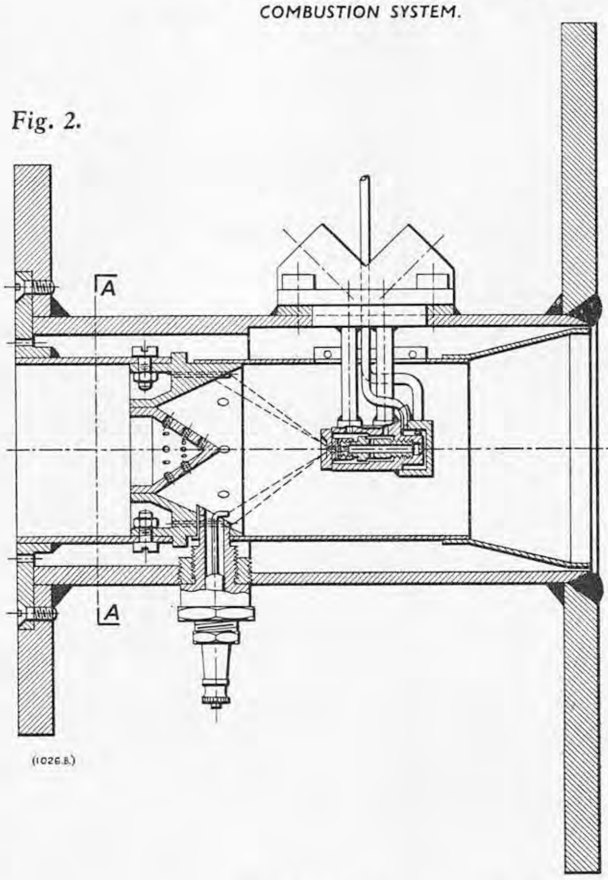


Fig. 3. SECTION AA.

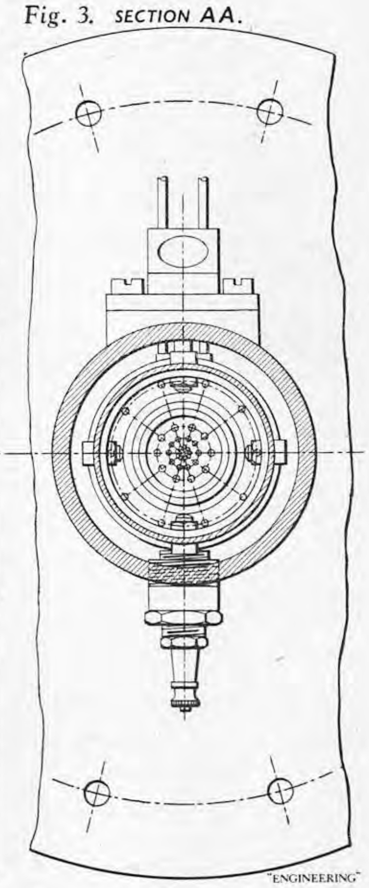


TABLE I.—SUPERSONIC HEAT-TRANSFER RESULTS.

Gas Total Temperature, T_0, Constant at 865 deg. C. (1,589 deg. F.).

Run Number.	Section Number.	Conduction Heat Flow, *q*, in Nozzle Section, Cent. Heat Units Per Second.	T_w	H	Nusselt Number, Nu.	Stanton Number, St.	$Re_L \times 10^{-4}$
1	1	0·583	205	343	248	0·00256	20·9
	2	0·443	160	230	179	0·00195	56·5
	3	0·403	142	192	161	0·00185	83·4
	4	0·364	127	159	144	0·00173	105·0
2	1	0·526	189	302	218	0·00255	18·5
	2	0·400	147	204	159	0·00195	49·8
	3	0·380	135	179	151	0·00195	73·8
	4	0·331	117	143	130	0·00175	92·8
3	1	0·484	176	273	198	0·00265	16·2
	2	0·384	142	195	153	0·00214	43·5
	3	0·356	127	166	140	0·00208	64·4
	4	0·304	109	130	119	0·00184	81·3
4	1	0·443	162	245	177	0·00265	14·4
	2	0·345	129	172	135	0·00211	38·9
	3	0·297	111	135	114	0·00190	57·7
	4	0·281	100	119	109	0·00188	72·7
5	1	0·405	151	220	159	0·00262	13·2
	2	0·323	121	159	124	0·00215	35·5
	3	0·295	108	134	113	0·00206	52·5
	4	0·263	95	110	101	0·00192	66·2
6	1	0·386	144	208	151	0·00274	11·9
	2	0·294	113	143	112	0·00226	30·3
	3	0·271	101	122	104	0·00220	45·0
	4	0·249	91	104	96	0·00211	56·8
7	1	0·333	128	176	128	0·00270	10·1
	2	0·268	104	129	101	0·00225	27·4
	3	0·249	94	111	94	0·00221	40·8
	4	0·227	85	94	87	0·00211	51·4
8	1	0·318	122	166	121	0·00284	9·2
	2	0·257	101	123	97	0·00238	24·8
	3	0·235	90	104	89	0·00230	36·9
	4	0·224	84	93	86	0·00231	46·6
9	1	0·538	198	313	225	0·00210	23·2
	2	0·459	168	241	187	0·00183	62·3
	3	0·414	149	199	166	0·00172	92·5
	4	0·382	135	169	152	0·00166	115·0
10	1	0·635	222	384	276	0·00233	25·7
	2	0·478	173	253	196	0·00173	69·1
	3	0·455	158	221	184	0·00173	102·0
	4	0·427	148	193	174	0·00169	128·8

high-speed flow is proportional to the difference between the actual wall temperature T_w and the adiabatic wall temperature T_{wa}, as given by the expression for the recovery factor $r = \frac{T_{wa} - T}{T_0 - T}$, where T_0 is the total temperature of the gas stream, T its true temperature, and *r*, the recovery factor, is about 0·88. In the present experiments, owing to the big temperature difference between the wall and fluid, little error is introduced by taking T_0 instead of T_{wa}. The wall temperature T_w was deduced by extrapolating from the measured nozzle wall temperatures. The Stanton number $\frac{H}{K_p G}$ was

* "Heat Transfer Coefficients and Friction Factors for Air Flowing in a Tube at High Surface Temperatures," by L. Humble, W. H. Lowdermilk and M. D. Grele. *Rept. of the Heat Transfer and Fluid Mechanics Institute, Berkeley, California*, page 165.

† "Heat Transfer at High Speeds," by W. F. Cope. *Proc. Seventh Int. Congress of App. Mechanics*, vol. 3, page 120, (1948).

HEAT TRANSFER IN A NOZZLE AT SUPERSONIC SPEEDS.

Fig. 4. THERMO-COUPLE FOR NOZZLE WALL.

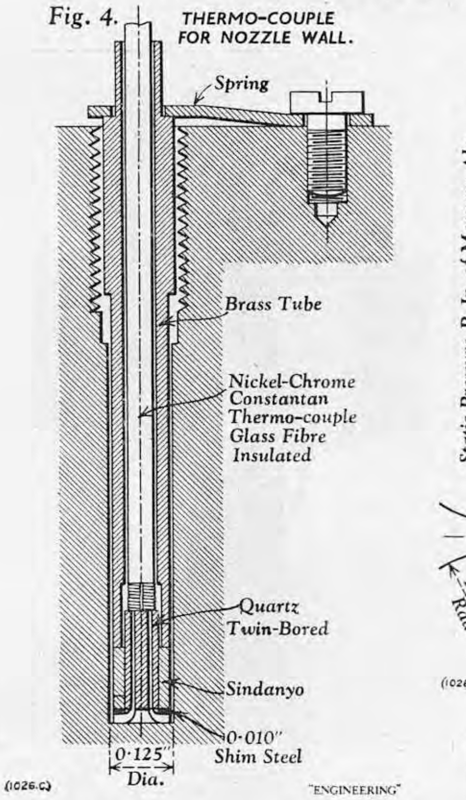


Fig. 5. STATIC PRESSURE, PRESSURE RATIO AND MACH NUMBER ALONG NOZZLE.

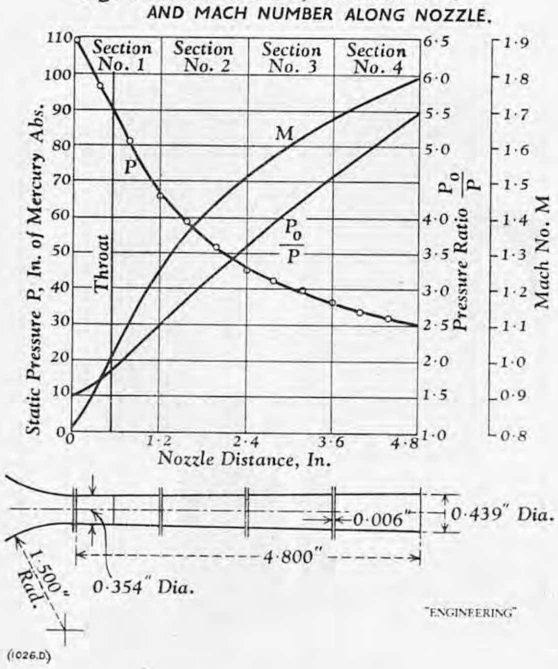


Fig. 6. HEAT TRANSFER RESULTS FOR SUPERSONIC TESTS AT DIVERGENT SECTION OF NOZZLE.

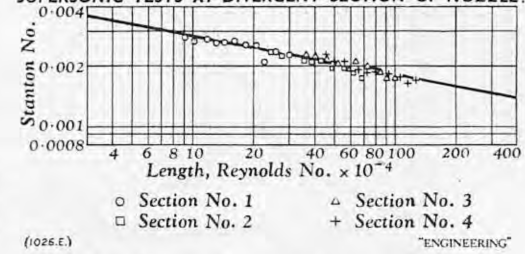


Fig. 7. HEAT TRANSFER RESULTS FOR SUPERSONIC TESTS AT DIVERGENT SECTION OF NOZZLE.

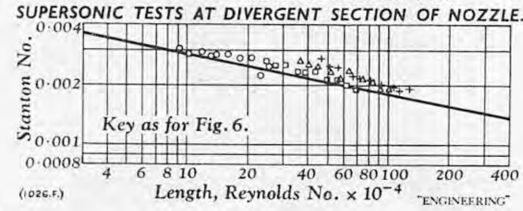
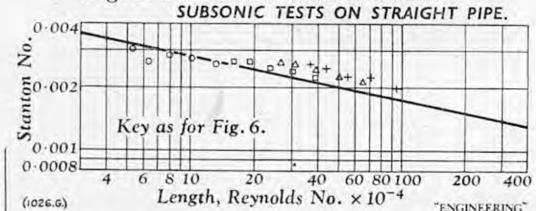


Fig. 8. HEAT TRANSFER RESULTS FOR SUBSONIC TESTS ON STRAIGHT PIPE.



thus calculated, the total mass flow and the cross-sectional area of the hole, taken at the mid-point of each section, being known; H is the heat-transfer coefficient in Cent. heat units per hour per square foot per deg. C., K_p is the specific heat at constant pressure, and G is the mass flow per unit area.

The Reynolds number $\frac{G\,L}{\mu}$ was also calculated from the known mass flow per unit area at the mid-point of each section, the viscosity, μ, being taken at the total temperature of the stream. The values of G decrease by about 30 per cent. between the first and last sections, on account of the divergence of the nozzle, but the main variation in the Reynolds number is due to L, the length measured from the nozzle throat.

RESULTS.

Fig. 5, herewith, shows the measured static pressure, P, at different positions along the nozzle. The total pressure, P_0, and total temperature of the central core of gas were assumed constant, at their measured upstream values, and hence the values of $\frac{P_0}{P}$ and M, the Mach number, given in the figure were deduced by the usual isentropic one-dimensional flow formulæ, using the appropriate values of γ (the ratio of the specific heats) for the combustion gases. The results in Fig. 5 are not used, however, in the calculation and correlation of the heat-transfer results, and are needed only in order to show the variation in Mach number along the nozzle.

Table I gives the heat-transfer results, which have been plotted in Fig. 6 by use of the Reynolds number based on the distance, L, from the throat. The temperature difference is based on a constant total temperature in the core of the gas stream. The agreement between the results for the four sections is remarkably good. If the length L is taken as measured from a starting position either before or after the throat, the correlation of the results for the four sections is found to be noticeably less good. It is also seen from Fig. 6 that the results fit in very well with the formula $St = \frac{0{\cdot}0285}{Re^{0{\cdot}2}}$, St being the Stanton number, $\frac{H}{K_p\,G}$, and Re the Reynolds number.

In Fig. 6, the temperature difference between wall and fluid has been based on the stream total temperature, assumed constant along the nozzle and equal to the upstream temperature before entry to the convergent section. The same results have been plotted in Fig. 7 on the assumption that the stream total temperature falls along the nozzle length owing to the removal of heat in accordance with the usual one-dimensional flow method of calculation; it will be seen that the correlation is distinctly less good than in Fig. 6, which is, of course, to be expected.

The simplified one-dimensional theory—which is adequate for calculating effects of changing cross-section, because these are propagated by pressure along Mach lines and the changes are communicated to the whole of the core of the gas without difficulty—is unsatisfactory for heat transfer and friction, which are propagated by tangential forces at a comparatively slow rate.

TABLE II.—SUBSONIC HEAT TRANSFER RESULTS.

Run Number.	Section Number.	Conduction Heat Flow, q, in Nozzle Section, Cent. Heat Units Per Second.	$T_0 - T_w$	H	Nusselt Number, Nu.	Stanton Number, St.	$Re_L \times 10^{-4}$
11	1	0·410	716	223	161	0·00263	13·2
	2	0·359	730	191	137	0·00226	39·6
	3	0·346	735	183	132	0·00216	66·0
	4	0·323	743	169	122	0·00200	92·4
12	1	0·350	744	183	131	0·00279	10·1
	2	0·310	755	160	115	0·00244	30·4
	3	0·302	758	155	111	0·00236	50·7
	4	0·294	762	150	107	0·00229	71·0
13	1	0·289	762	147	106	0·00290	8·0
	2	0·257	771	129	93	0·00255	23·7
	3	0·249	774	125	90	0·00246	39·6
	4	0·235	779	117	84	0·00230	55·4
14	1	0·210	771	106	77	0·00266	6·3
	2	0·210	771	106	77	0·00266	18·9
	3	0·210	772	106	77	0·00266	31·4
	4	0·203	774	102	74	0·00256	44·0
15	1	0·223	815	106	75	0·00305	5·3
	2	0·199	822	94	66	0·00270	16·0
	3	0·195	824	92	65	0·00264	26·6
	4	0·195	825	92	65	0·00264	37·3

DISCUSSION OF RESULTS.

The experimental values clearly indicate a variation with Reynolds number close to the turbulent law $St \propto \frac{1}{Re^{0{\cdot}2}}$, and the best correlation between the four sections is found when the length in the Reynolds number is measured from the throat. This is somewhat surprising, since transition would not be expected below about 8×10^5, according to Johnson and Monaghan* and others, and if the layer begins at the throat the majority of the nozzle will therefore be in the laminar condition. Both the downward pressure gradient in the direction of flow and the heat removal might be expected, if anything, to stabilise the boundary layer. The heat transfer values are also much above calculated values for laminar flow along a plate at low speeds, which would give $St = 0{\cdot}00057$ at $Re = 10^5$, compared to $St = 0{\cdot}0028$ observed and $St = 0{\cdot}0004$ at $Re = 10^6$, compared to $St = 0{\cdot}0019$ observed. The conclusion to be drawn is that the boundary becomes turbulent at, or very soon after, the throat, which means that transition must occur at or near the throat. These conclusions are supported by measurements of the boundary-layer thickness at the end of the nozzle.

Unfortunately, these measurements, which were made with traversing Pitot tube and thermo-couple just beyond the end of the nozzle, were subject to some error on account of the size of the thermo-couple and the difficulty in taking traverses very close to the nozzle without disturbing the flow; but, though the results were liable to some error, they indicated a boundary-layer thickness of about 0·12 in. at $Re = 5 \times 10^5$, which is to be compared with 0·126 on the assumption of a turbulent layer starting at the throat, and with 0·012 on the assumption that a laminar layer is possible over the whole nozzle, starting at the throat. The evidence,

* *loc. cit.*

ELECTRONICALLY-CONTROLLED CUTTING HEAD.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

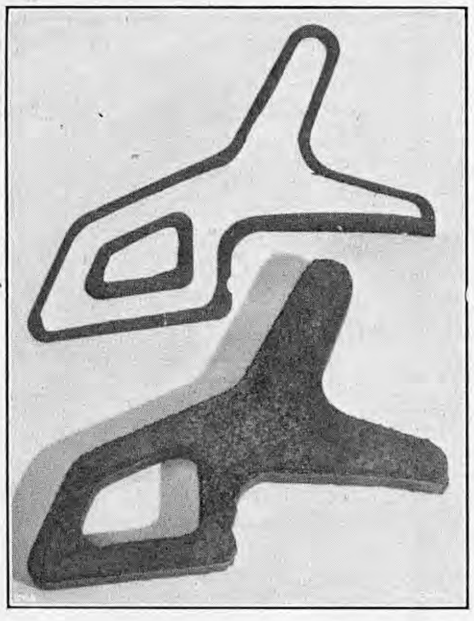


FIG. 1. PAPER TEMPLATE AND STEEL PRODUCT.

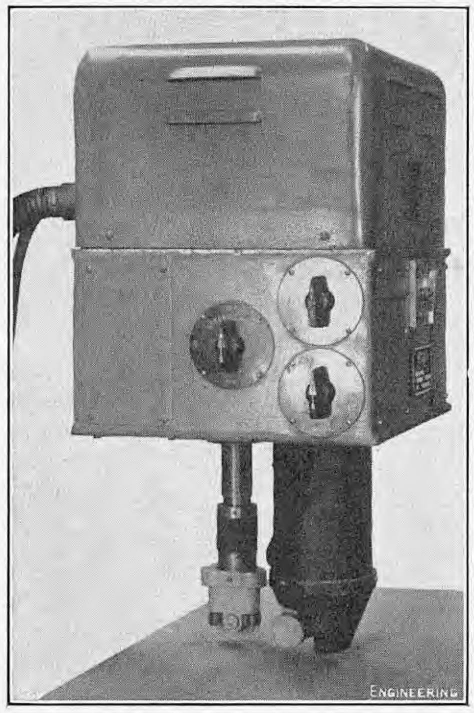
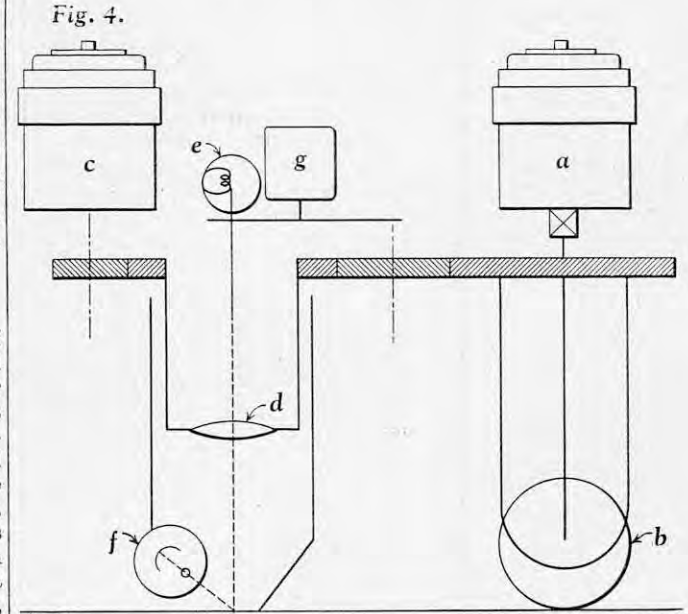


FIG. 2. TRACING HEAD AND OPTICAL SYSTEM.

FIG. 3. TRACING HEAD SHOWING MOTORS AND SCANNING DISC.

Fig. 4.



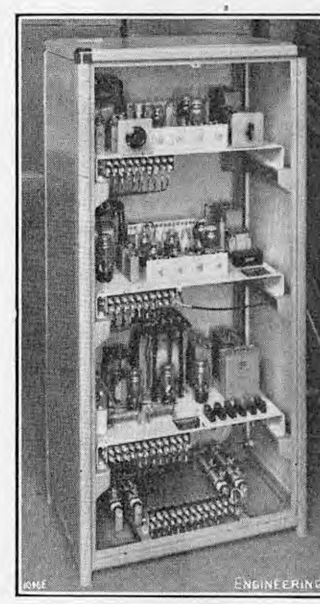


FIG. 5. ELECTRONIC AMPLIFIER AND POWER UNIT.

therefore, points to a breakdown of the flow into a very thin turbulent layer at the throat.

The mean line through the points in Fig. 6 is almost exactly the same as the law $St = \frac{0 \cdot 0285}{Re^{0 \cdot 2}}$, which is the theoretical expression for flat-plate heat transfer at low velocities under turbulent conditions (H. Latzko,* and Jakob†). It appears that the variation of Mach number up to 1·75 has no appreciable effect upon the heat transfer. As is shown by Latzko, the comparison of results for a slightly diverging tube with theoretical values for a flat plate is not quite justified, but for the nozzle used the difference is small, and the experiments agree remarkably well with the flat-plate theory.

SUBSONIC HEAT TRANSFER.

Some experiments with a straight pipe in place of the divergent section of the nozzle were also carried out, the straight section being divided into four equal lengths and the same technique used as with the divergent nozzle. As in Fig. 6, the temperature difference is based on a constant total temperature in the core of the gas stream. The results are shown in Table II and Fig. 8, page 283, and are, of course, all for subsonic speeds. The points for the sections nearest the throat agree closely with the flat-plate low-speed formula, but there is a progressive deviation for the positions farther along, due to the increased velocity of the core of fluid caused by the thickening boundary layer.

ALUMINIUM ROOF COVERINGS.—The Aluminium Development Association are displaying a number of models, illustrating recommended practice for fully-supported roof coverings in aluminium, at the Building Centre, 26, Store Street, London, W.C.1. The exhibits demonstrate the application of various grades of aluminium to this work, and the very high standard of workmanship and effective roofing that can be achieved with these materials. The materials used are aluminium (99·99 per cent.), S1A (99·8 per cent.), S1B (99·5 per cent.), S1C (99 per cent.), and NS3 (aluminium-manganese alloy), all in the "O" or soft condition. It will be seen from the exhibits that they compare favourably with the traditional methods employed with older types of roofing material and craftsmanship. Further information may be obtained from the Aluminium Development Association, 33, Grosvenor-street, London, W.1.

* *Zeit. für angew. Math. u. Mech.*, vol. 1, page 268 (1921).

† *Heat Transfer*, by M. Jakob, page 482. John Wiley and Sons, New York; and Chapman and Hall, London (1949).

ELECTRONIC CONTROL OF OXYGEN CUTTING MACHINE HEAD.

OXYGEN cutting machines are usually provided with a pantograph, one member of which carries the cutting torch, while the movement of the other is controlled by one of a number of methods. These include the use of a power-driven tracing wheel, which is guided either by hand or by a magnetised roller that follows the contour of a steel template; differentially-driven twin rollers on each side of a soft-metal strip; and a small roller, which is held by hand against the edge of a wooden or soft metal template, with or without a further template to press the roller against the template proper. The standard of work produced by a hand-guided torch depends, however, on the skill of the operator, while templates are tedious to set up, besides being expensive and requiring considerable storage space.

To overcome these drawbacks the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, have developed a motor-driven tracing head, which is mounted on one arm of the pantograph and is electronically controlled. This head follows an outline of the shape required, which has been drawn in Indian ink on white paper. The lines thus drawn must be at least $\frac{1}{4}$ in. thick and the outline must differ slightly in size from the final product in order to compensate for the width of the cut. These drawings, which are easily prepared and stored, replace the templates. A spot of light, not more than $\frac{1}{16}$ in. in diameter, is projected from the tracing head on to the edge of the inked lines. If it deviates from that position by more than 0·025 in., a photo-electric cell is energised, the electronic equipment operates and the motor restores it to its original position. A typical example of an outline and the final cut product is illustrated in Fig. 1, the difference in width between the two being less than 0·025 in.

TRACING HEAD.

The tracing head, showing the driving wheel and the tube housing the optical system, is illustrated in Fig. 2, and in Fig. 3, a head with the covers

ELECTRICALLY-CONTROLLED CUTTING HEAD.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

Fig. 6. STEERING UNIT.

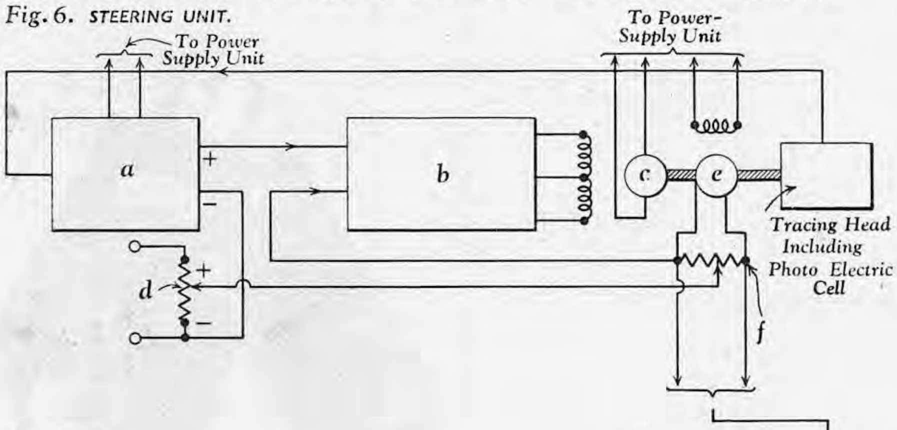
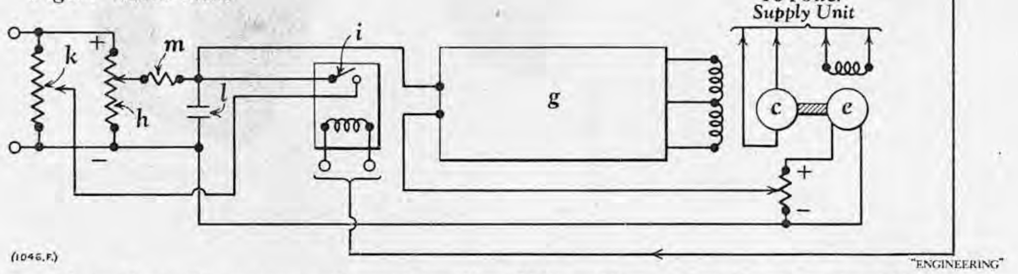


Fig. 7. TRAVEL UNIT.



removed to show the motors and scanning disc. The arrangement of the travel motor, steering motor and optical system is also indicated diagrammatically in Fig. 4. As will be seen, the travel motor *a* drives the wheel *b*, which propels the head, and the steering motor *c* guides it so that its path conforms with the outline. The steering motor also rotates the lens assembly *d*. Both motors are of the split-field type and carry tachogenerators on their shafts. The optical system consists of the bi-convex lens *d*, a projector lamp *e* and a photo-electric cell *f*. The lamp is of a compact filament type and is slightly under-run to prolong its life. The lens is placed so that a spot of light about $\frac{1}{16}$ in. in diameter is produced. The pencil of light from the lamp is interrupted about 1,000 times a second by a perforated disc, which is rotated by a small alternating-current motor *g*. The spot is slightly offset from the axis of the optical system by tilting the lens and its mounting. As this mounting is geared 1 to 1 to the column carrying the tracing wheel, the spot describes a circle when the column turns through 360 deg. The diameter of this circle is, of course, adjustable by varying the tilt of the lens assembly. The tracing-wheel column is also so arranged with regard to the optical system that its direction of travel is determined by a line drawn from the spot to the centre of the circle round which it is rotating. The photo-electric cell is placed so that it picks up reflected light from the drawing, the amount of excitation and thus the strength of the signal transmitted, being greater when the spot is on the white background than when it is on the black line.

STEERING AMPLIFIER.

The signals from the photo-electric cell, after amplification by a steering amplifier, are used to control the steering motor. The steering amplifier is set so that the steering motor rotates the column carrying the tracing wheel in one direction when the spot of light falls on a black line and in the opposite direction when it falls on white paper. The motor is only stationary when the spot is half on the white paper and half on a black line. As will be seen from Fig. 5, which is a diagram of the steering unit, two stages of amplification are employed, namely, an alternating-current pre-amplifier *a* and a directly-coupled power amplifier *b*, the latter being used to energise the split fields of the steering motor *c*. The combination of a 1,000-cycle "chopped light" signal, produced by the revolving disc, mentioned above, and an alternating-current pre-amplifier prevents the equipment from responding to slow variations in the extraneous light. After pre-amplification, the 1,000-cycle signal is rectified, thus producing a direct-current voltage, the amplitude of which varies with the amount of light falling on the photo-cell. This signal is balanced by a pre-determined voltage from the balance potentiometer *d*, so that, when the spot of light is half on a black and half on a white surface, the resultant signal is zero. When more of the spot moves on to the white paper the amount of reflected light is increased and a positive signal, which is greater than the pre-determined reference voltage, is generated in the photo-electric cell. When more of the spot moves on to the black line the amount of reflected light decreases and a negative signal, which is less than the pre-determined reference voltage, is generated in the photo-electric cell. The steering motor is therefore turned in one direction when the signal from the photo-cell is greater than the pre-determined reference and in the other when it is smaller. A part of the output of the tachogenerator *e* is also fed through the damping potentiometer *f* into the power amplifier *b* in such a way as to oppose any movement of the motor. As a result, the system is damped and the spot of light is prevented from hunting to one side or the other of the line that is being followed.

TRAVEL AMPLIFIER.

The travelling speed of the head is directly controlled by a second power amplifier, as shown at *g* in Fig. 6. The input to this amplifier is made up of two opposing voltages. One of these can be adjusted by the potentiometer *h*, which acts as a speed controller, while the other consists of a pre-determined part of the voltage of the travel tachogenerator. The result is that the signal input to the amplifier is reduced so that it is only just sufficient to unbalance the motor fields and to allow the motor to run against the opposing torque. Infinitely variable speed control of the travel motor is thus provided. To reduce the speed of the travel motor to a fixed low value when the tracing head is traversing corners, an adjustable relay *i* is connected across the output of the tachogenerator *e* and is set so that it operates when the steering speed exceeds a certain value. When this relay operates, the signal to the travel amplifier *g* is reduced to a value which is pre-determined by the setting of the potentiometer *k*, and the speed of the motor rapidly falls to a low figure. After the steering motor has guided the head round the corner, the travel motor speed is slowly increased by allowing the input signal from the main speed-control potentiometer *h* to build up through the condenser *l*, which is supplied through the high resistance *m*. This enables intricate shapes, square corners and even acute angles to be followed with great precision.

The travel and steering amplifiers are mounted in a sheet-steel cubicle, as shown in Fig. 7. This cubicle also contains a power unit from which the lamp, the chopper motor and the fields of the travel and steering tachogenerators are supplied. Further, a constant current supply is given to the motor armatures. Three switches for controlling the travel and steering are mounted on the tracing head, as can be seen in Fig. 2.

OPERATION.

For operational purposes, the speed of travel is set to a value which depends upon the thickness of the material that is to be cut. After the cutting flame has been adjusted, the travel motor is switched on and the head is guided by hand towards the drawing. When the spot of light falls on the edge of the black line the steering motor is switched on. The spot of light then automatically follows the outline of the figure. The equipment can be adjusted so that the spot of light follows the edge of the black line and is exactly bisected by it. If the spot tends to run on to the white part of the drawing so that more light is reflected on to the photocell the control system comes into operation and the steering motor is turned in the direction which will restore the original position. The amount of light falling on the photo-cell then again becomes normal and the travel wheel is turned so that it runs tangentially to that part of the outline which the head is traversing at that time. The path traced by the cutting torch is exactly similar to that described by the light spot, so that a replica of the outline is reproduced in the material that is being worked.

CONTRACTS.

HUNTING AEROSURVEYS LTD., 29, Old Bond-street, W.1, have been awarded a contract by the Crown Agents for the Colonies to carry out air photography of up to 25,000 sq. miles in British Guiana, and 1,250 sq. miles in Jamaica. The photographs will be used for the preparation of topographical maps and for photographic interpretation in connection with the assessment and development of the natural resources of those Colonies.

INDUSTRIAL WASTE ELIMINATORS LIMITED, 7 to 11, Old Bailey, London, E.C.4, have received, through their agents Hubert Davies & Co. Ltd., Johannesburg, the contract for the supply of slaughtering and by-products equipment for the new municipal abattoir at Vereeniging. This is the first of several projected municipal abattoirs in the Union of South Africa. The plant is fully mechanised and will deal with some 400 cattle and a proportion of smaller animals a day.

F. BRADFORD & CO. LTD., Angel-road, Edmonton, London, N.18, have received the contract for a reinforced-concrete barrel-vault shell roof, flat roofs, suspended floors and staircases for the new road-motor depot of British Railways, London Midland Region, at St. Pancras-way, London, N.W.1.

LEONARD FAIRCLOUGH LTD., Chapel-street, Adlington, Lancashire, have secured several contracts from British Railways. These include the renewal of a quay wall at Bow goods depot; the reconstruction of the gables of a warehouse at the Liverpool-road goods depot, Manchester; and the reconstruction and lengthening of bridge No. 123, carrying road A 533 over the railway at Winnington-lane, Northwich.

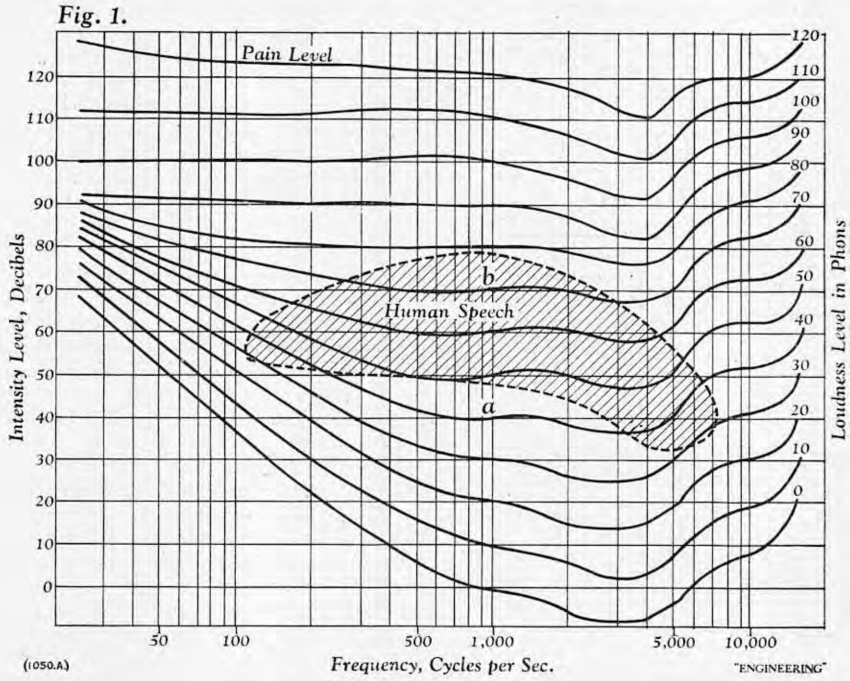
THE DE HAVILLAND AIRCRAFT CO. LTD., Hatfield, Hertfordshire, are to supply two series 2 Comet jet air liners fitted with Rolls-Royce Avon engines to the Linea Aeropostal Venezocana (L.A.V.), Venezuela, for use on a direct non-stop express service between Caracas and New York, a distance of 2,140 statute miles. Delivery of the aircraft is expected in the middle of 1955.

THE BRITISH THOMSON-HOUSTON CO., LTD., Rugby, have received from the United States Army, European Headquarters Command, an order for military electronic equipment valued at approximately 4,200,000 dols.

"THE FUTURE OF THE IRON AND STEEL INDUSTRY"; ERRATUM.—In the last paragraph, on page 145, *ante*, of the article with the above title, we stated that the former Iron and Steel Board had "functioned excellently . . . under the statesmanlike direction of the late Sir Andrew Duncan." The reference should have been, of course, to Sir Archibald Forbes, to whom we apologise for the error.

SOUND AND VIBRATION ANALYSIS.

Fig. 1.



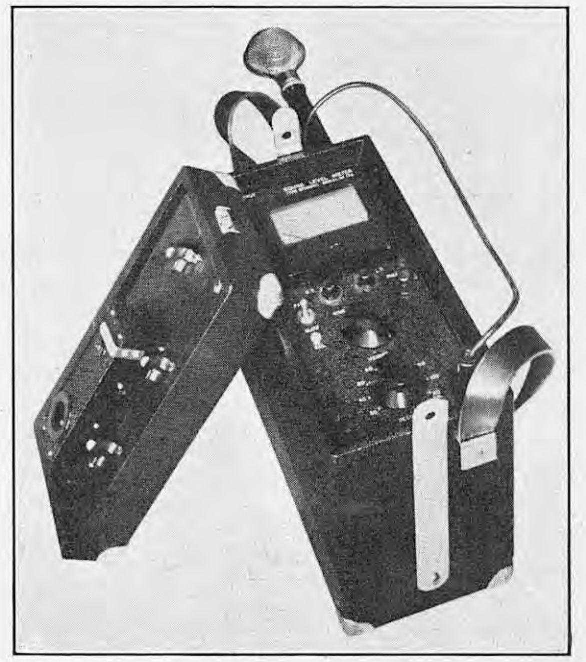


Fig. 2. Sound-Level Meter.

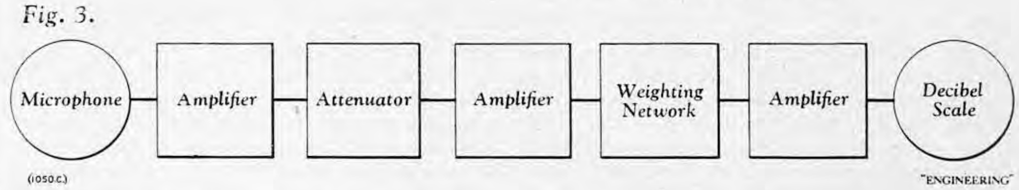
SOUND AND VIBRATION ANALYSIS.

The detection and measurement of sound and vibration are being used more and more for the elimination of faults in design and construction. The basic principles are discussed in this article and the uses of certain proprietary measuring instruments are described.

Lord Kelvin once said: "When you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind." This saying is as true of sound and vibration analysis as it is of most other fields of science. Unfortunately, the measurement of sound presents some unique difficulties. These arise largely from the fact that sound has subjective as well as objective characteristics, and these twin properties must be correlated if the measurement is to be of any practical value. The objective features of sound—namely, energy and pressure—are measurable by a sound-level meter, but it then remains to interpret the effect of varying energy levels on the human ear. It might be thought that to double the energy of a sound would be to double the effect on the human ear. In fact, however, the sensitivity of the human ear falls off roughly logarithmically with increased sound level, so that it requires a tenfold increase in sound energy to give the human ear the sensation of doubling the sound level, and no less than a hundredfold increase in the objective phenomena to give a quadrupling of the subjective sensations. Sound level is therefore defined logarithmically. The decibel rating of a sound, in fact, represents ten times the logarithm of the ratio of the energy of the sound to that at the threshold of hearing (i.e., 10^{-16} watts per square centimetre). The ten is added to space out the scale so that a sound can be expressed, with sufficient accuracy for all practical purposes, as an integral number of decibels, without bringing in fractions.

The intensity of sound at the threshold of hearing is incredibly low, and such a sound over an area of 5×10^{16} sq. cm. (about 1,400 miles square) would only represent a total energy of about 5 watts. To take another example, the energy contained in one pound of coal, if perfectly converted, would provide enough energy to allow all the inhabitants of a medium-sized city, such as Coventry, to talk in a medium tone of voice for a period of 650 hours. These very low intensities render the design of sound-level measuring equipment difficult, and it is only by the use of modern electronic amplifying circuits that it has been done.

Fig. 3.



The sensitivity of the ear also falls off at high and low frequencies. Both these effects can be seen from Fig. 1, which represents the equal-loudness curves of Fletcher and Munson. These curves show the sound level in decibels at different frequencies required to produce an equal sensation of loudness to an average man and, though recent work has indicated certain small changes to these curves, they show fairly closely the performance of a person of average hearing. It is apparent that, to obtain an impression of equal loudness, a sound level of 73 decibels will be required at 30 cycles per second, 40 decibels at 200 cycles per second, 20 decibels at 1,000 cycles per second, and 30 decibels at 10,000 cycles per second. Clearly, this subjective response must in some way be built into any sound-level meter, which must cater not only for this variation of sensitivity with frequency, but also for noise level.

The problem is solved in the sound-level meter shown in Fig. 2, by including suitable weighting networks in the circuit. This instrument, like others referred to in this article, is made by Dawe Instruments, Limited, 83, Piccadilly, London, W.1. The networks are shown in the block diagram, Fig. 3, which also indicates the microphone for converting the sound into a suitable electrical signal. The attenuation coming next in the line enables the sound-level meter to handle the tremendous range from 30 to 126 decibels, representing a variation in sound energy of from over 1,000,000,000 to one. Returning to the weighting networks; there are three of these. The first corresponds to the equal loudness countour marked *a* in Fig. 1 (i.e., 40 decibels level), the second to the contour marked *b* in Fig. 1 (i.e., 70 decibels level), and the third network gives an equal or "flat" response at all frequencies, such as that of the human ear at loud sound levels (over about 85 decibels). Table I shows the decibel rating of a number of common sounds. In practice, the network corresponding most nearly to the actual noise level being measured is switched in and the meter then gives a response for steady sounds closer to that of the human ear than the random error which may be expected in a normal group of observers. For non-steady sounds, an effective correlation of meter reading with subjective response depends on the ballistic characteristics of the instrument being reasonably similar to those of a human ear. This is, in fact, one of the features of the sound-level meter (Fig. 2), which also has provision for heavy damping of the galvanometer movement to give the average level of fluctuating sound, should this be required.

Rapidly-fluctuating sounds, however, are better

Table I.—*Ratings of Common Sounds.*

	Decibels.	—	Intensity Units.	Sound Pressure, dynes per sq. cm.
		Threshold of pain		
	120		1,000,000,000,000	200
Deafening.		Thunder, artillery		
		Nearby riveter		
	110		100,000,000,000	
		Underground train		
		Boiler factory		
	100		10,000,000,000	20
Very loud.		Loud street noise		
		Noisy factory		
	90		1,000,000,000	
		Lorry unmuffled		
		Police whistle		
	80		100,000,000	2
Loud.		Noisy office		
		Average street noise		
	70		10,000,000	
		Average wireless		
		Average factory		
	60		1,000,000	0·2
Moderate.		Noisy home		
		Average office		
	50		100,000	
		Average conversation		
		Quiet wireless		
	40		10,000	0·02
Faint.		Quiet home or		
		Private office		
	30		1,000	
		Average auditorium		
		Quiet conversation		
	20		100	0·002
Very faint.		Rustle of leaves		
		Whisper		
	10		10	
		Sound-proof room		
		Threshold of audibility		
	0		1	0·0002

SOUND AND VIBRATION ANALYSIS.

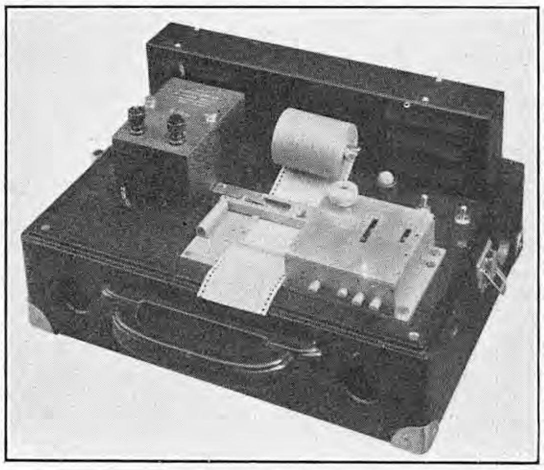


FIG. 4. HIGH-SPEED LEVEL RECORDER.

Fig. 5.

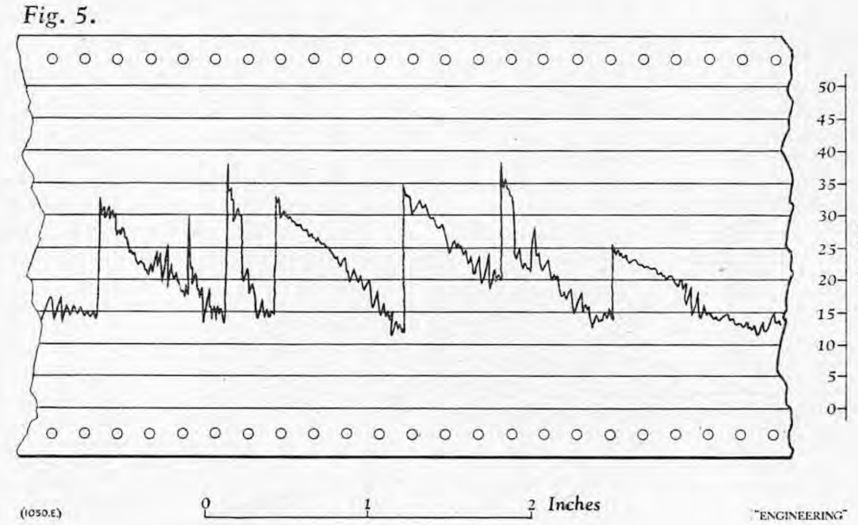
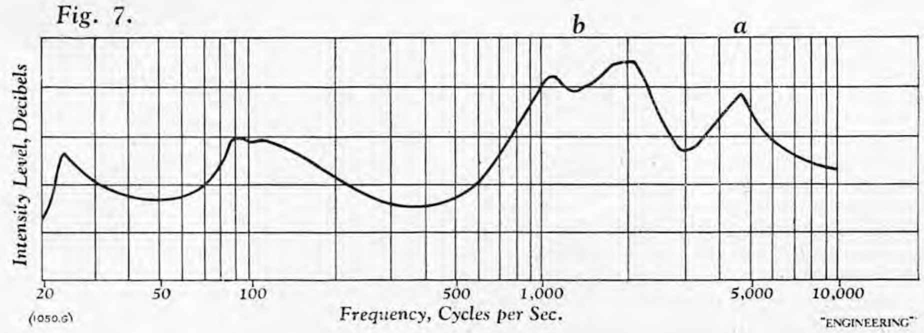


Fig. 7.



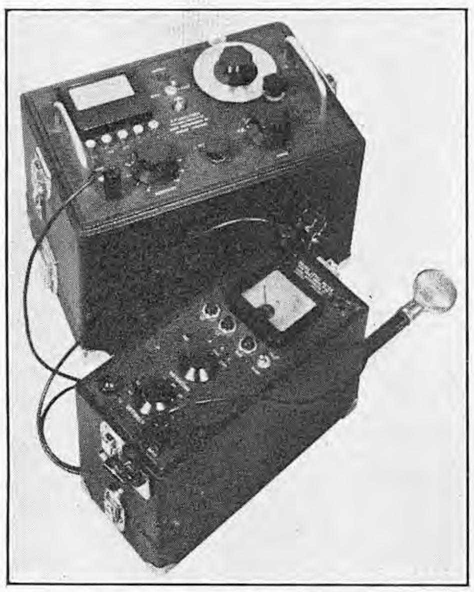


FIG. 6. SOUND-LEVEL METER AND AUDIO-FREQUENCY ANALYSER.

handled by a high-speed level recorder, such as that shown in Fig. 4, above. This instrument is suitable for recording the rapid change of signal level in such instruments as microphones, amplifiers and loudspeakers, and is also excellent for recording the reverberation periods of halls, broadcasting studios and the like. A particularly useful application is in monitoring noisy telephone lines, where the line can be switched out of service and a recorder can note the sound level continuously. In addition, a record of such short-time events as changing gear on a motor-car, or reversing the engine on a ship, can be made on this instrument and examined later at leisure.

REVERBERATION.

Whenever sound is produced indoors, an observer will not only receive the sound direct, but will also hear reverberations and echoes from walls and other reflecting surfaces. The difference between echoes and reverberations is that there is a distinct pause between the completion of the sound and its return as an echo, while with reverberations the sound is continuous and decreases slowly in intensity. True echoes, however, are more common outside than indoors, and it is sufficient for the present purpose to concentrate on reverberation. Fig. 5 shows a portion of a chart from such a recorder, illustrating what happens if a series of notes from a vibraphone is injected into a room. The ruled ordinates form a calibration in steps of 5 decibels (or 2·5 or 7·5 decibels, as desired), as indicated at the right of the chart. The perforations at the edges of the chart give a positive drive from sprocket wheels on the instrument, since horizontal measurements of distance represent times. Thus, knowing the chart speed, a time base can be added. In fact three chart speeds of 50, 10 and 1 mm. per second are obtainable, and, at the maximum writing speed, the full-scale movement (from 0 to 50 decibels in the illustration) can be carried out in 0·12 second. With the maximum range of 75 decibels in use, this gives a writing speed of 625 decibels per second. When it is considered that reverberation time is normally defined as the time in seconds for a signal to fall to one millionth of its steady state value (i.e., a fall of 60 decibels) measured from the point when the sound is cut off, it will be seen that the high-speed recorder can measure reverberation times above about 0·10 second. Since the lowest reverberation time contemplated for any hall is in the region of 0·6 second, this range is obviously more than adequate.

In the early days of concert-hall design, there was a tendency to try to reduce the reverberation time too much. Indeed, the early amphitheatres were open and the sound passed by the audience never to return, so reducing reverberation time almost to zero. Such design not only reduces the total volume of sound by absorption or dissipation to such an extent that the audience have difficulty in hearing the performers (Roman performers, in fact, wore masks containing a sort of megaphone), but such places also sounded hard and "dead." The modern tendency is therefore to design the acoustics and reverberation time of the hall to suit the particular class of sound (for instance, organ music, orchestral music, or speech) which will be most common. Typical optimum reverberation times for a hall of 50,000 cub. ft. are 1·4 second for heavy organ music, 1·0 second for light classical music, and 0·8 second for normal speech.

FREQUENCY ANALYSIS.

So far, we have discussed the measurement of the total volume of sound, irrespective of the frequency at which it occurs (except to make a suitable correction for the sensitivity of the human ear). It is often valuable to be able to measure the sound level at a particular frequency. This function is carried out by the audio-frequency analyser shown in Fig. 6, which enables a sound to be split up into a frequency spectrum of the type illustrated in Fig. 7, above. From this spectrum, the frequencies at which the greatest noises occur can be seen in an instant. Fig. 7, for instance, covers the noise (noise being merely unpleasant sound) emitted by a typical commercial refrigerator. The first step in improving the acoustical performance of the refrigerator is to deal with the peaks marked *a* and *b*. The cause of these peaks can quickly be ascertained by setting the analyser to the frequency in question and then operating or exciting the various parts of the refrigerator separately. The electric motor can be removed from the refrigerator and the compressor driven by flexible shafting or otherwise; similarly the motor can be disconnected from the compressor and run on its own. It is also possible to remove the panels of the refrigerator body and see how this reduces the total sound intensity at the particular frequency. In fact, the peaks under discussion might well have been tracked down to the panels and piping. Having removed the panels, one of the peaks would, perhaps, be drastically reduced (say, peak *a*) thereby showing that this peak may be caused by the vibration of the panels. By elimination, therefore, peak *b* would be due to the piping, and this could be duly confirmed by exciting or tapping the piping in the presence of the analyser. Another method is to set the analyser to a particular frequency and then to trace lines of equal noise level round the machine under test. This equal noise-level contour will be found to lie farthest away from the point where noise at this particular frequency is generated. Though this latter method is somewhat insensitive for a small item like a refrigerator, it is an extremely powerful method for large machines such as steam turbines or Diesel engines.

A particularly useful feature of the analyser is that it enables peaks of fairly low magnitude to be detected at high frequencies. Such high-frequency noises have a nuisance value out of all proportion to their loudness. This is, of course, well known, when expressed in other terms, since quite a soft high-pitched squeak will set most peoples teeth on edge. While, therefore, it is a good general rule that the loudest noise should be tackled first, since this gives by far the greatest reduction in noise, it is sometimes advisable to give priority to the elimination of any physiologically unpleasant sound, even if it is fairly quiet. Every car owner knows how much time can be wasted in hunting for the cause of a rattle. With an analyser this task becomes very simple. The filter on the analyser is merely set to the desired frequency and the microphone moved round the equipment until the meter registers a maximum. This clearly indicates the offending portion of the equipment, which can then be suitably treated by the use of insulating material, increased or decreased stiffness, anti-vibration mountings or other suitable remedies.

VIBRATION ANALYSIS.

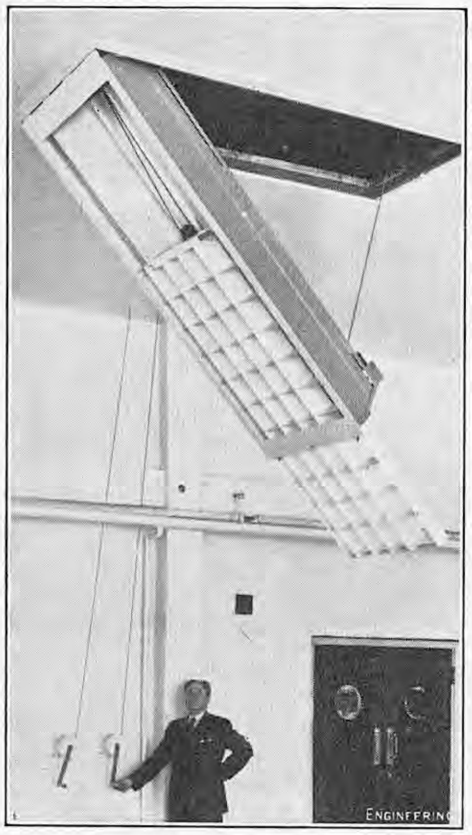
Another instrument for acoustical analysis which has highly selective properties is the vibration meter. Sound originates as a vibration in some body, and it is possible to detect this vibration by placing a piezo-electric probe in contact with the surface of the body. Fortunately, the measurement of both sound and vibration can be carried out by means of the same instrument, with a vibration probe and adaptor in place of the microphone shown in Fig. 2. Since the vibration probe is in direct contact with the part causing the disturbance, it will pick up only the vibration from this part, and will be completely unaffected by background or airborne noise. Unfortunately, measurements of vibration do not give a true indication of the noise that can be expected. This is because the vibration must be coupled into the air for sound to be transmitted, and the efficacy of this coupling entirely controls the sound volume heard. This can be seen from the fact that a vibrating violin string held between concrete blocks would scarcely be heard, whereas when assembled in a complete violin, the vibration of the strings will give a note which can be heard throughout a large hall. It is for this reason that vibration measurements are most effective when applied to roughly similar components. Vibration analysis has a further important field of its own, quite apart from sound analysis. It is employed for the testing of bearings, the balancing of rotors, and indeed anywhere where smooth mechanical motion is required. In this case, a meter designed solely for vibration is normally used, since this can measure vibration at very low frequencies (down to 2 cycles per second), which a converted sound-level meter will not do, as these frequencies are, strictly speaking, outside the acoustical range.

Acoustical analysis can be divided into four main classes: (1) the acoustical testing of articles before production is started, including the testing of the prototype; (2) the routine acoustical testing of articles from the production line (confined at present largely to domestic appliances, vehicles and electrical apparatus); (3) the reduction of noise in buildings, factories and offices; and (4) obtaining the best acoustical results in concert halls, churches and lecture theatres. The instruments described in this article are generally applicable to all four classes of analysis, the emphasis, however, being on certain instruments for certain work. The essential instrument for classes (1), (2) and (3) is the sound-level meter, and the high-speed level recorder for class (4). With these instruments much useful work can be done, though when the operator has familiarised himself with the problems involved it is then often convenient to employ additional equipment.

FUEL EFFICIENCY COURSE.—A refresher course for works and other engineers interested in the subject of fuel efficiency has been organised by the Ministry of Fuel and Power and, by kind permission of Professor W. R. Hawthorne, will be held at the University of Cambridge Engineering Laboratory, Trumpington-street, Cambridge, from Monday, September 22, to Friday, September 26. It will consist of a series of lectures on boiler plant and its operation, steam utilisation and the possibilities of self-generation of electricity and use of exhaust steam. The utilisation of electricity, gas and compressed air will also be dealt with, as will refrigeration plant, gas turbines, heating, hot-water supply and ventilation, structural and thermal insulation, boiler plant instrumentation and feed-water treatment. Accommodation will be available in Trinity College and inquiries should be made to Mr. J. Woolford, Ministry of Fuel and Power, Brooklands-avenue, Cambridge.

ACCESSIBLE MOUNTING FOR CEILING LIGHTS.

A DESIGN of recessed and louvred ceiling laylight which is likely to prove convenient in many applications of fluorescent lighting, since it is easy to maintain, has been developed by the Edison Swan Electric Company, Limited, 155, Charing Cross-road, London, W.C.2. In the case of ceilings of moderate height, replacement of the lamps and cleaning of the reflectors may be carried out by one person unaided and without the use of ladders. One of these lights, installed in a building having a 14 ft. high ceiling, is shown in the accompanying illustration, which also shows the method of lowering the light. The laylight has a fixed outer frame within which a second frame, carrying the lamps and reflectors, is hinged. This hinged frame is fitted with a louvre which slides within it and opens gradually as the frame is lowered, and is



retracted when the frame is raised. The whole operation of opening and closing the light is effected by means of a single hand-operated and self-sustaining winch, to which is attached a cable working over a system of pulleys. In its closed position, the light is secured automatically by a catch.

When the light has to be opened for cleaning, or replacement of lamps, the catch must first be released by means of a pole provided with a hook at the top. Unwinding the winch alone before releasing the catch cannot cause the light to descend and, should this be attempted and the cable slackened off, the weight of the frame on the catch prevents the subsequent release of the catch by means of the pole. When the louvred portion of the light has reached the end of its slide, the lamps and interior of the housing are readily accessible, and the louvred section may, if desired, be removed. The starting control for the lamps is mounted on the steel framework within the ceiling and consists of a series of units, each feeding one lamp. Plugs and sockets are fitted, by the aid of which any defective lamp may be quickly located and isolated prior to its replacement by another.

INCORPORATED PLANT ENGINEERS.—The date of the inaugural meeting of the new branch of the Incorporated Plant Engineers at Blackburn has been postponed to Thursday, September 11. The address of the head office of the Institution is 48, Drury-lane, Solihull, Birmingham.

BOOKS RECEIVED.

Wellington Harbour Board. Statement of Accounts with Annual Reports and Other Statistics, for the Period ended 30th September, 1951. Offices of the Board, Wellington, New Zealand.

The British Electrical and Allied Industries Research Association. Technical Report No. G/T 264. *Network Analyzer Study of Inherent Restriking Voltage Transients on the British* 132 *kV Grid.* By L. GOSLAND and J. VOSPER. [Price 10*s*.] No. L/T 255. *Excitation Temperatures of Hydrogen Arcs.* By H. EDELS and J. D. CRAGGS. [Price 12*s*.] No. P/T 105. *Commercial Pulverising Experience: Report Based on Replies to a Questionnaire.* [Price 15*s*.] No. Q/T 122. *The Design of Capacitor-Transformers.* By S. SILBERMANN. [Price 24*s*.] No. Q/T 129. *The Measurement of Copper Losses in Transformers, and Reactors: A Critical Review of Existing Methods.* By M. WATERS. [Price 12*s*.] No. W/T 24. *Electrical Soil Warming for Salad Crops in Frames.* By A. E. CANHAM. [Price 9*s*.] Offices of the Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey.

Forces in Framed Structures. By T. LYLE MORGAN. E. and F. N. Spon, Limited, 22, Henrietta-street, London, W.C.2. [Price 25*s*.]

TRADE PUBLICATIONS.

Oxidation and Wear-Resisting Alloys.—Follsain-Wycliffe Foundries, Ltd., Lutterworth, near Rugby, have sent us two brochures. The first is concerned with the Penetral process, which, it is stated, enables mild steel to resist oxidation up to 1,000 deg. C. This is basically an impregnation process in which a complex aluminium alloy is made to penetrate the surface of a steel component to a depth which may be as much as $\frac{1}{16}$ in. The other brochure concerns C.Y. abrasion-resisting alloy cast iron, which is used for colliery haulage surge-wheel pads, rollers, pump impellers, conveyor spirals and coke-chute liner plates, components of brick and tile-works, and quarry and gravel-pit machinery, cement-works plant and railway brake blocks.

Aluminium Alloys.—A reference file of 125 pages many consisting of folded sheets of tabular matter has been issued by High Duty Alloys, Ltd., Slough, Buckinghamshire. It gives details of the range of the firm's "Hiduminium" alloys, including their physical and mechanical properties, recommendations on pre-service treatments, and suggested applications. Notes on welding, brazing, soldering and machining are included, together with hints on the protection of the materials against corrosion.

Mechanical Seals.—A revised and enlarged edition of their brochure on mechanical seals, for providing a pressure-tight seal round a rotating shaft, has been issued by the Seals Division of Crane Packing, Ltd., Slough, Buckinghamshire. Four new seals are introduced, namely, the Compact, types 6 and 7, for low-pressure applications, and the Monitor, types 8 and 9, for mounting adjacent to ball or other bearings.

Cast-Iron Tunnel Segments.—An illustrated brochure dealing with the properties, dimensions and typical applications of cast-iron segments for lining tunnels, colliery shafts, etc., has been received from Head, Wrightson & Co., Ltd., Ship House, 20, Buckingham Gate, London, S.W.1.

Industrial Instruments.—The complete range of Moore "Nullmatic" instruments for the automatic control of industrial processes is now manufactured under licence in England by Sunvic Controls, Ltd., 10, Essex-street, Strand, London, W.C.2. Details of the instruments for the measurement and control of flow, temperature, liquid level, density and pressure are given briefly in Bulletin 509, available on request from the above address.

Steel Castings.—Parker Foundry (1929), Ltd., Tropenas Steel Works, Derby, have issued a brochure containing particulars of their high-permeability steel castings for electrical equipment, pearlitic manganese-steel castings for arduous service, and other special-purpose products.

Foundry Equipment and Products.—Eight leaflets and catalogues have been issued by Foundry Services, Ltd., Long Acre, Nechells, Birmingham, 7. These deal, respectively, with the Foseco spray guns for dressing sand moulds and other purposes; core jointing compounds; core and mould dressings; "Lomags" for removing magnesium from melts of aluminium alloys; products for use in the melting and casting of copper and nickel and their alloys: similar products for use in iron and steel foundries; a general list of the principal Foseco products; and, finally a list of the firm's associated companies and representatives overseas.

Pressure Cabin Controls and Equipment.—Normalair, Ltd., Yeovil, Somersetshire, have issued an illustrated technical brochure describing the operation of their aircraft pressure-cabin controls, valves, and air-conditioning systems; also the pressure-demand oxygen regulator which they make under licence from the Bendix Aviation Corporation of America.