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DOUNREAY AND HARWELL

On November 14, after a series of delays and some hard re-thinking around its design, the Dounreay fast breeder reactor was made critical. The delays were not unexpected if one recalls the high heat rating of the reactor and the inherent difficulty of removing the heat from a reactor core which has a volume smaller than a 2ft cube. Indeed, if it were run at anything like full rating, the core would probably be the most concentrated heat-and-power source devised by man. The problems of extracting the heat generated are sharply accentuated by the danger that any failure of the coolant system or any instability leading to overheating might result in melting of the core, with the formation of a dangerously critical fissile assembly. The mishap that befell a similar though smaller reactor in the U.S.A. offered a timely warning that the design of the reactor, its geometrical form and its safety arrangements required careful reappraisal. Other matters that were expected to be troublesome have proved to be abundantly so. It was known, for example, that the presence of even minute quantities of oxygen in the primary cooling circuit (sodium potassium alloy) would be unacceptable because of its affinity for, and incompatibility with, the niobium of the fuel element cans.

It can be assumed that solutions of these problems have been developed to the point where the reactor can now be started on its initial programme, which will consist of low-power operation for some months, followed, perhaps, by shut down for any modifications necessary to enable the reactor to be worked up to power in stages. It is planned to use the reactor in the first place to yield experimental information on the physics and control characteristics of the fast breeder system. The next phase of the work will be intensive development and testing of various kinds of fuel elements. It would be premature to look beyond this stage except, perhaps, to recall that the goal is to gain enough experience to design, first, a prototype and, eventually, a commercial power reactor using the principle of fuel breeding, whereby the amount of fissile material generated, during operation, in the core and in the surrounding blanket of natural uranium, will exceed the fuel consumed. That the system is feasible may be accepted. But whether it can be translated into engineering hardware that will operate with safety and economy, in competition with other power sources, is a question that only time and hard work can resolve.

It may seem a far cry from the Dounreay fast breeder reactor to the new neutron research laboratory at Harwell, but a useful link can be traced between the two. Not only were both installations started up in the same week, but the one is likely to be complementary to the other. For the neutron laboratory at Harwell, as described on page 633 of this issue, is something much more practical than a purely recondite research toy. Roughly half its working time, we are told, will be spent in providing the day-to-day nuclear data required by the designers of current and future reactor systems. This multiple-experiment neutron spectrometer—an ingenious combination of accelerator and neutron multiplier—should prove to be as keen a research tool as any of its kind (and there are not many) in the world. It is a highly complex installation and must be almost unique in its versatility, ranging from fundamental research in nuclear physics to *ad hoc* experimental work which can be carried out with great speed and accuracy. It is destined, therefore, unobtrusively to play a leading part in the development of the present and future generations of nuclear power reactors.

THE SIX AND THE SEVEN

By the time this article appears in print it is probable that the representatives of seven countries meeting in Stockholm will have reached agreement to set up a European Free Trade Area. The countries concerned are the United Kingdom, Austria, Denmark, Norway, Portugal, Sweden and Switzerland. Under that agreement the nations concerned will progressively abolish tariffs amongst themselves though maintaining their individual tariffs against the products of other nations. The first reduction of tariffs is likely to occur on July 1, 1960, and to amount to 20 per cent. Thereafter reductions will be made in steps of 10 per cent every six months or so until the process is completed. Should the existing European Economic Community created by the Rome Treaty and consisting of Germany, France, Italy, the Netherlands and Belgium and Luxembourg decide to accelerate the reduction of tariffs the F.T.A. would probably follow suit, since there appears to be substantial agreement that there would be little objection to a shorter period of adjustment and the timing has been adopted mainly with the object of keeping in step with E.E.C.

As compared with the original plan, which was still under discussion only a year ago, for a Free Trade Area around the E.E.C. and linked with it so as to create an area roughly commensurate with the Organisation for European Economic Co-operation within which there would be no tariff barriers except for agricultural products, the F.T.A. is decidedly second best. Deplorably, when it comes into being, Europe will have been divided into two economic groups instead of acting as a unity and there will remain tariff barriers impeding trade between the two groups. There is inevitably the possibility in such a situation that a trade war might develop. Fortunately, however, the F.T.A. nations are at one in stressing that their conception of the purposes of the area includes that of bringing the nations together again. Precisely and fully why the negotiations for the setting up of a free trade area around the E.E.C. failed has, we confess, never been very clear to us. Possibly amongst the reasons which led the French, in particular, to oppose the proposition was a doubt whether it is practicable to operate a free trade area in which each participating

nation maintains its own individual tariffs against the outside world. That arrangement necessitates that the origin of goods shall be defined lest goods from outside be poured into the F.T.A. through a nation whose tariff is low and thence transferred without payment of any further duty to one whose tariff is high. The advent of the F.T.A. will test the practicability of preventing such actions. It is also not beyond the bounds of possibility, we suppose, that some harmonisation of tariffs may take place with the same purpose in view. It is also encouraging to note upon the other side that certain nations within E.E.C. are anxious that there shall be no breach between that organisation and the F.T.A. Spokesmen of the Netherlands have expressed themselves strongly on the point and it is difficult to see what profit there could be for Germany, as an example, in a trade war. For it would inevitably reduce the trade, at present increasing, between that country and the U.K.

It is natural to consider what may be the effect of the coming into being of the F.T.A. Almost a quarter of the trade of this country takes place with Western Europe as a whole and about 12 per cent of it with the E.E.C. countries. Trade with the F.T.A. countries amounts to about 9 per cent of the whole. Those figures serve to put the matter into perspective. For it will be seen that the trade of the U.K. with neither E.E.C. nor F.T.A. alone is of really major importance though the trade with the two combined does amount to a significant fraction of the whole. Also it will be seen that as far as the U.K. is concerned there appears to be almost as much advantage in belonging to the F.T.A. as there would be in joining the E.E.C., were that possible. However, the advent of the E.E.C. may trigger off a bigger expansion of trade within its borders than will the advent of the F.T.A. Within F.T.A. the U.K. is by far the dominant member. It takes nearly twice as many imports from the F.T.A. area as any other F.T.A. country and it exports almost 25 per cent more to the area than its nearest competitor, Sweden. The U.K. accounts for over two-thirds of the exports and imports of the area to countries not in O.E.E.C.

We do not think the engineering industries of this country have very much to fear from competition within the F.T.A.; whereas they will enjoy substantial export advantages within that area, especially in competition with German products. But by contrast the advent of the E.E.C. may lose them markets within that Community. Papermaking and watch and clock manufacture are the only two industries which are expected to be at all seriously affected by competition within the F.T.A. For our part we think engineering firms in this country should (and for the most part already have) regarded the coming of the F.T.A. in terms of an opportunity opening up before them. But, despite the good it may bring, the F.T.A. is only a second best idea. The majority of engineering firms in this country, we believe, will continue to hope that some means will soon be found to bring the F.T.A. and the E.E.C. together again so as to create a single market covering the whole O.E.E.C. area.

CONTROL OF RADIOACTIVE WASTES

Perhaps it is not surprising that the disposal of radioactive waste (except for that produced by the United Kingdom Atomic Energy Authority) is subject only to the law governing normal waste disposal. For this, legislation, dealing with ordinary waste products, has been built up gradually over the centuries and was largely in existence before the special hazards of radioactive wastes were appreciated. Special legislation was introduced in the Atomic Energy Authority Act, 1954, to ensure *inter alia* that no ionising radiations from waste discharged by the Authority should cause " hurt to any person or any damage to any property." Under the terms of the Nuclear Installations (Licensing and Insurance Act), 1959, any discharges from nuclear power stations, private reactors and other installations covered by the Act, are subjected to the same provisions as those that govern discharges of radioactive wastes from the United Kingdom Atomic Energy Authority.

However, there are large sectors of private industry, including many users of radioactive isotopes, that remain outside the scope of this legislation; the only controls over the disposal of their radioactive wastes are those governing ordinary wastes. These conditions create a growing element of risk to public health as the use of radioactive sources becomes more widespread. Moreover, the risk, mainly genetic, is particularly insidious since remedies can usually be applied only when the harm has begun. The point was appreciated by the Radioactive Substances Advisory Committee which set up a panel to examine and report on the disposal of radioactive wastes. As a result of this panel's findings, the Government decided to revise the existing system of controls and the Radioactive Substances Bill was introduced on November 13. The report of the panel is published in a White Paper, " The Control of Radioactive Wastes " (Cmnd.884, H.M. Stationery Office, price 2s. 6d.). Its recommendation is that central control should be exercised over radioactive wastes, since the genetic hazard resulting from exposure to excessive radiation is a national rather than a local issue. Moreover, the specially qualified staffs needed to advise on radiation hazards are not likely to be available to most local bodies and would in any case be better deployed in a central organisation. In applying these principles, the new Bill proposes to make permanent the existing temporary controls, whereby any discharge of radioactive waste by the U.K. Atomic Energy Authority and other licensed nuclear installations is under the supervision of the Minister of Housing and Local Government and the Minister of Agriculture, Fisheries and Food or, in Scotland, the Secretary of State. Other users of radioactive materials will also be required to register their premises with the appropriate Minister—in England and Wales, the Minister of Housing and Local Government and, in Scotland, the Secretary of State. Disposal of any radioactive wastes will be permitted only on an authorisation from the appropriate Minister, who will have power to arrange a national disposal service to handle wastes that cannot safely be dealt with at the place of origin.

These measures call for little comment. The proposal to register premises using radioactive materials seems a necessary preliminary to the exercising of effective control and need not in itself prove irksome. For the rest, it is reassuring to learn from the White Paper that the panel considers that radioactive wastes can generally be disposed of by conventional methods, subject to suitable precautions. Flow in sewerage systems and rivers is believed to be sufficient to dilute radioactive wastes to harmless levels. It is thought that the activity of most solid waste is low enough to allow of disposal at the local authority's refuse tips. The main exceptions that would require special disposal arrangements as envisaged in the Bill are concentrated liquid wastes from chemical processing of reactor fuel elements ; spent closed sources, for example those used in radiography, thickness gauges and therapeutic irradiation ; and solid waste from luminising processes.

NUCLEAR PROPULSION—U.S. NAVY PROGRESS

In the Naval sense, Britain has been handicapped by the decision to concentrate her nuclear knowledge and resources on the building of power stations. The Royal Navy, moreover, has been completing a building programme—planned before the days of the H-bomb—of conventionally-powered submarines. It is also difficult to find money for a substantial new naval building programme, in view of the decision to supplement the V-bomber deterrent with land-based rockets and their costly underground sites. Thus, at the present time only one nuclear-powered vessel is under construction for the Royal Navy—the submarine " Dreadnought." The United States, on the other hand, has an immense programme of nuclear-powered ships under way and in recent months her naval spokesmen have released a number of details of this programme, either in evidence before Congress or to American technical journals. Including three more " Polaris " submarines recently approved by Congress—which at the same time authorised preliminary arrangements to be made for a second aircraft carrier—no fewer than forty submarines, two carriers, a cruiser and a 7900-ton ship of " destroyer-leader " type, all nuclear propelled, are now built, building or authorised for the United States Navy.

Of the forty underwater vessels, eight may be regarded as built to ascertain the most suitable type of reactor and replacement submarine. The 3200-ton " Nautilus "—the first to be laid down—was followed by the " Seawolf," a vessel of much the same size, which is now having her sodium-cooled intermediate-neutron reactor replaced by a pressurised water type. Then came the four vessels of the 2350-ton " Skate " class, nearly 1000 tons smaller than the " Nautilus " and intended as a replacement for the normal " patrol-attack " submarine with diesel electric drive. Concurrently with the " Skate " class, Congress authorised two more submarines of a special type—the 6000-ton radar-picket " Triton " to accompany Task Forces ; and the " Halibut," equipped with a hanger for launching the " Regulus " guided missile. Shortly afterwards the U.S. naval authorities made another big decision. They decided to build a submarine with an improved but not thoroughly tried-out reactor, and with a hull form like that of a whale. The new vessel—the 2800-ton " Skipjack "—was commissioned early this year and has been so successful that both her reactor and hull shape have been adopted for future submarines of all types, including the nine " Polaris " rocket-firing submarines now building or authorised. It is interesting to note in this connection that United States naval opinion seems to be coming round to the British view that the " hunter-killer " submarine of the " Skipjack " type—which is providing the prototype for the British " Dreadnought "—is adequate to carry out all the tasks normally required of a submarine—apart from the large 5600–6000-ton " Polaris " launchers for use as a deterrent. But the later vessels of the " Thresher " type—including three submarines originally intended to be equipped with the " Regulus " and since converted for anti-submarine work—though similar to the " Skipjack " are nearly 1000 tons larger.

HEALTH IN NON-FERROUS FOUNDRIES

This week, there has been published the second report of the Joint Standing Committee on Safety, Health and Welfare Conditions in Non-Ferrous Foundries. It deals solely with known and potential health hazards in non-ferrous founding and is based on an investigation of those hazards by a technical sub-committee. The report recalls that non-ferrous foundries, as exemplified by some older foundries casting yellow brass, have for long been looked upon as rather unhealthy places in which to work. In the past, attention used to be centred mainly on the considerable exposure to nascent zinc oxide fumes with their typical symptoms of ague. In more recent times, however, it has been established that ague from zinc fumes is no longer an outstanding risk in non-ferrous foundries. The medical advice tendered to the sub-committee indicates that the introduction of new alloys and new metals, together with developments in technology, has brought about an entirely new group of health risks, the extent of many of which has still to be evaluated. In addition, there is a growing weight of evidence that pneumoconiosis, which has been looked upon as of relatively minor significance in non-ferrous foundries, is more prevalent than is commonly realised. An appendix to the report comments in some detail on the hazards arising principally from dust and fumes. The committee, of course, is not unaware of the work on dust and fume suppression that continues to be done by the appropriate research bodies and by the founders themselves. It does suggest in its report, nevertheless, that medical supervision is desirable in non-ferrous foundries with a view to avoiding difficulties in the future. The committee says also that it would welcome a general medical survey of the non-ferrous foundry industry in order to establish the kind and magnitude of the health risks involved. These are useful suggestions which, we feel sure, will not be pigeon-holed by the industry.

The Engineer—100 Years Ago (NOVEMBER 18, 1859)

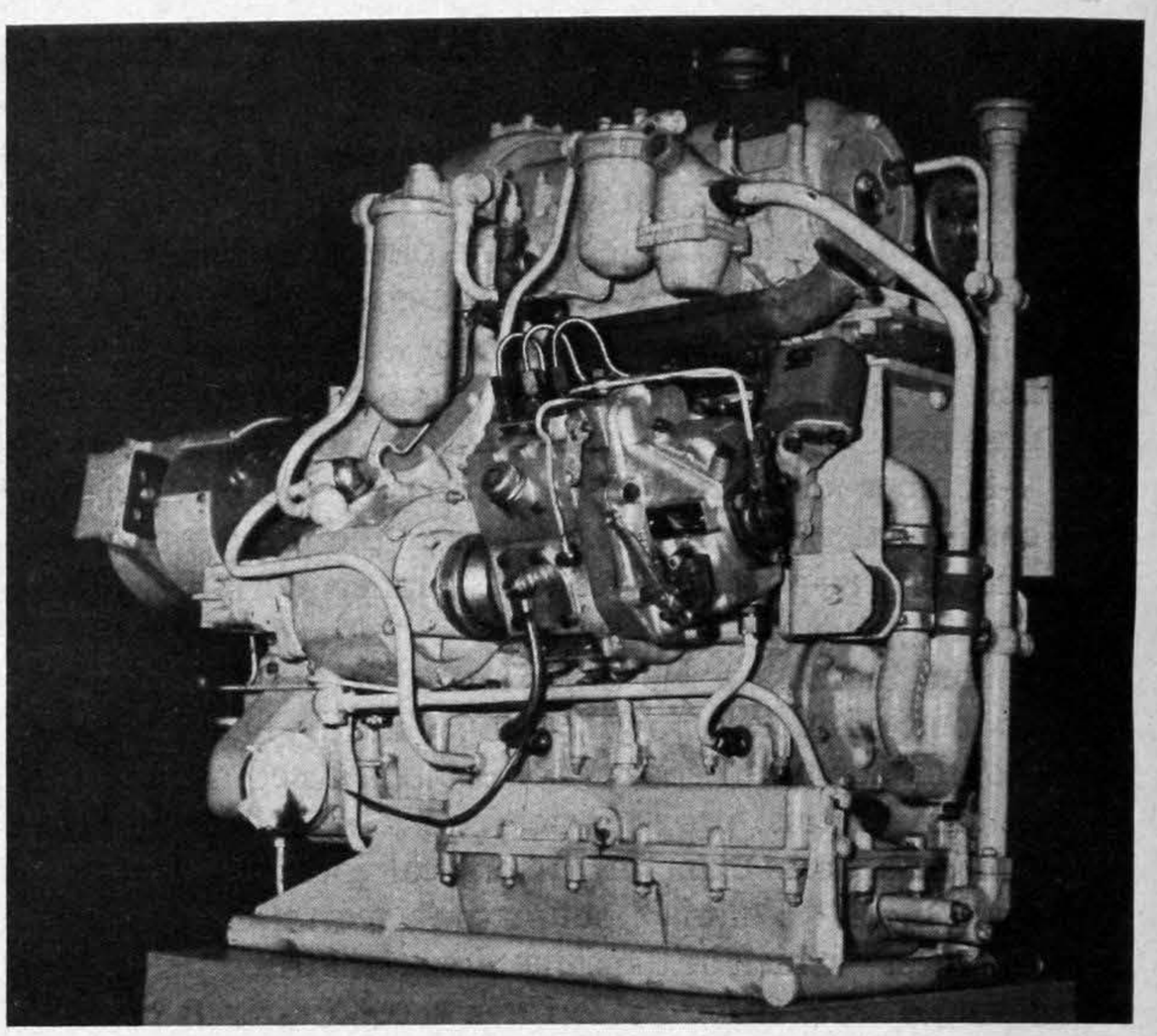
" City Railways "

" The London streets have long been threatened with an invasion of railways. We have had all manner of plans for great central stations, through which the passenger from John O'Groat's to the Land's End, or from Holyhead to the North Foreland, would pass almost unconscious of his proximity to the metropolis. We were to have a sort of grand railway exchange at Smithfield ; then it was to be in Lincoln's-inn-fields. Enterprising projectors made no more of taking a great railway line through the City of Westminster, than the London District Telegraph Company have done in carrying their wires under our sidewalks . . . .

" Propositions for intersecting London with railways are coming to be looked upon as a matter of course, and many of them are likely to be carried out in earnest. In the meantime, we are beginning to inquire whether it will not be better to give the horse-drawn traffic of London the benefit of railway communication also, or, in other words, to economise horseflesh by laying down rails, even for omnibuses, and those locomotive monsters of Pickford and Co.'s and Chaplin and Horne's. If a horse can really draw eight times as much upon a level railway as upon a turnpike—and everybody knows he can—why not provide the rails and secure the gratitude of the Society for the Prevention of Cruelty to Animals. Mr. Redman, engineer to the Commercial-road Trust, has called the attention of the Commissioners of Sewers to the advantages of a system of wheelways over ordinary paving . . . He proposes, therefore, cast-iron tramways in the principal streets of London, and estimates the cost at £7,000 or so per mile, against £6,000 in ordinary granite paving. We suppose the plan proposed by Mr. Redman is much the same as that of the tramways which have rendered such excellent service in Woolwich Arsenal for the last two or three years . . . It is well to interpret the tendencies of the present time, and to avoid incurring, some years hence, the unenviable distinction of having, in the year of grace 1860—now close at hand—opposed street railways."

Multi-Fuel Engines

The War Office now requires all wheeled and tracked vehicles to have "omnivorous" engines. For fighting vehicles, a series of opposed-piston designs of three basic cylinder sizes has been announced. Opposite is illustrated the three-cylinder engine of the smallest range, which gives 30 h.p. at 3000 r.p.m. continuously from a swept volume of 1 litre.



LAST week, the Fighting Vehicles Research and Development Establishment held a Symposium to discuss the work done at Chobham to adapt and evolve petrol-burning compression-ignition engines, and to demonstrate and display the results. The War Office now requires that any engine shall be able to run on any fuel from gas oil and aviation gas turbine gasolene to 74 octane and 80 octane petrol, the latter containing up to 3·6 ml per Imperial gallon of tetra-ethyl lead ; it is also desired that the engines should burn premium grade civilian petrol. It has been found that numbers of existing engines, particularly those that are highly rated by the fundamental standard of power per unit area of piston, will burn fuels of low cetane number satisfactorily, and one in particular, the Commer T.S.3, manufactured by Rootes Motors, Ltd., under licence from Sir W. G. Armstrong Whitworth and Co. (Engineers), Ltd., has proved so suitable that it is now available commercially in multi-fuel form. On the other hand, jerk pumps of the conventional Bosch design are liable to severe deterioration when using petrol if the camshaft is running in the fuel ; this can easily be overcome by adding a few per cent of lubricating oil to the fuel, but this solution is not acceptable to the War Office on the grounds that, under the stresses of active service, the inclusion of the lubricant might be overlooked.

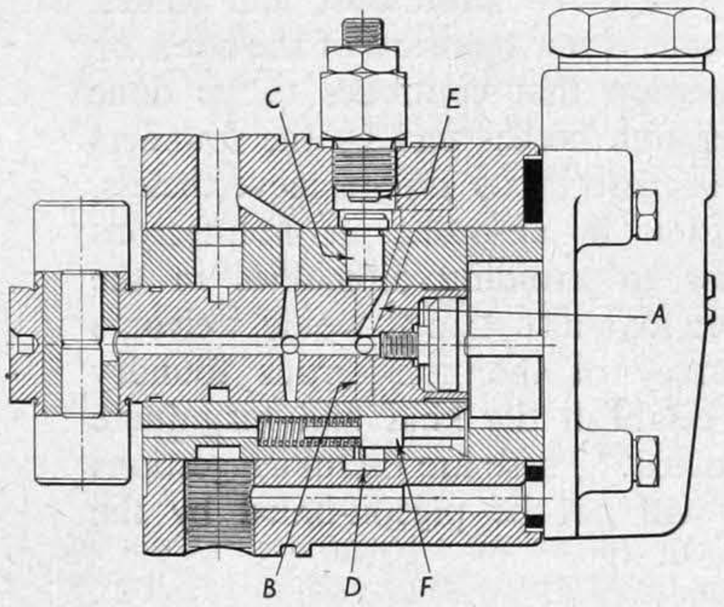


Fig. 1—Distributor pump with external fuel adjustment giving automatic excess fuel at starting

Modifications for conventional fuel injection equipment have therefore been developed, consisting essentially of a groove round the pumping element to which lubricating oil is supplied, thus both lubricating the plunger and sealing off fuel from the camshaft chamber. Fuel which does pass between the plunger and the bore at the high pressures of injection is trapped in another groove higher up and drained away.

A further problem common to all engines with positive displacement fuel systems is that of vapour locking ; vaporisation in the pump is precipitated by the spilling of fuel at high pressure from the elements. This can be circumvented by pressurising the pump and draining fuel back to the tank continuously ; pressures of the order of 20 lb per square inch may be necessary in high ambient temperatures.

A further detail of difficulty with volume-metering fuel systems is that changes in fuel density will affect the output. This effect will be masked by all-speed governors, but the maximum torque available will be reduced. The performance of the engine can be restored reasonably closely to original by moving the maximum fuel stop : simple two-position devices for this purpose have been designed for camshaft pumps. Hydraulic servo governors must be provided with a closed circuit, which for convenience is filled with lubricating oil.

The distributor pump, at least the Roosa Master/C.A.V. DPA familiar in this country, is a different proposition in these respects, since it normally runs full of fuel under pressure. Tests by C.A.V., Ltd., have shown that the pump does not suffer from running on gasolene, and since there is no spill action the normal circulation of fuel through the pump is adequate to prevent vapour lock, though additional venting points may be necessary in high temperature operation. On this pump, however, the maximum fuel stops take the form of slots in a circular plate rotating with the plungers, and hence are not adjustable when running. A modified pump is available to meet the need for continuous control of maximum delivery, and its operation can be understood from the accompanying illustration, showing a section of the pump through the delivery passage *A*. The rotor is drilled with a set of ducts *B* equal in number to the cylinders to be supplied (unless the pump is running at half speed on a two-stroke) and arranged so that during the delivery stroke the ducts are opposite the plunger *C*. This plunger runs freely in its bore, and its travel is limited by the adjustable stop *E*. The

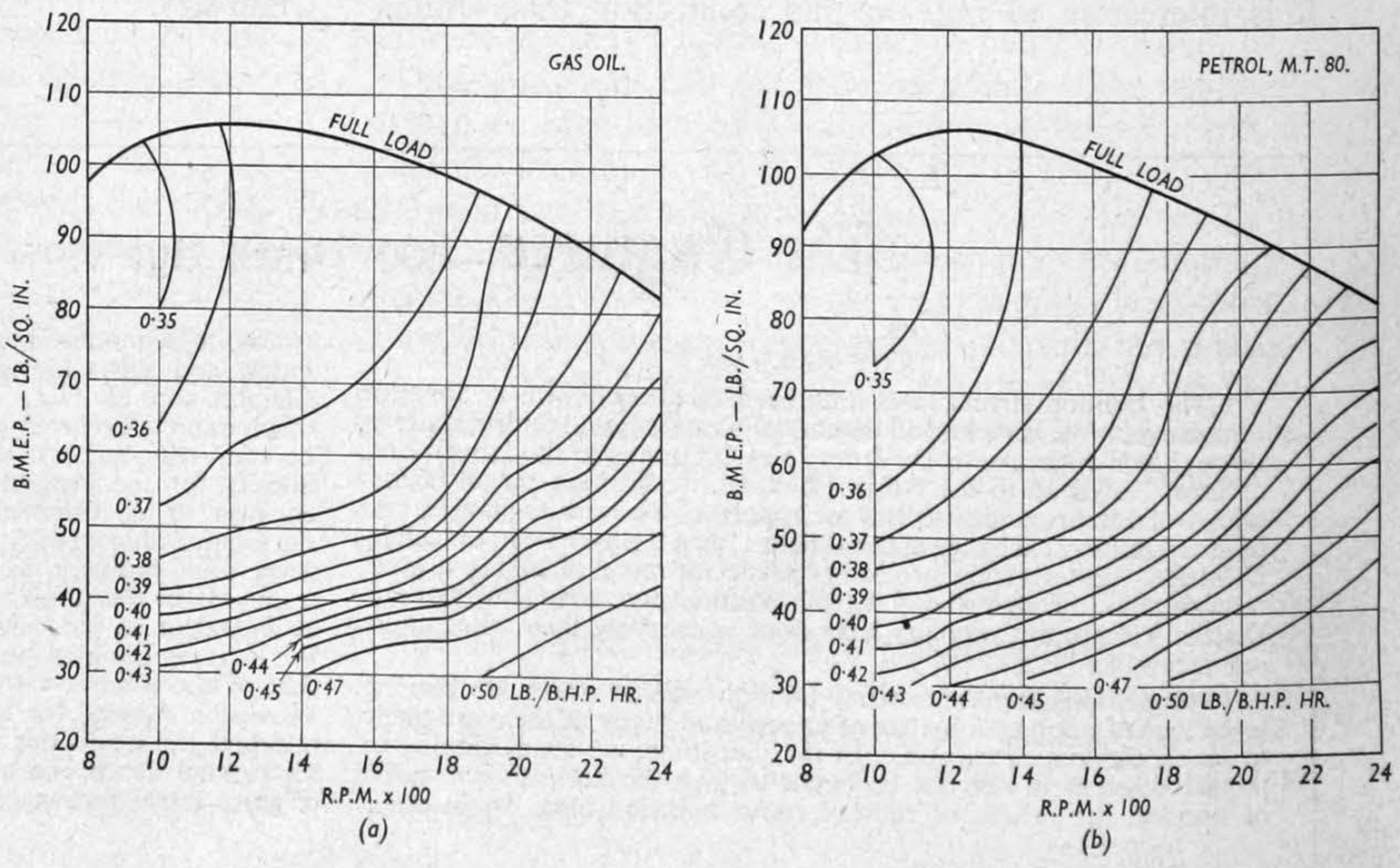
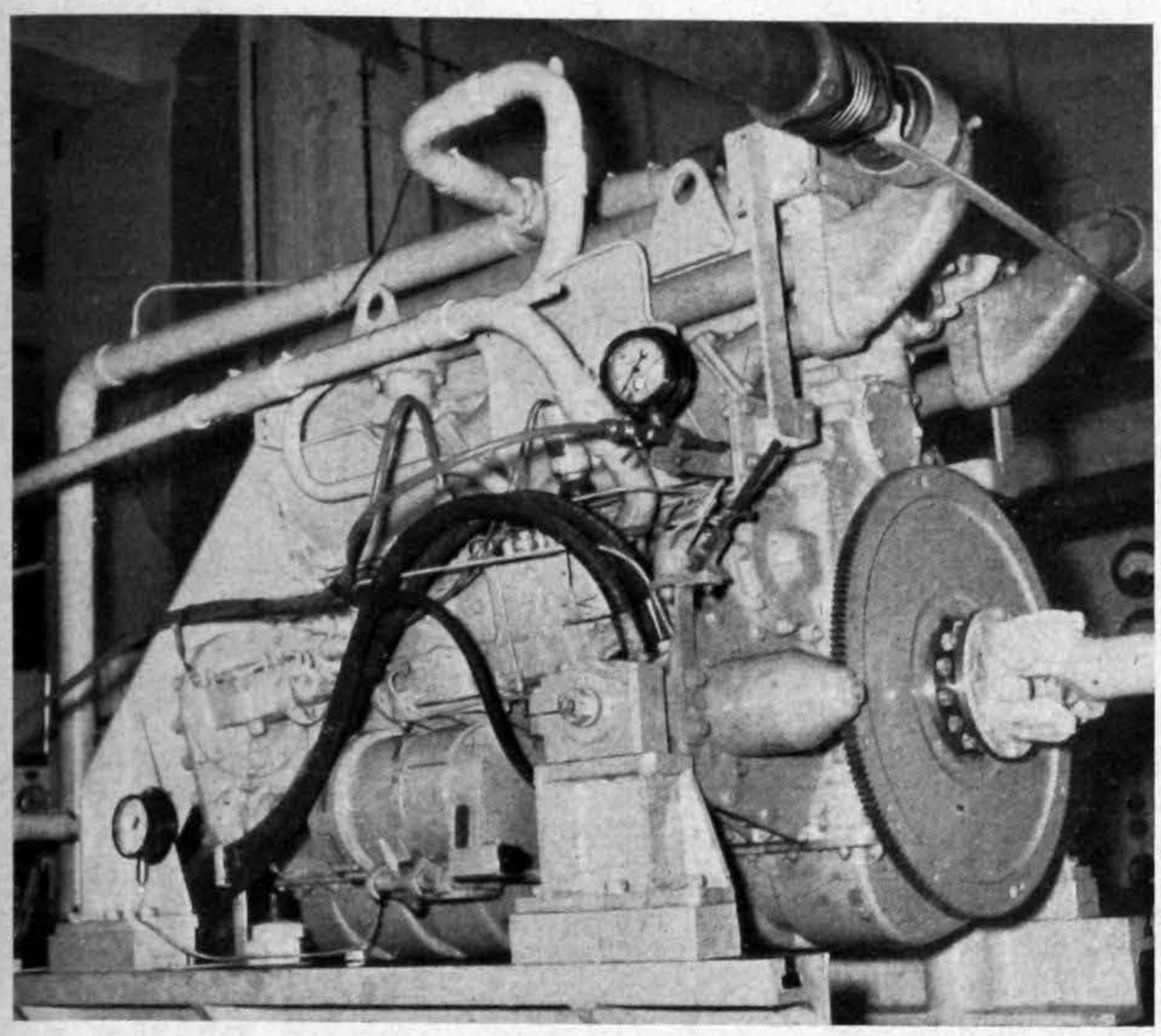
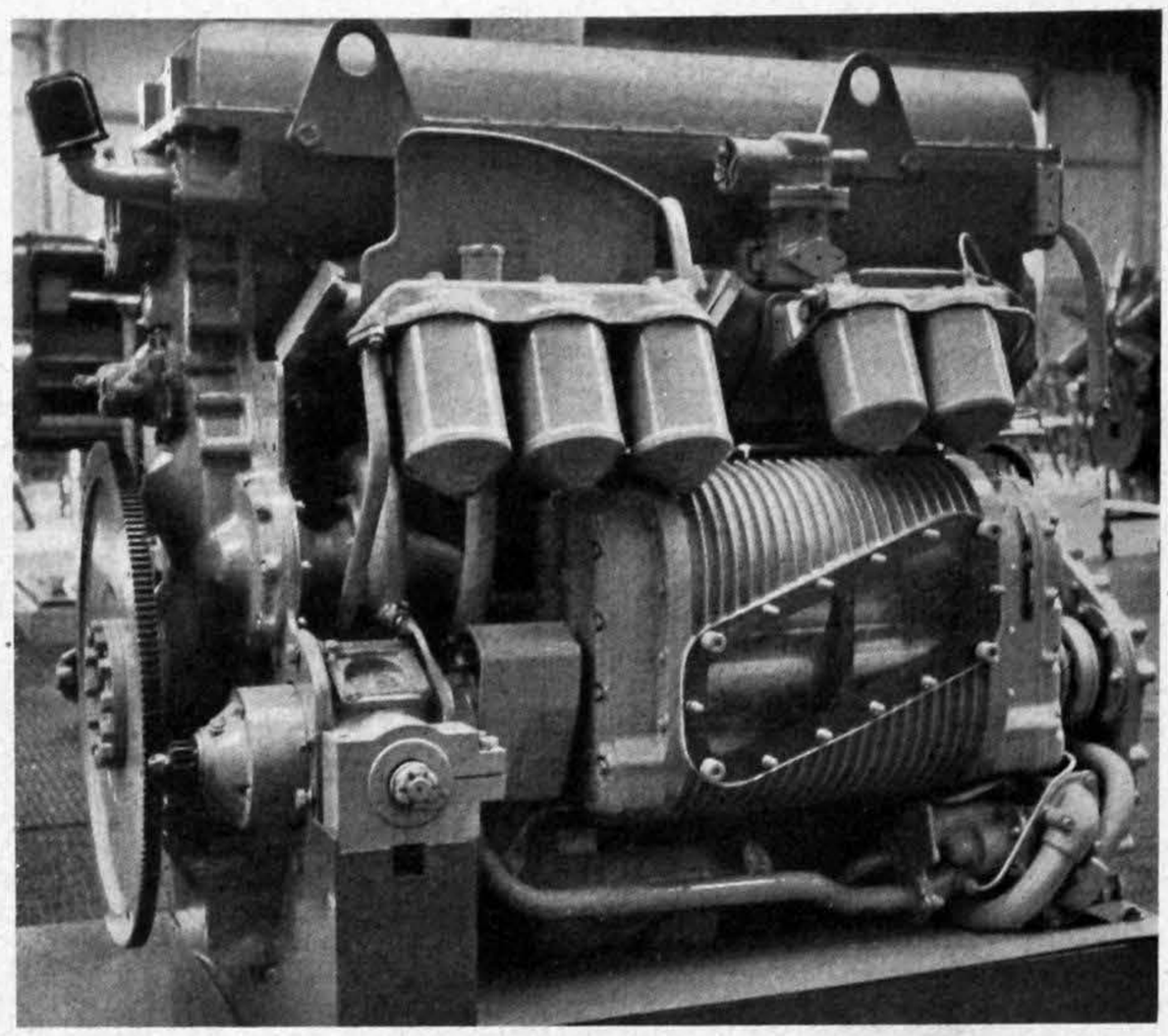


Fig. 2—Rootes diesel engine : performance on typical fuels





Figs. 3 and 4—The L-60 : on the left can be seen the hydraulic starter motor with the dynamo in front of it. On the right can be seen the three lubricant and two fuel filters, one of each of the water pumps and thermostats, and, below the blower, the oil-to-water heat exchanger and the lubricant pumps

space *D* into which the plunger rises is supplied with fuel at transfer pressure, and the fuel delivered to the underside of the plunger—and hence denied to the injector—is returned to the rotor as soon as unloading is over. Thus at the next delivery the plunger will again absorb a small quantity of fuel, which can be varied by adjusting stop *E*. The device also functions as an automatic excess fuel device for starting (independently of the provision of excess fuel by the automatic adjustment of timing) ; the fuel is admitted to annulus *D* past a spring-loaded valve *F*, and for transfer pressures less than that at idling speed this valve remains closed—the plunger therefore rises to its stop on the first delivery and remains there, so that all subsequent deliveries are of the full volume set by the plunger stroke.

The most important multi-fuel engine in Great Britain is the Rootes (-Lister) or Tilling Stevens TS-3. An account of the performance of this engine presented at the Symposium included sets of consumption contours, which are reproduced here. It was reported that the engine runs quite steadily at high speeds and light loads where, as can be seen, the consumption is deteriorating fast. These curves are the current standard ratings, but with increased rates of fuel injection short period outputs up to 117 lb per square inch brake mean effective pressure have been achieved at 2400 r.p.m. This engine is cold starting, needing no aid down to 0 deg. Fah. on gas oil, but it appears that with M.T.80 the starting performance corresponds to that with diesel fuel at a temperature 20 deg. Fah. lower. Thus M.T.80 can be used, without aids, in England, all the year, but premium petrol of 95 octane research method is more difficult still. It is reported that, while with diesel fuel and a highly detergent oil port fouling does not present any real difficulty, on petrol it just does not occur.

The successful utilisation of a wide range of fuels by this engine led to the adoption of the opposed piston design for a range of standard engines of three different cylinder sizes for fighting vehicles. The Rootes Group is developing a single-cylinder unit for the largest, " L," series, with a target of a maximum power of 116 h.p. and maximum brake mean effective pressure of 115 lb per square inch, the latter having already been attained. The performance curves of the T.S.-3 show clearly that torque and efficiency fall off together at all but the lowest speeds, suggesting that the mechanical efficiency is low or, rather, that the frictional losses are high. The new engines have abandoned the single crankshaft design with rocker beams, which in any case leads to a bulky engine ; the TS-3 was intended to fit under the seat of the Commer truck, one of the few full forward control designs, so that the width was limited by the ladder-design frame.

The first engine of the " L " series being built is the six-cylinder L-60, to give 700 h.p. at 2400 crankshaft revolutions per minute. It has been built by Leyland Motors, Ltd., who consider that the engine will prove suitable for use in wheeled vehicles, earth-moving plant, cranes, and oilfield equipment, and accordingly have provided for the following auxiliaries :

(*a*) Oil pumps : two scavenge pumps and one pressure pump built as a single unit.
(*b*) Heat exchanger : to cool lubricating oil.
(*c*) Generator : provision is made to drive a generator of any size up to 190mm diameter or 4·3kW capacity.
(*d*) Supercharger.
(*e*) Electric starting motor, developing up to 12 h.p.
(*f*) Hydraulic starting motor.
(*g*) Hydraulic pump.
(*h*) Hydraulic booster pump.
(*i*) Water pump.
(*j*) Fuel pump.
(*k*) Solenoid stop control for fuel pump.
(*l*) Electric tachometer.
(*m*) Hours counter.

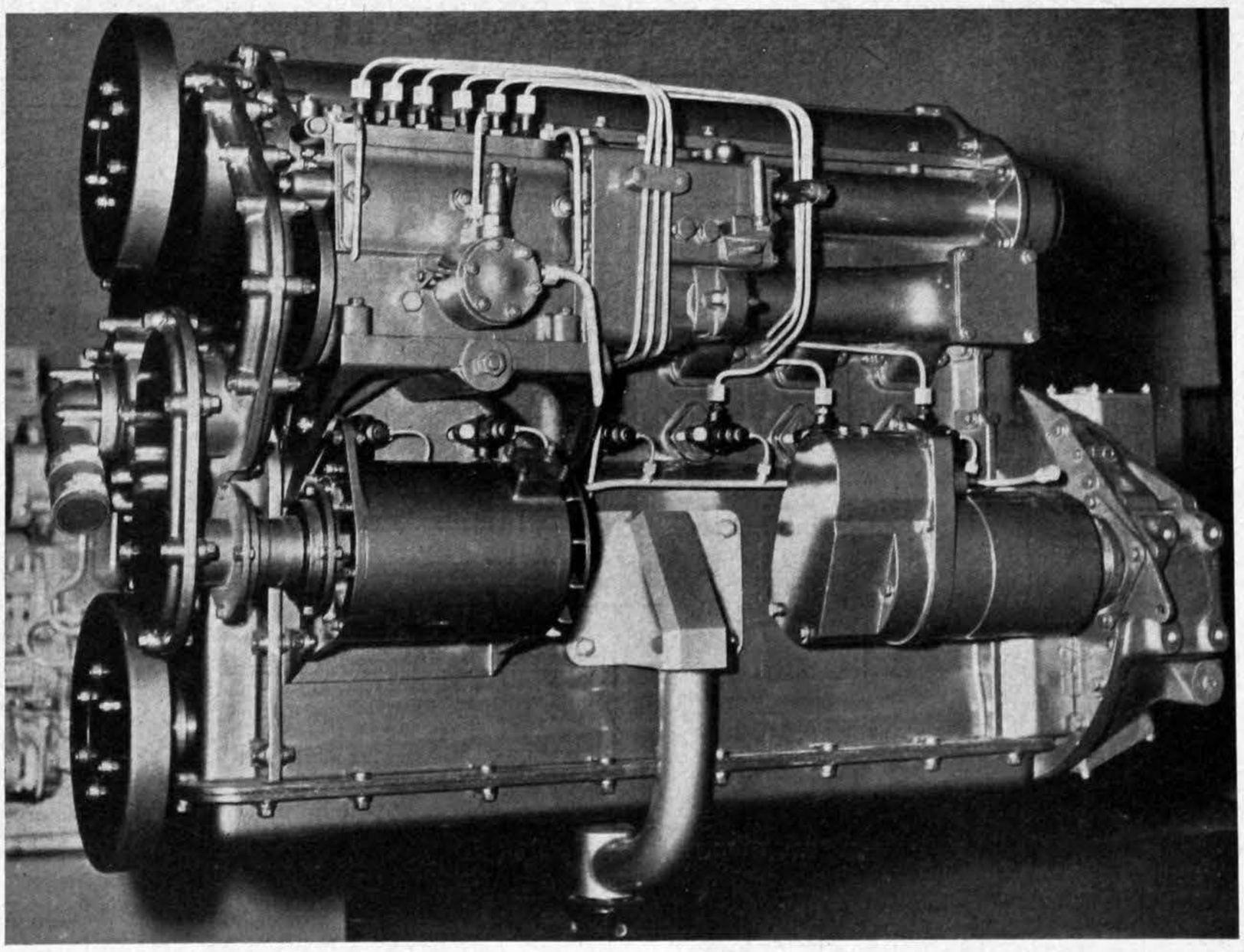


Fig. 5—A model of the K-60 : the crankshafts carry viscous dampers externally, but the wheelcase at the front end is actually driven by a torsionally flexible shaft in the tunnel above the exhaust manifold. Notice the differing lengths of the injection pipes ; numbers one and two unions are hidden by the dynamo

HIGH-SPEED TWO-STROKE COMPRESSION-IGNITION ENGINE

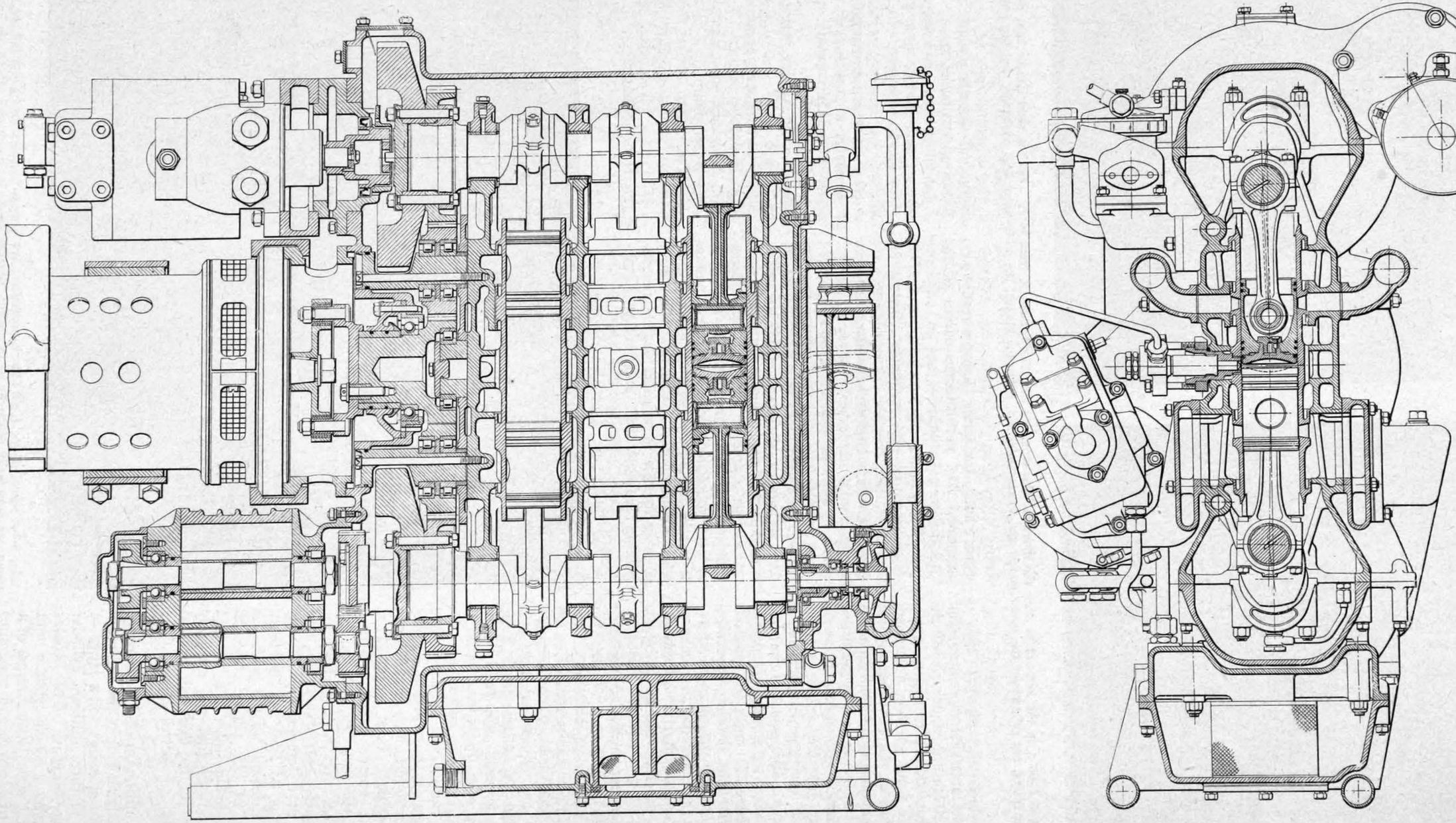


Fig. 6—Coventry Climax 1-litre engine : bore 2·166in, stroke 2·75in. by 2. Notice the size of the fuel pump

(*n*) Fuel filters.
(*o*) Lubricating oil filter.

The engine has consequently become notably complex, with gear trains at both ends. The provision for hydraulic starting is due to the requirement for cranking in very low temperatures, it being easy to arrange a variable ratio drive in a hydrostatic transmission ; it is envisaged that the source of power would be an auxiliary engine which would be installed and operated independently of the main engine.

Since in many applications the radiators will be remote from the engine, no provision is made for fan drive, since hydraulic motors can provide an easily controlled source of power for the fans. However, it is pointed out that a belt drive could be furnished by extending one of the crank or timing shafts forward through the casings.

There is a six-element fuel pump, each element being able to deliver up to 205 cubic millimetres per stroke, and the pump has a hydraulic governor. The design shows each element feeding two injectors through branching pipes, but the actual engines displayed were fitted with one injector only.

One unusual feature of this engine is that the exhaust ports do not start to close until the corresponding piston is some way from outer dead centre, and as the exhaust crank lead is small the exhaust closing is rather late, only 1½ degrees before inlet closing.

The second series of engines was intended to use the same size cylinder as the TS-3, but when the design of the " K " series was commenced by Rolls-Royce, Ltd., it became clear that a two-crankshaft engine of the same bore and stroke would be extravagantly large in the direction of the cylinder axes. The stroke/bore ratio was therefore changed from 1·25 to 1·05, the resulting reduction of 0·4in in the stroke of each piston lessening the overall size by 4⅛in ; this change also served partially to restore the low obliquity of the connecting-rods, and hence the low side forces on the pistons, of the single-shaft design. The brake mean effective pressure at the same specific consumption was slightly improved by up to 3 per cent at the ends of the speed range 1500–2500 r.p.m. It is pointed out that further development towards a " square " engine implies a reduction in port areas.* This change has led to a slight increase in swept volume, the K.60 that is in the design stages now having a capacity of 401 cubic inches compared to the 199 cubic inches of the TS-3.

The K.60 is required to take the place of the largest of the true standard engines, the B.80, and this has dictated the ratios of the main gear train. As on the carburetter engine, there is a gear case at the end remote from the flywheel ; all gears run in plain bearings, except the output which, having to accept clutch thrust, has rolling bearings, but it is nevertheless claimed that backlash in the synchronising train is minimal.

As on the rocker beam engine, the main internal loads are taken by steel studs running right through a divided crankcase, but on the " K " engines the split in the crankcase—which is cast iron, although a light alloy version might save 30 per cent in weight—is near the top (exhaust end) of the liner ; the engine must be completely dismantled to remove a liner. In the initial stages it is expected that cylinder pressures up to 1500 lb per square inch will be encountered, but the mechanical design has been based on a figure of 2000 lb per square inch ; it is indicated that this engine will be up-rated by pressure-charging and not by increasing the swept volume, in direct contrast to the B.80.

As on the TS-3, the pistons are of cast iron with a steel crown, the weight reduction offered by light alloy being unimportant in the presence of combustion loads on the majority of inner dead centres. Oil cooling, to bring down the temperature of the ring belt, can be incorporated if proved necessary, the connecting-rods being drilled.

There is also a requirement for a smaller engine to act as an auxiliary power plant in tanks. This engine will be used to start the main engine, and so must be capable of being started with the vehicle completely cold, and will be kept running whenever the tank is manned to power the wireless sets and other services. While a gas turbine provides a light and readily available engine with good cold starting characteristics, it was considered that the distinctive and carrying nature of the noise was tactically objectionable. As a result, there has been conceived a high-speed diesel engine such as has seldom been seen or projected in the past ; one of the smallest fuel injection engines, it has a continuous rating of 10 h.p. per cylinder. Sir W. G. Armstrong Whitworth and Co. (Engineers), Ltd., has in the past produced a 250 c.c. single-cylinder single-crankshaft opposed-piston engine designed to give 7½ h.p. at 3000 r.p.m., and this engine has run successfully on 80 octane gasolene. Thus, the Coventry Climax " H " series, of which the H.30 No. 4 Mark IA is at present running, is not smaller or faster running than all predecessors, but it is, nevertheless, an unusually highly rated small engine ; the quoted power is continuous, the corresponding automotive rating, which is more nearly comparable with those assigned to the " K " and " L " series, would be 38 h.p., with 40 h.p. or more attainable in the course of development. Sixty to seventy hours' running have been completed to date, mostly on MT80 ; on that fuel consumptions of 0·518 lb per horsepower hour at 3000 r.p.m. have been achieved, at 65 lb per square inch brake mean effective pressure with an only just visible exhaust at a temperature of 675 deg. Fah., and at 78 lb per square inch brake mean effective pressure, with a slightly shaded exhaust at 750 deg. Fah. This high consumption is not surprising in view of the proportionately large surface area of the combustion chamber ; it may be expected that at part load the consumption will compare favourably with that of a gas turbine or a carburetted engine.

The cold starting case is met by an unusually large electric motor, which drives the top crankshaft through a countershaft. Hand cranking is also provided, and it is found that starting is normally by one pull up.

Fig. 6 shows sectional arrangements of the engine and it will be seen that the engine housing consists of a cylinder block, a gear casing and an upper and lower casing. The cylinder block is in high grade cast iron. For production simplification, the gear casing and upper and lower casings are also produced in cast iron.

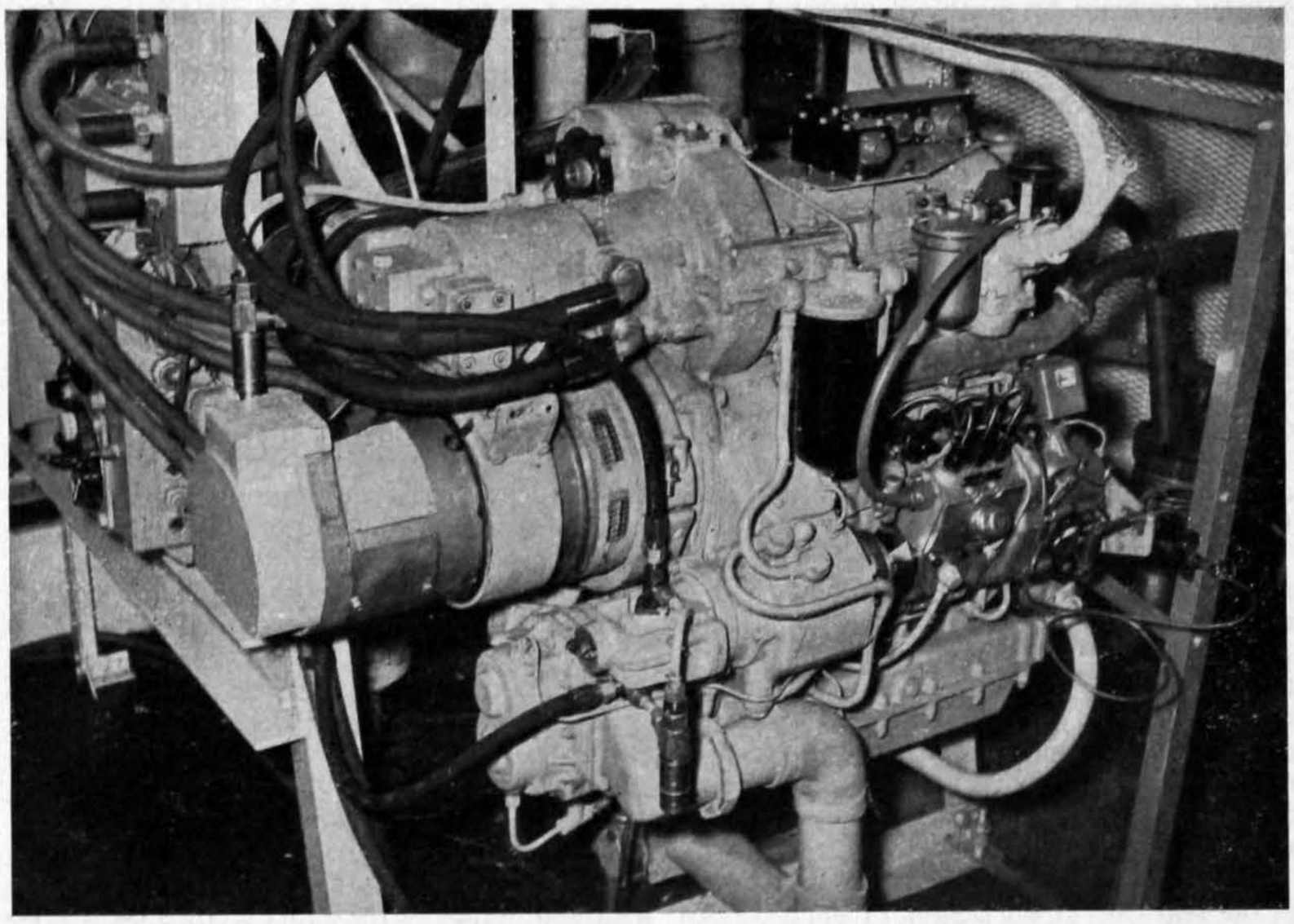


Fig. 7—H.30 complete with 4000 r.p.m. generator : beyond the hydraulic starter motor can be seen the dogs for hand cranking. On the lubricant and fuel pump drive is fitted a hydraulic boost pump

The cylinder liners in high-grade cast iron are water cooled and incorporate lips which support the liner and serve as water and gas seals. To simplify assembly, the diameters of the lip seals increase in steps of approximately 0·010in from the air to the exhaust end of the liner.

Each liner has eight machined air ports to induce tangential entry of the air charge and thus provide rotational air swirl in the cylinder.

To prevent high air pressure fluctuation in the induction system, an air chamber of ample capacity common to all cylinders is provided, partly in the cylinder block itself, and in the side enclosure casings.

The exhaust ports are rectangular-shaped, tapering towards the bore of the liner. Two of the port bars diametrically opposite mate with a centre wall in the cylinder block, thus forming two exhaust ducts per cylinder, which lead to exhaust manifolds studded to each side of the cylinder block.

The injector sleeve serves to locate the cylinder liner.

The first ring of each piston is of the composite fire-ring type. Two wedge-type

* Another limitation on the output has been perceived by Mr. H. Grylls, of Rolls-Royce, Ltd. "The fuel injection rates are obviously a major problem in high-speed two-stroke engines because the event occurs twice as frequently as in the four-stroke, for a given engine speed."—ED., THE E.

compression rings are located between the fire-ring and the gudgeon-pin. After the gudgeon-pin is the gas-sealing ring and twin-stepped oil control ring. All rings except the fire-ring are prevented from rotating.

The performance of the small 250 c.c. single-cylinder engine, to which reference has been made, can largely be attributed to the design of the piston assembly. The two-part piston with the small area of contact between crown and skirt reduces the heat losses. The fire-ring is not radially located relative to the piston and whilst protecting the compression rings from the direct heat of combustion and preventing their sticking, its freedom of movement reduces its own tendency to stick. It further ensures positive air and exhaust port timings and results in better compression, which is of extreme importance for starting.

The dished piston crowns and small bumping clearance form the complete combustion chamber.

The gudgeon-pin is fully floating and is located endwise by means of two end plates expanded into the piston.

The connecting-rod is a steel stamping of " H " section, drilled for small-end lubrication. The caps are attached to the rods by two bolts.

The gudgeon-pin bearing is steel backed with copper-lead lining. Four main bearings, steel backed, support each of the two crankshafts. The pressure or cap halves of these bearings are lined with copper lead, whilst the non-pressure or block halves are lined with white metal.

Similar bearings are also fitted to the connecting-rod big end, but in this instance the copper lead halves, which take the load, are fitted to the rod end.

The " air " and " exhaust " crankshafts are machined from nickel steel stampings and are not surface hardened. Flywheels are flange-mounted to each crankshaft and with the full load of the engine being transmitted through the gears, these must be, in the case of the twin-crankshaft opposed piston engine, of ample proportions. The loads being transmitted by each crankshaft, by virtue of their phasing, differ considerably.

The two crankshafts are geared together at the rear end of the engine through a train of five straight-toothed spur gears. The timing of the gears is such that the exhaust crankshaft leads the air crankshaft by 12 deg. The teeth of all gears are case-hardened and ground. To reduce friction at sub-zero temperatures where the viscosity of the oil changes considerably, the bearings of the gear train only are of the ball or roller type.

Aspiration takes place through a Roots blower having straight two-lobe involute form rotors, gear-driven by way of the air crankshaft. The blower runs at 1·818 engine speed and supplies air to the chest surrounding the air inlet ports. To facilitate starting at sub-zero temperatures, an ether primer is provided in the air ducting between blower and air chest. Lubrication to the bearings and rotor gears housed at the rear end of the blower is metered from the main lubrication system.

From the centrifugal pump driven from the free end of the air crankshaft, circulating water is channelled to the lower end of the block for even distribution to all cylinders. The cooling water rises through the restricted slots round the liner in the region of piston inner dead centre, thus ensuring a high velocity flow past the combustion chamber part of the liner. The water enters a common top division with outlet to the thermostat which is of the by-pass type and allows good circulation around the engine during the warm-up period.

The lubricating oil pressure pump is of the gear type and oil from the tank underslung from the lower engine casing is delivered to the engine via a felt full-flow filter. Oilway drillings of the crankpins provide, in conjunction with the grooved and drilled rod half-bearings and connecting-rod, an intermittent oil feed to the gudgeon-pin. Lubrication for the main crankshaft gear train is provided by oil jets in the side of the gear case piped from the oil junction box. Lubrication of the fuel pump and governor bearings is automatically supplied from the engine system, as is also the sealing and lubrication of the fuel pump plungers. To accommodate angles of inclination and tilt, two scavenge pumps are mounted with the pressure pump in the engine gear case.

The governor, which is supplied by the Isospeedic Company, Ltd., is of the " idling and maximum " type, arranged to give a warming-up speed of 1200 r.p.m. and an operating speed of 3000 r.p.m.

The selection of " warming-up " or " operating " is effected by a control lever; a separate lever-controlled stopping mechanism is provided.

To ensure adequate lubrication and to cater for the severe inclination and tilting to which the engine will be subjected, the most important bearing surfaces are positively lubricated from the engine system.

As was made clear at the commencement of this article, there is also a requirement for civilian production engines to burn petrol in service use, and a number of engines have been modified to comply. To compensate for the lower cetane number, it is desirable not only to increase the temperature after compression but also the air velocities in the combustion chamber. Modifications have been effected to increase the peak pressure and to direct the incoming charge towards the hot exhaust valve, by changing the shape of the head and the configuration of any mask on the inlet valve. The interesting outcome of these modifications is that often the performance with the original fuel has been improved. Both the B.M.C. 5·1 litre and the A.E.C. 11·3 litre engines showed higher peak power and improved efficiency over most of the speed range after modification to accept petrol. The Rolls-Royce C.6 engine, which would not normally be expected to be satisfactory as a substitute for a Hercules diesel in a Diamond T tractor, was given a maximum torque of 445 lb-feet at 1300 r.p.m. on M.T.74, in contrast to 400 lb-feet at 1600 r.p.m. on diesel fuel; this engine has a compression ratio of 20. The rather smaller Thornycroft KRN6 gives 550 lb-feet at 1000 r.p.m., a brake mean effective pressure of 144 lb per square inch, on petrol or diesel oil, with a compression ratio of 16. A precombustion chamber engine has also been modified, the Land-Rover unit of 2286 c.c. This has involved raising the compression ratio to 27, and the maximum torque has been reduced and crept up to 2000 r.p.m.; the engine seemed still to have a loud and penetrating noise.

Family of "L," "K," and "H" Engines

Particulars	L.60	K.40	K.50	K.60	H.30
Number of cylinders	6	4	5	6	3
Bore, in.	4·625	3·4375	3·4375	3·4375	2·166
Stroke, in.	5·75×2	3·6×2	3·6×2	3·6×2	2·75×2
Swept volume	19 litres (1159 cu. in)	4·38 litres (267·28 cu. in)	5·475 litres (334·1 cu. in)	6·57 litres (400·92 cu. in)	0·9945 litre (61 cu. in)
Crankshaft r.p.m.	2400	2400	2400	2400	3000
Output shaft, r.p.m.	2670	3750	3750	3750	3000 or 4000
Power rated	700 b.h.p.	160 b.h.p	200 b.h.p.	240 b.h.p.	30 b.h.p.
B.m.e.p., lb per square inch	98	95	95	95	65
Maximum torque, lb per foot	1600 at 1500 r.p.m.	400 at 1750 r.p.m.	500 at 1750 r.p.m.	600 at 1750 r.p.m.	63 at 1700 r.p.m.
Length, in.	50·5	31·375	36·5	41·625	30
Width, in	34·0	27	27	27	20·5
Height, in.	44·75	30	30	30	28·5
Net dry weight per lb	3100	1120	1350	1570	450

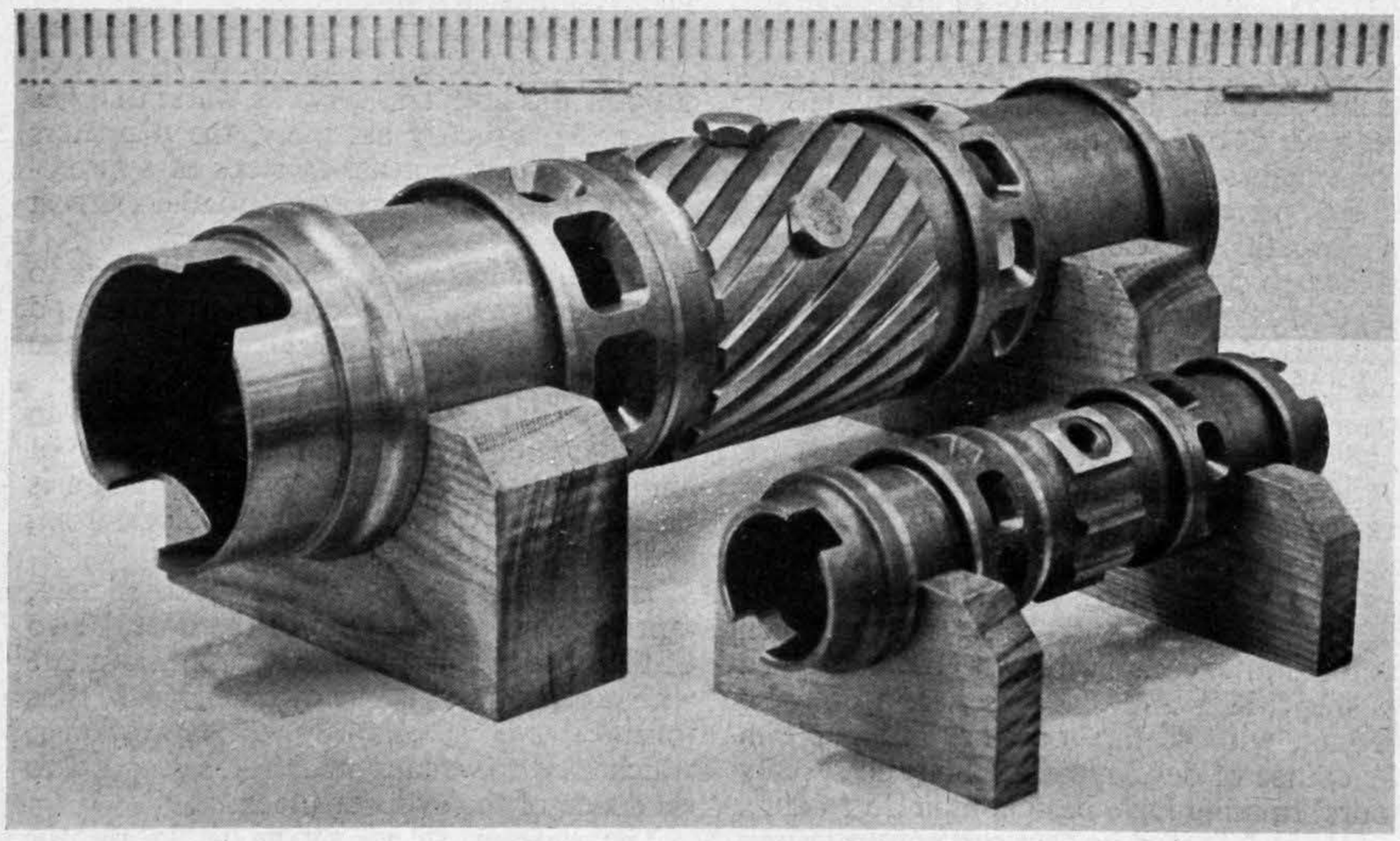


Fig. 8—The liners of "H" and "L" series engines compared. The lands opposite the combustion chamber direct the flow of water. In the smaller engine the liner is located by the injector boss

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INTERNATIONAL COMBUSTION ENGINE CONGRESS.—At a meeting held in Paris in October, it was agreed that the next International Congress on Combustion Engines will be held in Copenhagen in 1962. The theme for the Congress will be " Recent developments with diesel engines and gas turbines above 3000 h.p. per engine and with gas engines above 1500 h.p. per engine."

Harwell Neutron Project

A new laboratory housing a pulsed source for neutron physics experiments based on time-of-flight measurements is in operation at the United Kingdom Atomic Energy Research Establishment, Harwell. The equipment is a combination of a particle accelerator and a neutron booster. It consists essentially of an electron linear accelerator to generate a pulsed beam of electrons which bombard a mercury target to produce X-rays which in turn strike a uranium target to produce neutrons ; by making the neutron target in the form of a sub-critical reactor considerable multiplication of neutrons is produced. Compared with neutron choppers the Harwell installation offers the basic advantage that simultaneous experiments can be worked on several flight paths. More than half the work will be concerned with producing nuclear data for current reactor programmes. The rest will deal with the anticipated data requirements for future reactors and with pure research in nuclear physics.

A NEW laboratory known as the Neutron Project came into operation at the Atomic Energy Research Establishment at Harwell on November 5. The equipment it contains is intended to provide information about the detailed behaviour of neutrons of known velocities when they meet the materials used in the construction of reactors. Accordingly it should yield nuclear data of great value in the design of reactors both present and future. It should, for example, provide accurate information on materials used directly in reactors ; it should enable neutron spectra to be measured and predicted; and it should facilitate many detailed studies of the interaction of neutrons with nuclei and thus assist in the testing and further evaluation of nuclear theory.

Briefly the Neutron Project consists of a pulsed source for neutron physics experiments in which the energy of the neutron pulses is deduced by measuring their time of flight along a path of known length. Neutrons derived from a pulsed source as described below are allowed to travel along a number of evacuated tubes (or flight paths) which radiate from a neutron source. Some of these tubes—they range in length up to about 650ft (200m)—can be seen in the illustration, Fig. 1. The time of flight is determined electronically to an accuracy of one ten millionth of a second, by measuring the time interval between the initiation of the pulse and its arrival at the far end of the tube. The neutron speeds in which physicists are interested range from 500m per second to 5,000,000m per second.

The neutron pulses are produced by an indirect process, as follows. A pulsed beam of electrons is first generated in a linear accelerator which increases the energy of the electron pulses to about 30 MeV, the pulses (each of about 3A) being of about $\frac{1}{4}$ microsecond duration at a frequency of about 750 pulses per second. At the remote end of the accelerator these pulses are allowed to bombard a mercury target which has the dual role of producing X-rays and of removing the heat generated in stopping the beam. The X-rays are then absorbed in uranium to produce neutrons by photo-disintegration and by photo-fission. A tenfold increase in the neutron output has been obtained by making the uranium into a sub-critical ^{235}U assembly which multiplies the primary neutrons liberated on absorption of the X-rays. Care has been taken in designing this assembly to prevent the pulse being lengthened by the multiplication process as otherwise the energy resolution of the instrument would be impaired and the advantage of the extra intensity lost. Table I gives performance figures for the source.

During the pulse the fissile assembly of uranium is reacting at about 8MW power, although because of the pulsed nature of the source the mean power will never rise above $2\frac{1}{2}$kW. This means that it can be very small in size compared with a conventional 8MW reactor and it is possible for the beam tubes to "look at" its whole surface. On the other hand in the usual combination of reactor-plus-neutron chopper only a small portion of the reactor is effective as a source, with consequent loss in beam intensity.

The accelerator and the neutron-producing targets are housed in a specially designed building intended to permit many experiments to be carried out simultaneously. The targets are contained in cells with concrete walls 6ft thick, and subsidiary shielding walls a further 4ft thick have been erected outside this.

TABLE I

Number of sections in linear accelerator	6
Length per section	1m
Power input per section (peak)	6MW
Frequency	2998 Mc/s
R.F. power source	Klystron amplifiers driven by magnetron
Beam energy	25 MeV to 35 MeV according to load
Peak beam current (best achieved)	400mA
Normal running beam current	350mA
Pulse length (variable)	0·2 to 2 microseconds
Pulse repetition frequency (variable)	Up to 750 pulses per second
Rate of neutron output during pulse (calculated value for maximum beam current actually achieved, multiplication by booster not taken into account)	2×10^{16} neutrons per second
Rate of neutron output using fissile target	2×10^{17} neutrons per second
Fuel	Highly enriched uranium 235

The building and some of the neutron flight tubes can be seen in Fig. 1.

Linear Accelerator

In the travelling-wave linear accelerator the pulses of electrons are "bunched" and accelerated by a process roughly analagous to that of surf riding, the pulse power being fed into each section of the waveguide by a klystron or some equivalent. In the Harwell accelerator (which was built by Metropolitan-Vickers Electrical Company, Ltd.) it was decided to design for a beam current of 1A which would require a peak radio frequency input of at least 31MW from six klystrons.

The waveguide is in six sections, the first of which is 1·2m long and embodies a bunching section in which the initial phase velocity is $0{\cdot}4c$ to match the velocity of the injected electrons ; the phase velocity increases along the section in step with the increase in the velocity of the electrons as they are accelerated.

Each section of the waveguide (Fig. 2) is an internally corrugated structure built up of a series of cup-shaped copper discs (each spigoted to its neighbours) the whole

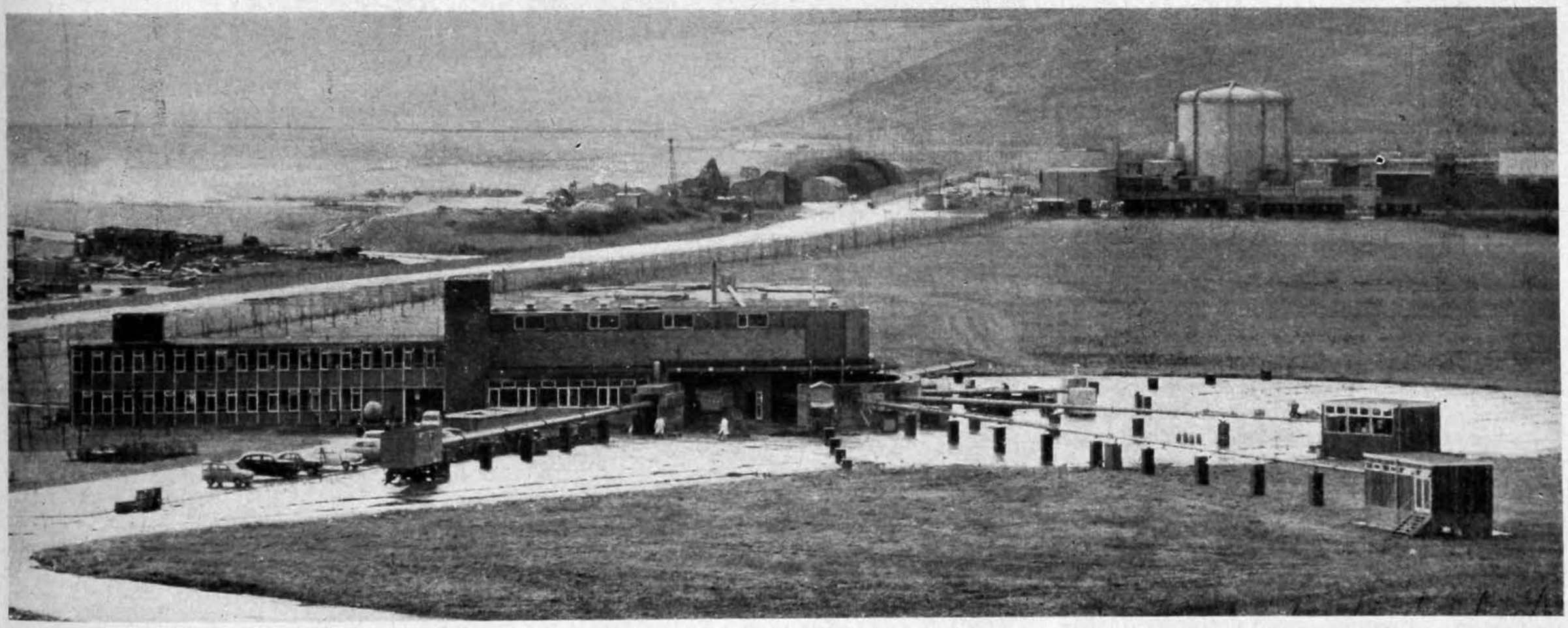


Fig. 1—The Harwell neutron laboratory contains an intense neutron source consisting of an electron linear accelerator associated with a multiplying target assembly (or booster) to produce neutrons for time-of-flight experiments. The booster is housed in the right-hand end of the building and some of the tubular flight paths radiating from it can be seen here

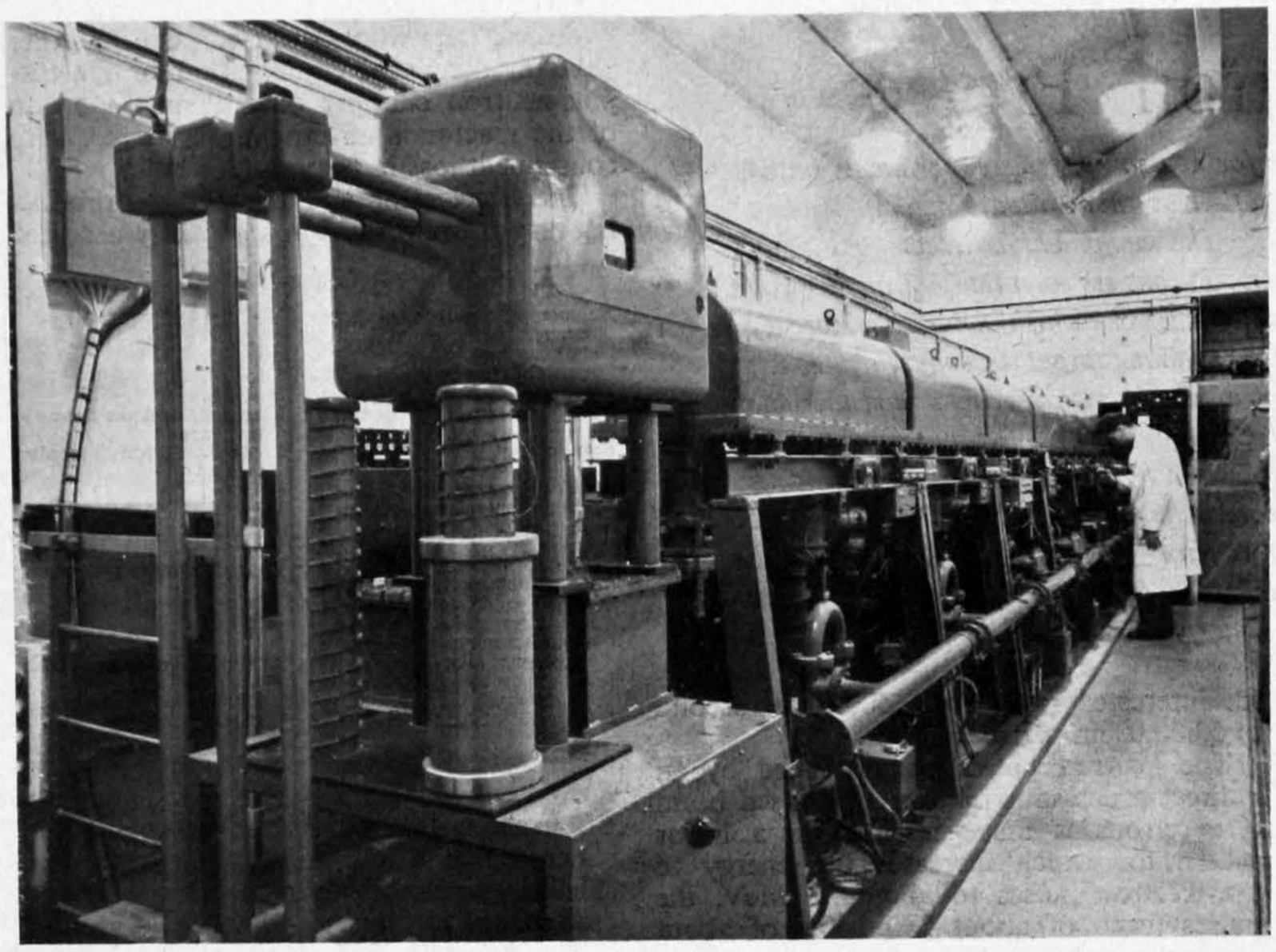


Fig. 2—An intense pulsed beam of electrons is generated in the linear electron accelerator which consists of six stages of corrugated waveguide as shown here

assembly being clamped by tie bars.* Focusing is effected by a coil of copper tubing fitted round the assembled waveguide which is mounted on a steel plate with the waveguide transformer sections whereby power is fed into and taken out of the corrugated waveguide. This steel plate and the steel cover form a vacuum chamber for each section. An oil diffusion pump with baffle and valve is suspended from the centre of each plate. To allow free passage of the electron beam the vacuum chambers are joined in series by metal bellows.

The source of the electrons is a triode gun fitted directly on the vacuum chamber of the first waveguide section. A steady p.d. of 45kV is maintained between anode and cathode, and negative grid bias ensures that no electrons are injected into the waveguide unless positive pulses of about 3kV have been superimposed ; pulses of 0·2, 0·5, 1 and 2 microseconds can be applied. To allow the fields to build up in the waveguide and to ensure that the timing and shape of the electron pulse is determined by the gun pulse the r.f. pulse is made longer than the gun pulse. Normally the r.f. pulse is 2·5 microseconds but it can be reduced to 1·25 microseconds with the shorter gun pulses, to economise in power consumption. To allow for changing of the cathode without disturbing the vacuum system the gun is fitted with a turret carrying four cathode assemblies. At the other end of the accelerator there is a quick-acting vacuum valve to reduce the ill-effects of any failure of the target assembly.

Each klystron tube is a three-cavity amplifier which is rated at 6MW peak power output at 10cm wavelength. The klystrons are driven by a magnetron through directive feeds from a common drive line, with an attenuator in each branch to set the correct drive conditions. The magnetron is designed to give pulses of 1MW peak for 3 microseconds, at 2998 Mc/s, the design frequency for the linear accelerator.

The klystrons are continuously-evacuated equipments mounted on combined transformer and vacuum pumping units in a room parallel to the accelerator room to keep short the waveguide connections to the accelerator. Although the installation was initially equipped with continuously-evacuated klystrons, the possibility of a change to sealed klystrons was envisaged. Trials are now in progress, using a sealed valve, the 6MW S-band klystron, which has been specially developed by The English Electric Company, Ltd., for use in linear accelerators. In the present installation there are seven pumping sets in the klystron room, so that a spare valve can be evacuated for replacement.

At the time when the installation was being designed there was no switch valve available to handle the 18MW of power per pulse (90A at 200kV) taken by each klystron. Spark gap modulators proved unsuccessful and the problem of designing suitable modulators was solved by using the largest hydrogen thyratrons available ; four of these B.T.H. thyratrons are connected to discharge a separate pulse-forming network through each of the four primary windings of a combining pulse transformer. Each modulator has a power supply unit which supplies a maximum of 5A at 9kV to recharge the pulse-forming networks and so allow the klystrons to be run at their full mean power rating. Grid-controlled rectifiers provide smooth control of the h.t. voltage and enable fast-acting protective systems to be used.

The linear accelerator and the associated auxiliary equipment were supplied by Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester.

Neutron Booster

There are two target rooms, with provision for fifteen neutron windows. The first of these target rooms can accommodate two targets : one target is for use with lattice spectrum measurements and contains three windows, which can be used only one at a time ; the other is a non-multiplying target and has three windows. However, the main interest lies in the second room which has nine windows and is equipped with a multiplying target for neutron cross-section work of all kinds. As already mentioned, this multiplication of neutrons is effected by building a sub-critical assembly of fissile material around the target.

This sub-critical assembly, known as a neutron booster, is illustrated in Figs. 3 to 6. The electron beam (from the linear accelerator) is led to the centre of the booster, where the X-rays produced by electron bombardment of the mercury target can excite the uranium, to produce neutrons by photo-disintegration and photo-fission. Multiplication of these primary neutrons takes place in the sub-critical ^{235}U assembly, yielding a tenfold increase in neutron output. As can be seen from the diagram of the booster, Fig. 3, *A* is the mercury electron target. The X-rays produced lie in a narrow forward cone and are absorbed mainly in the central zone of ^{235}U at *B*, where heat generation is a maximum, and the difficulties of cooling are

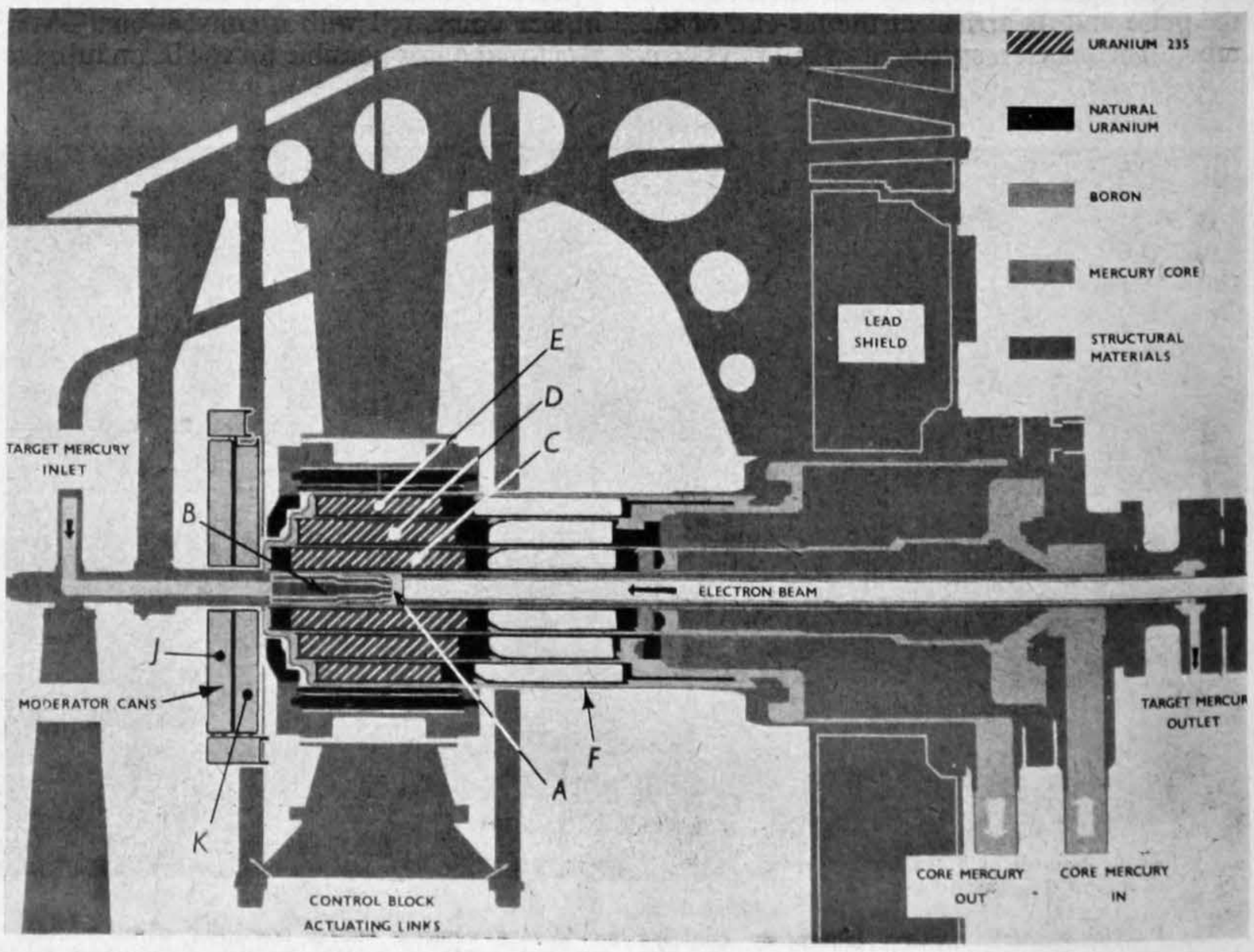
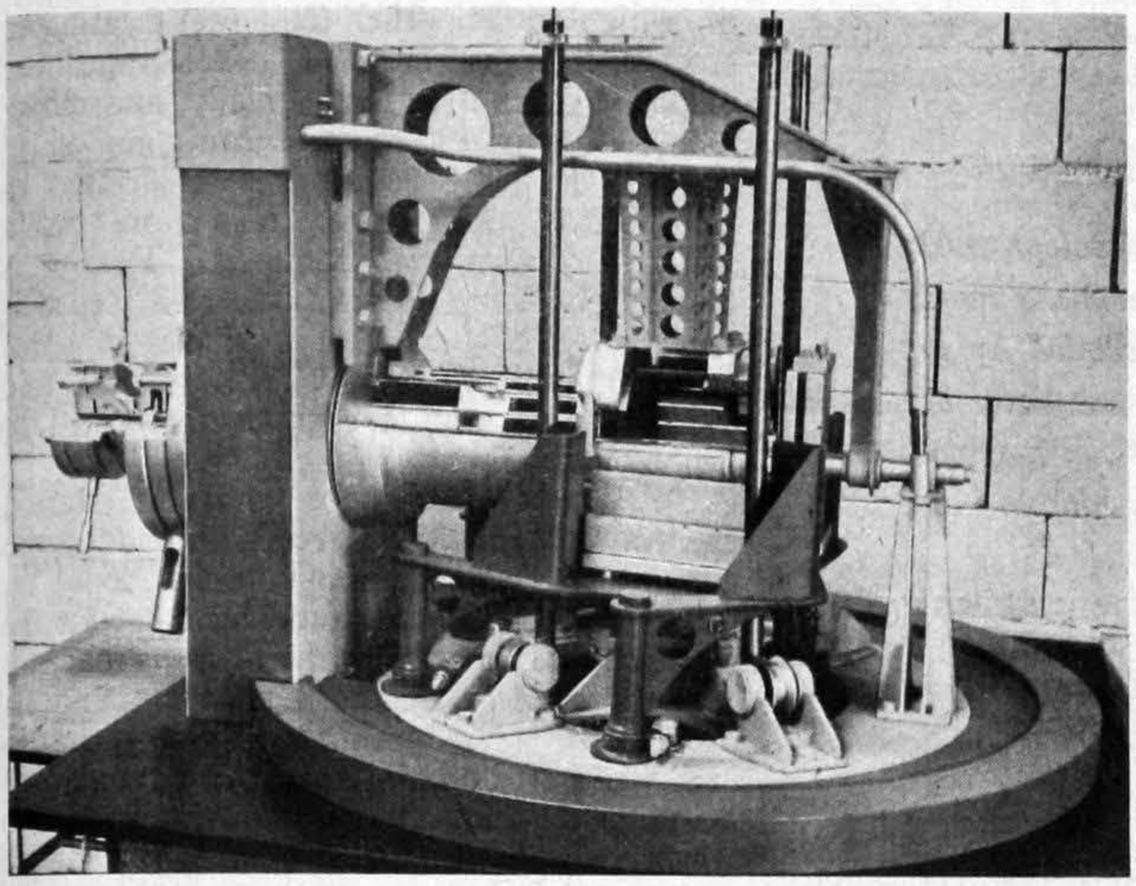


Fig. 3—Diagram of neutron booster

* "Design of a High Intensity Pulsed Source Using a Neutron Booster Target." (Page 59.) Geneva, 1958.



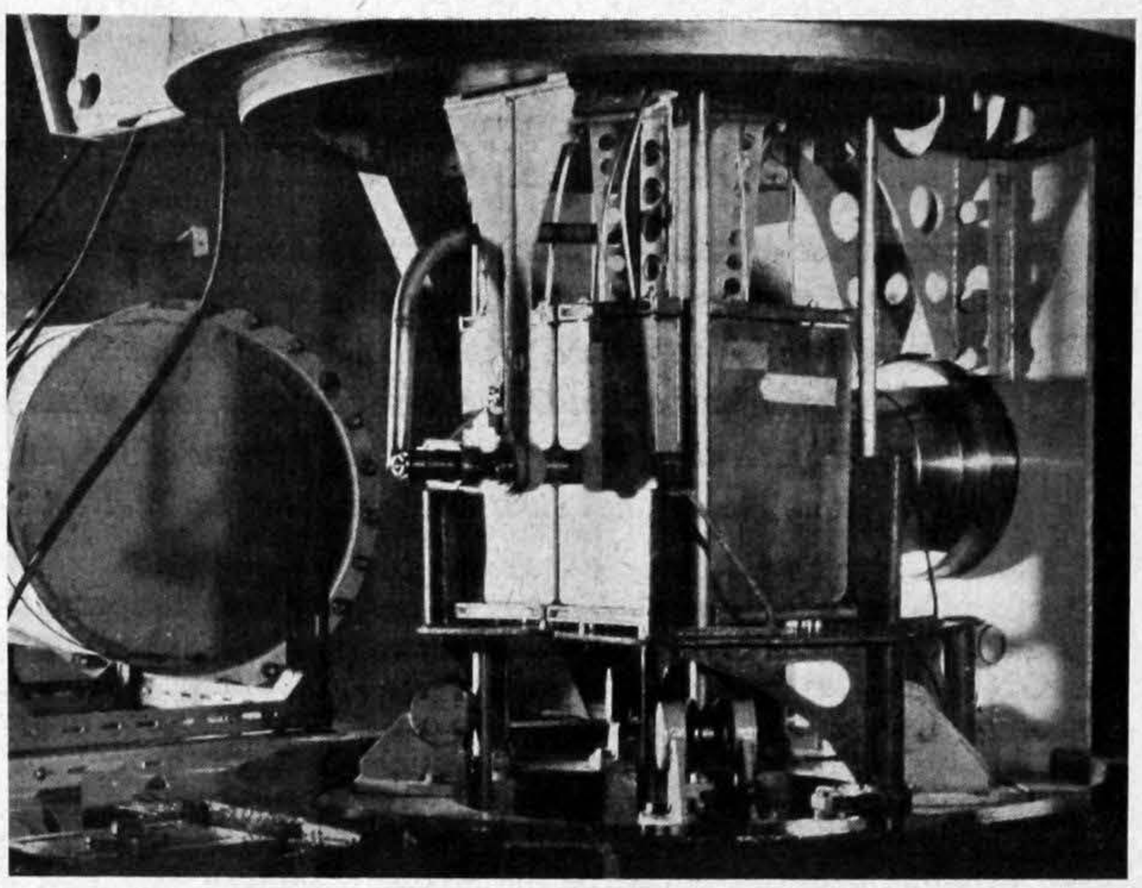


Fig. 4 (Left)—The neutron booster is essentially a sub-critical fast reactor in which pulsed neutrons derived from the linear accelerator are multiplied about tenfold. In this cut-away model the sub-critical assembly is on the right. Fig. 5 (Right)—Neutron booster with lead shield removed to show moderator cans in position

overcome by the circulation of mercury. The electron beam and mercury coolant channels are kept as small as possible to reduce neutron leakage and minimise the amount of fissile material required.

The main core of the booster is water-cooled and is housed in three cylindrical annular cans *C*, *D*, *E*, which are mounted concentrically around the target *A*. The outer cylindrical surfaces of the cans are splined to locate adjoining cans and to provide channels for the cooling water. This fissile assembly is contained in the stainless steel outer shell *F*. A thin reflector of natural uranium surrounds the core and is divided equatorially, the upper half being fixed while the lower half can be given sufficient movement to sever as a control-and-safety system. This reflector is an assembly of solid uranium end pieces which are canned in aluminium and support a ring of uranium rods arranged to form the cylindrical surface of the reflector. The end piece of the reflector nearer the accelerator is encased in the fuel cans themselves and is therefore an integral part of the core. This construction was chosen because it enabled the assembly to be built up safely, making the initial approach to criticality without depending solely on theoretical estimates of critical size.

Water is used as the moderator, in flat tanks *J* (2cm thick), on three sides of the reflector. The moderator tanks are shielded by boron shields *K* (Fig. 5) and by the biological shield which is a ribbed lead container, as shown in Fig. 6. This lead shield is roughly cylindrical, with a wall thickness of about 12cm, and weighs 12 tons. The central part of this shield is supported on screw jacks and can be lowered to expose a belt 2ft (61cm) wide around the booster. It is estimated that, with the lead shield closed, the radiation from the residual activity in the booster will be reduced to 6·5 mr per minute, which will permit a limited amount of maintenance to be done around the booster.

The main problem in the engineering design of the booster was that of providing sufficient coolant, moderator and structural materials without lowering the nuclear performance. Excessive moderator would slow down the neutrons and lengthen the pulse. Similarly, an excess of coolant would increase the requirement of ^{235}U and the larger core would accentuate transit-time effects and so degrade the pulse. Similar reasoning applied to the inclusion of canning and structural materials in the core. Accordingly, the aim was to limit the cooling and canning material in the core to 10 per cent of the total volume and to limit the water to 5 per cent. In the final design, the actual figures were slightly worse, being 3·6 per cent steel and 8 per cent water.

In the centre of the core the only practical solution was to use a moving column of mercury, both for the electron target and for the primary coolant. The mercury is pumped along an annular space around the beam

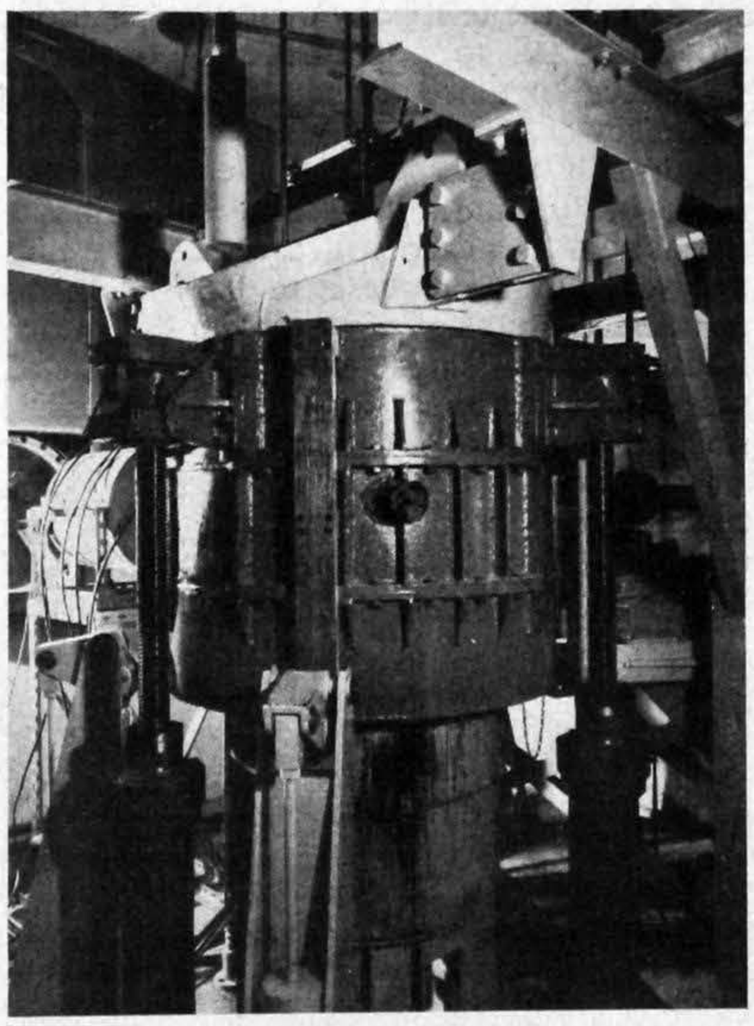


Fig. 6—Neutron booster with lead shield closed

tube, the design flow of mercury being 1·5 gallons per minute at a pressure of 90 lb per square inch, for an expected temperature rise of 30 deg. Cent. The mercury circulatory system can be removed independently from the core. Provision is made for filling the mercury system under vacuum, to avoid the possibility of air locks which would allow the electron beam to be transmitted directly to the uranium and would cause melt-out of the core centre.

The beam tube penetrates to the centre of the booster and the electron beam enters the mercury through a stainless steel "window," 0·008in thick, which has been prestressed under a pressure of 1000 lb per square inch and tested to the point of collapse of the support tube at a pressure of 5000 lb per square inch, without rupture of the "window" itself. Because of the importance of the integrity of this "window" between the vacuum and the mercury, a spark gap detector is placed close behind the "window." On failure of the main vacuum, the gap will break down and trigger a quick-acting gate valve at the accelerator, about 30ft away from the booster. This valve is designed to close within 15 milliseconds of triggering.

The main core is cooled by water pumped through the four annular channels between the uranium cans. Splines prevent thermal expansion from closing the channels, which are necessarily narrow. There is a pressure drop of 60 lb per square inch in the water circuit and the flow is 15 gallons per minute.

Both the primary coolants are circulated in stainless steel systems with heat exchangers and secondary cooling by mains water. As these circuits are regarded as potentially active loops, they are provided with radiation detectors in addition to the usual flow, pressure and temperature indicators.

High-Speed Data Processing

WORK has been begun by Ferranti, Ltd., Hollinwood, Lancs, on the first production models of a new high-speed electronic data-processing system known as "Orion." The new system is fully transistorised and incorporates "Neuron" logical elements enabling complex systems to be built around the central computer with the minimum of components. An example of these elements was illustrated in our May 29 issue in connection with the company's "Sirius" computer. In designing the "Orion" equipment, the problem of keeping a large machine working at full capacity has been met by providing facilities for sharing the time of the central computer automatically between several programmes. A fully automatic system selects programmes according to given priority levels.

The computer has a magnetic core working store with a capacity of between 1024 and 16,384 words, depending on requirements. The store is backed by a number of magnetic drum units which are treated as peripheral devices. Speed of addition and subtraction will be 36 to 68 microseconds, multiplication 60–200 microseconds and division will take 300–900 microseconds. Magnetic tape will be processed at very high speeds, enabling 4,500,000 words to be read or written by the computer per minute. Various high-speed printers can be attached, including the "Xeronic," which can produce up to 3000 lines of finished data per minute. Although smaller, it is stated that "Orion" will be up to twenty times faster than "Perseus," the largest data-processing system made in Europe.

North Foreland Radio

The early use of radio for marine communication stimulated radio development in so many directions that other services have tended to obscure the more recent history of the ship-to-shore facilities. Much of this has been recalled by the commemoration of the Post Office coast radio stations golden jubilee on November 4. In the following article we give an account of the daily work of a typical station, one of the original eight which passed into Post Office ownership in 1909.

ONE of the best-known call signs of the Post Office coastal radio stations must be GNF, North Foreland Radio. The station site, some 2 miles inland from North Foreland lighthouse and the headland which thrusts into the sea between the Straits of Dover and the Thames and Medway estuaries, explains why this is one of the busiest of the eleven stations which handle medium-range (medium-frequency) communication with ships.

This is the golden jubilee year of the coastal station service. Beginning when radio was an unknown quantity to most, except those professionally engaged in it, the stations passed through a phase in the early days of broadcasting when a wider public became aware of them as intrusive voices which sometimes interfered with B.B.C. programmes and refused to be exorcised by the normal tuning processes of that day. This was the period of the spark transmitters, but even then irritation was tempered by a general appreciation of their essential work for the safety of shipping around our coasts. Since that time their activities have reflected the growing importance of communications in commerce and social life. They now handle more than 100,000 telephone calls annually between ships and subscribers on shore, and this side of their business is expanding so fast that at North Foreland and its nearest neighbour, Niton, in the Isle of Wight, v.h.f. channels also are in use for a growing amount of telephony traffic.

In a commemorative ceremony held at the Baltic Exchange, London, on November 4, the Postmaster-General, Mr. Reginald Bevins, recalled that, in addition to marking the golden jubilee of the stations under Post Office ownership, the present year was also the silver jubilee of the radio telephone service which they now provided.

We visited North Foreland Radio recently in order to see the medium-range coastal radio service in operation, and the following description applies particularly to that station, but is representative of the facilities as a whole. Surprisingly, the station is out of sight of the sea—a single-storey red brick building lying back from a country road behind grass and flower beds and entered through a highly domestic front door. From outside, two aerial masts suggest its function (although quite unobtrusively). The superintendent's office looks out over fields and woods, but a fine display of ship photographs links the place with the sea and to those who work there no doubt recalls many occasions when the GNF aerials have been alive with urgent business for the vessels portrayed.

North Foreland is equipped for medium-frequency radio telegraphy and for both medium-frequency and very high frequency radio telephony. Radio telegrams from ships are taken down in the operating room and passed to the adjacent teleprinter room, from which connection can be made by direct dialling to all points on the Post Office T.A.S. (teleprinter automatic switching) network. The teleprinter room also receives incoming telegrams for ships which have been handed in at, or telephoned to, Post Offices throughout the United Kingdom.

Both telephony services provide for direct link connections between ships and subscribers on the G.P.O. telephone system anywhere in the United Kingdom. The station is equipped with two telephone line termination bays for connecting two-wire telephone circuits with pairs of two-wire circuits to the radio transmitters and receivers, and a VODCA (voice-operated device constant amplifier) unit which fulfils the same purpose and automatically maintains a constant level of speech input to the transmitter.

In order to provide these public communication and other facilities, operators at North Foreland keep a twenty-four hour watch on the international calling and distress frequencies—500 kc/s for telegraphy and 282 kc/s for telephony calls—and loudspeakers at the telephony operating positions are connected to a permanently operating v.h.f. receiver tuned to the safety and calling frequency of 156·8 Mc/s. The v.h.f. receiver is normally muted to eliminate background noise, but the muting is removed automatically as soon as a carrier is received. The calls received may be requests to pass telegrams or to establish telephone connections, routine information on ships' movements which all vessels are required to give to the coast stations in whose area they are sailing, or emergency and distress messages. When contact has been established, ships are instructed to change from the calling and distress frequency to a working frequency on which traffic, other than that relating to emergencies, is handled. Telegrams are disposed of as described already, and movement information from ocean-going ships (known as TR messages) is teleprinted to the G.P.O. long-range ship-shore radio station at Burnham, Somerset. Here it is filed in the Ships Bureau, where a record is maintained of the latest positions of some 6000 British and many Commonwealth and foreign ships, and a copy is forwarded to Lloyd's in London.

Contact with ships for which the station has traffic is made by regular broadcasts in telegraphy and telephony. Ships reply on hearing their call sign and listen out on the working frequency until their turn is reached. The station also makes regular w/t and r/t broadcasts of navigation and gale warnings and weather bulletins, and in r/t only, of warnings relating to the Decca navigation system should there be any interruption or disturbance of normal service from the Decca chain stations.

Radio telephony traffic is increasing rapidly, 2 Mc/s equipment being now carried by many of the larger ships as well as in the small coasting and fishing vessels without w/t operators. Its advantage in providing direct link calls to shore telephones are obvious for business and social messages, and of even greater value in connection with the Medical Advice Service in that masters of ships may be connected direct by telephone with the medical authority. The Medical Advice Service was launched by the Post Office in 1926 as a free radio-telegram service for ships requiring assistance of this kind, and is now available both on w/t and r/t. All coastal station operators have a knowledge of French and German for assisting foreign ships.

Operating consoles at North Foreland are equipped with goniometers for taking bearings on ships' transmissions. A d/f service is continuously available on w/t on 410 kc/s and the same facilities are used on r/t and in emergency and distress working. The original Bellini-Tosi aerials are now being replaced by an Adcock system about half a mile from the station site. All other receiving aerials are $1\frac{1}{4}$ miles away near North Foreland lighthouse, and are connected with the station by coaxial cables.

Emergency and distress messages call for



Station building and m/f aerial masts

a high degree of co-ordination between all members of the station staff. As soon as a call has been received the essential information has to be embodied in messages sent by landline from the teleprinter room to four different destinations and the station re-broadcasts the message so that the largest possible number of ships may hear it. Automatic cam-operated keying equipment is installed for sending the w/t alarm signal of four-second dashes at one-second intervals for one minute which precedes the transmission of details and triggers the automatic alarm equipments in ships. This signal is also sent by the ship in distress in so far as circumstances permit, but the re-broadcast from the coast station increases the range and effectiveness of the warning. Automatic equipment is also provided for re-broadcasting the r/t two-tone alarm signal. At coast stations and in the larger ships this signal is generated electronically, but in small vessels a whistle with a plunger for selecting the two tones alternately is sounded close to the microphone. North Foreland is equipped with a " Redifon " w/t distress receiver and a Plessey r/t distress receiver for sounding alarms in the operating room when emergency signals are received, for although the station is permanently on watch an operator might be temporarily handling traffic on a working frequency. While distress working is in progress, supplementary call and answer frequencies (512 kc/s for telegraphy and 2381 kc/s for telephony) are brought into use so that other traffic can still be handled by other operators. At the time of our visit we were informed that up to September 2 in the current year, 139 emergency calls had been dealt with. The area covered for distress and emergency traffic extends from Happisburgh in Norfolk to a line drawn southwards from Beachy Head. The Goodwin Sands are on the station's " doorstep."



Operating consoles with w/t, r/t and d/f facilities

Because of its geographical position, North Foreland does not operate on the full power of which its transmitters are capable in order to avoid interference with other stations on both sides of the Channel. The average maximum ranges at which ships can be worked are 150 miles on m.f. telephony, 40 miles on v.h.f. telephony, and 300 miles by day and 500 miles by night on m.f. telegraphy. North Foreland is one of four stations shortly to be equipped for ship-shore radio telephone calls up to longer ranges.

The m.f. telegraphy and m.f. telephony services at this station are provided by two Post Office " W5 " transmitters each with eight crystal-controlled frequencies selected by push-buttons from the operating consoles. Three frequencies on each transmitter are in the m.f. w/t range and five in the m.f. telephony band of 1·6 Mc/s to 3 Mc/s. The 5W crystal oscillator stage is coupled to an intermediate pentode amplifier which in turn drives a power amplifier stage consisting of two pentodes in parallel. Modulation is taken either from a local microphone, a telephone line, or from an 800 c/s oscillator for telegraphy. Keying is effected in the amplifier stages of the crystal oscillator unit. The modulation amplifier output is applied to the suppressor grids of the transmitter final output valves. There are two r/t positions in the operating room, both of which may be in use simultaneously for working traffic or making broadcasts. The moving coil microphones have directional properties, and a limiting circuit in the modulation pre-amplifier assists in suppressing extraneous noise.

In the special circumstances at North Foreland mentioned already, the transmitters operate at 500W on w/t and 465W on r/t. For w/t transmission they are directly coupled to a Marconi inverted " L " three-wire aerial carried on two 180ft lattice masts. One of the masts also serves as a radiator for r/t transmission on m.f., and a second radiator for this service is provided by a three-section cage monopole aerial with a height of 165ft. Both m.f. mast radiators are connected to the transmitters by 75-ohm coaxial lines. A third r/t transmitter is also available in the station as a standby.

The v.h.f. installation consists at present of two Marconi HX86 transmitters, one of 40W–50W and the other of 25W aerial output power ; and two HR86 receivers. This equipment has all been modified for its particular application at North Foreland and is contained, with its power supplies, in a single cubicle installed alongside rack equipment for telephone line connections. The v.h.f. transmitting and receiving aerials are mounted on one of the m.f. masts.

The four operating consoles in the operating room are each fitted with a Marconi " Mercury " receiver, a goniometer for d/f work and a switch and push-button panel for transmitter and frequency selection. At the r/t positions indicator lamps are fitted for monitoring v.h.f. link calls. When a ship calls on v.h.f., a lamp is illuminated if the signal strength is such that extension to a telephone line will be satisfactory. In the absence of this indication, messages may be relayed by the operator. If the " circuit extend " lamp lights, a link call may be established and while in progress a " line on " lamp will be alight. When it is concluded the " line on " lamp is extinguished and a " line clear " lamp lights up. Should the ship move out of range during the call, a " radio fail " lamp comes on and the operator can then intervene to assist as necessary. Otherwise, the monitoring is completely automatic. Calls on the m.f. band are monitored by the operators. Each r/t position has a telephone line and dial with facilities for speaking to line and holding the line while a link call is being established. Ships on m.f. may be worked simplex or duplex according to their installations.

A workshop and generator room at one end of the station building houses a Lister diesel alternator set capable of carrying the full load of the station in event of a mains failure. The set is rated at 26·3kVA, three-phase, 230V/400V. It is started electrically by operating a push-button.

The twelve operators on the North Foreland staff are responsible for all normal radio maintenance, except work on aerials and masts requiring special equipment, for which Post Office engineers are available. For this brief survey of their work we are indebted to facilities provided by the G.P.O. Press and Broadcast Division and to the interest and co-operation of the station superintendent.

Obituary

SIR FREDERICK WEST, G.B.E.

WE record with regret the death of Sir Frederick Joseph West, which occurred at Wilmslow, Cheshire, last Saturday, November 14. Sir Frederick, who was born at Maidstone in 1872, was the second son of John West, the founder of the West's Gas Improvement Company. Throughout his life he was closely associated with the gas industry, and he succeeded his father as chairman of the company which, with passing years, has developed into an organisation known throughout the world.

For many years Sir Frederick was a prominent figure in the gas industry, and in addition to other offices he served as president of the Institution of Gas Engineers in 1941–42 and president of the Society of British Gas Industries in 1947–49. He was also a member of the Institution of Civil Engineers, and a member of the Institution of Mechanical Engineers.

As well as being a highly successful engineer and industrialist, Sir Frederick was a humanist and his firm was one of the first to introduce a works committee for liaison between the management and employees. He became a founder-member of the Manchester Engineering Council, a body open to all in industry, which provided opportunity for management and workers to meet and discuss freely problems of mutual interest. He took a keen interest in technical education and became chairman of the Manchester College of Technology in 1921. In that capacity Sir Frederick was largely responsible for instituting the developments which resulted in the college becoming one of the leading technological training establishments in this country. As a result of his services in this connection Manchester University conferred upon him the honorary degree of Doctor of Laws.

Sir Frederick was also closely concerned with civic life in Manchester, and became a member of the city council in 1905, eventually attaining the office of Lord Mayor in 1924. As a result of his services he was appointed a C.B.E. in 1920, created a K.B.E. in 1943, and advanced to G.B.E. in 1947.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

EARNINGS OF ENGINEERS

SIR,—In your issue of November 6, you publish a letter from Mr. E. M. Ackery, giving figures for the relative earnings of engineers in Great Britain and U.S.A. These figures are in themselves suspicious but, even accepting them, the conclusion he draws is not only not "fair," but downright misleading. He gives figures to show that Americans earn roughly in the rates of 10 dollars to £1 earned by a British engineer in a similar position on the salary ladder. All this proves, therefore, is that for an engineer in a corresponding position on the salary ladder, 10 dollars is needed to give the American the standard of living he expects, where £1 gives the Englishman the standard of living he is used to. This is certainly not the same thing as saying that 10 dollars gives an American a similar financial position to that given to the Englishman by £1. Especially it does not at all carry the implication that British pay is worth more than three times as much as its face value on the official rate of exchange. Mr. Ackery's statement does imply this.

A large proportion of the population suspects statistics: they say "figures can be made to mean anything." This is an attitude that engineers cannot afford to subscribe to; figures for them are a very real thing and must have a precise meaning. I am, therefore, surprised to see such a letter in your magazine—one which certainly gives ammunition to the "statistics—phooey!" brigade.

A. DAVY
S. MANDELZWEIG

London, S.W.11,
November 10, 1959.

IMPERISHABLE TRAM

SIR,—Your delightful leading article "The Imperishable Tram" admirably captures the feeling of nostalgia that the tram so often evokes. I cannot help wondering, however, whether the principle of the tram is necessarily out of date, and whether its revival in a modern form may not be to the advantage of urban development.

Numerous examples can be found of tramways being adapted to present-day conditions. In Brussels, tram subways and reservations have been incorporated in the new road system, while in Boston, U.S.A., trams have recently been extended over a moribund suburban railway. Even in Britain, Blackpool is introducing trailer trams on the busy coastal tramway, and Birmingham has been studying a "rapid transit" scheme that is basically a revival of trams on certain routes.

This form of modern light railway or tramway offers the acknowledged advantages of railed traction and electric operation in the carriage of heavy passenger loads, together with the possibility of segregating public from private transport, to the benefit of both in busy urban areas. May not this new concept of the tram be worthy of consideration in view of the present condition of city transport and congestion?

J. JOYCE, B.Sc. (Econ.)
Hon. Secretary,
Light Railway Transport League,
245–7, Cricklewood Broadway,
London, N.W.2,
November 14, 1959.

CHISWICK FLYOVER

SIR,—In your issue of November 13 you published a letter from "An Engineer" in which reference was made to our statement in your issue of October 16. It would seem that an important point was overlooked by your correspondent in quoting from our statement. Although we stated that steel was in short supply when the scheme was designed in 1956, we also indicated that comparative estimates were prepared for alternative types of construction for the approaches to the main bridge and that the design adopted was found to be the more economical and did not involve the use of steel. There was therefore no question of adopting a design which was more expensive in order to save steel, as stated by your correspondent, and certainly no waste of public money as he implies.

HARRY BROMPTON AND PARTNERS
Westminster,
London, S.W.1,
November 16, 1959.

Book Reviews

Operations Research, Methods and Problems. By M. SASIENI, A. YASPAN and L. FRIEDMAN. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 82s.

To date very few books have been written on what the Americans call Operations Research and we call Operational Research, and all so far, at least in English, are by Americans, including the work under review. As the outlook on industrial O.R. in the U.S.A. is, as a rule, somewhat different from that in this country, this fact should be borne in mind. O.R. in America is held for the most part to be distinct from, though linked loosely with, industrial statistics, whereas in this country industrial O.R. has in many cases grown almost imperceptibly from the applications of statistical methods to management problems.

The make-up and general outlook of the book under review is in line with the point of view that O.R. is distinct from industrial statistics, and although the authors state that an understanding of probability theory is fundamental, they only assign the two brief opening chapters to "Probability" and "Sampling," neither chapter being on the high level of the remainder of the book. After the opening the authors settle down to a series of chapters which are genuinely useful, on inventory or, as we say, stock control, replacement, waiting lines (queueing), competitive strategies, allocation (linear programming), sequencing and dynamic programming. In each chapter there is first exposition, then problems with solutions, problems as homework, and a bibliography on the subject under discussion. The explanations are lucid and not overburdened with mathematics.

The chapter on inventory or stock control starts on conventional lines with the basic "square root" formula, but continues as a consideration of "probabilistic demand." The short chapter on replacement is followed by three chapters on waiting lines, competitive strategies and allocation which are perhaps the best in the book. In the "waiting line" chapter the authors make the important point that the so-called Monte Carlo simulation method described in the "sampling" chapter can be very usefully applied to queueing problems. "For one thing, simulated sampling, especially when done on a digital computer can develop months or years of 'data' in a matter of a few minutes. Another advantage is that manipulation can be made of those factors that are subject to control, for example, we can readily assess the effects of adding one or more service facilities without actually having to go to the trouble and expense of installing them." The chapter on competitive strategies is an introduction to the theory of games which has not yet actually been used to solve business problems, but which is worth study; the theory of yesterday in operational research has a knack of turning into the practice of to-day.

The chapter on allocation is the longest in the book and is in fact a miniature textbook on linear programming, a technique which is rapidly emerging from the suspicion that it is impractical, and is being applied with success by hard-headed business concerns, particularly in the metallurgical, oil and animal food industries. The chapter is well laid out, showing the developments of the linear programming technique with clear explanations and a number of completely worked out examples, all of a highly practical character as for instance "to determine the amounts of each of three types of alloy steel, given the process flow chart and within the limitations of sales and machine capacities." Following a short and somewhat disappointing chapter on sequencing, the final chapter is devoted to dynamic programming, "a newly developed mathematical technique which is useful in many types of decision problems." The purpose of dynamic programming is to make a decision on overall policy instead of a series of step by step decisions, and as with the theory of games, this is a method rather of the possible future than the present.

The book under review is intended to form a basis for serious private study of O.R. by those who are unable to attend the lectures at the Case Institute of Technology, Cleveland, on which it is based. Engineers, physicists and other technologists who are interested in finding out what operational research is and how it can be applied in industry will find the book of value.

Introduction to the Theory of Compressible Flow. By SHIH-I PAI. D. Van Nostrand Company, Ltd., 358, Kensington High Street, London, W.14. Price 73s.

IN just less than 400 pages the author aims at developing from first principles an explana-

tion of the main features of compressible flow, including chemical change and ionisation effects. The degree of success in achieving this aim is very considerable, though for a few topics more outside knowledge is required for a proper appreciation than may be apparent at first glance. With the present state of the subject matter this may be inevitable in a one-volume discussion. For example, the chapter on " Method of Characteristics " is so condensed that a newcomer to the subject would find it very difficult to follow even though it does start from first principles.

Apart from the details of treatment, there are three main features of the presentation which account for much of the book's success. From clear, axiomatic statements of fundamentals each branch of the subject is developed with a logical inevitability which is by no means always found in texts on this and similar topics. In particular, the restrictions under which any set of equations or solutions of equations holds, i.e. adiabatic or non-adiabatic, reversible or non-reversible, rotational or irrotational flow, &c., are always apparent in the development. In such a predominantly consistent scheme, occasional lapses are all the more noticeable and so it is a little odd to read on page 298 that " Flow with heat addition is sometimes called 'diabatic flow'" when it has been called that through the book from page 14.

Secondly, the prose is clear and lucid. The British reader will note occasional unusual usage, the use of the word " gotten," for example, but this does not impair a style which is pleasant to read, at times deceptively easy since a lot of material is packed into simple, short sentences.

Thirdly, the typographical layout is very good. From the nature of the subject as much space is used by equations, (many of them complicated), and symbols, as is used by text, and these are all clearly and easily read.

The book is intended for the student studying an advanced course in gas dynamics and will be equally useful as a reference book for the research worker and teacher in the subject. The most valuable chapters are the first fourteen. The last three deal too briefly with specialist topics—viscous compressible fluids with chemical reaction, boundary layers in viscous compressible fluids, and magnetogasdynamics which now certainly needs a volume to itself.

The first two chapters state basic physical laws in mathematical form for use throughout the book. Extensive discussions of validity are, quite reasonably, not undertaken ; these are left to the various references given. The mathematical aspect of the discussion is emphasised from the start, the book being, in fact, the " applied mathematics " of the subject matter, e.g. entropy is given most prominence when introduced, as a function arising from converting dQ into a complete differential in the equation $dQ = C_p dt - (1/\rho)dp$ by means of an integrating factor. Chapter III is on one-dimensional inviscid flow, followed by a chapter on shock waves. Then, after obtaining in Chapter V the fundamental equations for compressible inviscid flow in a non-conducting fluid, a sequence of chapters follows on methods of solution (mainly two-dimensional)—Small Perturbations, Potential Flow, Hodograph Method, Method of Characteristics, Transonic Flow. Some discussion of three-dimensional flows then follows.

The system of references and bibliography is not always as helpful as it could have been. Each chapter is followed by a list of publications, some of which are referred to in the text of the chapter, but not all. This results in much duplication since the same book or paper will appear in more than one list. Certain entries also seem rather arbitrary. For example, after the chapter " Aerodynamics of a Compressible Fluid," we find A. S. Ramsey's book *Hydrodynamics* mentioned, it is not referred to at any point in the text of the chapter and Ramsey specifically excludes discussion of compressible fluids. As very general background, Lamb already quoted by Pai would be quite adequate. Again, the author implies at one point that the reader may not be familiar with the elementary properties of a complex variable and refers to Whittaker and Watson's *Modern Analysis*. The advanced student must surely be acquainted with these ideas, and, if not, the reference is rather a high-powered one for an introduction. A reverse situation occurs late in the book where the suffix convention of tensor analysis is suddenly used without explanation or reference ; here the student may legitimately be on uncertain ground.

The book is a valuable addition to the literature on the subject, but is expensive and most students will have to rely on library copies.

The Locomotives of the Great Western Railway. Part 6: Four-Coupled Tank Engines. By F. J. TABOR and others. The Railway Correspondence and Travel Society. Obtainable from the Hon. Publications Officer, 57, Heathfield Road, Kings Heath, Birmingham, 14. Price 10s. 6d. post free.

THIS book is one of a twelve-part series on the locomotives of the G.W.R. and deals with the company's four-coupled tank engines, except for a few classes covered in other parts of the work. They are grouped for purposes of description as shunting engines, front-coupled classes, the 2–4–0T and 2–4–2T classes, and experimental locomotives. Each class is described generally, with dimensions, then details and alterations are noted, and after some comments on allocation and work the history of the class is summarised in a table of numbers and renumbering, building and withdrawal dates. There are twenty-six pages of illustrations, mostly four to a page, and a colour frontispiece from a painting by H. M. Le Fleming of " Metro " class 2–4–0T No. 275 as built and arrayed in the Armstrong livery. The book forms a detailed record of the life history of the various classes and individual locomotives, based on the painstaking collection of facts and figures of interest to the locomotive historian. Many early photographs are reproduced, sometimes accompanied by later views showing successive stages in the life history of a particular locomotive. Six experimental locomotives are described, most of which had a short life in their original form but achieved a respectable span later. An appendix giving dimensions of boilers fitted to many of the classes concludes the book.

Books Received

Elementary Practical Hydraulics of Flow in Pipes. By C. T. B. Donkin. Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 21s.

Praktische Spannungsoptik. Second edition. By L. Foppl and E. Monch. Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3, German Federal Republic. Price DM.30.

Intermediate Engineering Drawing. Fifth edition. By A. C. Parkinson. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, London, W.C.2. Price 12s. 6d.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

CONVERSION FACTORS AND TABLES (BASIS OF TABLES ; CONVERSION FACTORS)

No. 350 : Part 1 : 1959. Price 15s. B.S. 350, Conversion factors and tables, is being revised, and a first part has now been published in a 114-page, fully indexed volume. The standard will be much enlarged in scope by its revision, and when this has been completed it will cover, broadly, units, their abbreviations, conversion factors and detailed conversion tables for a wide range of subjects falling under the general headings of metrology, mechanics and heat. Part 1 gives extended basic information on units, together with the standard abbreviation for each unit or combination of units considered. A feature of the standard is the inclusion of comprehensive tables of conversion factors, showing the relationship between any two of the British and metric units used in the measurement of a given physical quantity. Summary tables of units and conversion factors are also included, together with an appendix on thicknesses of sheets and diameters of wires.

Officially sub-titled " Part 1 : Basis of tables ; conversion factors," the new publication will eventually be joined by a " sister " part—Part 2—which is now being prepared and will include a more extended range of tables than those in B.S. 350 : 1944. A list of the detailed conversion tables allotted to Part 2 will be found in Part 1. When Part 2 is ready, the two parts will be available either separately or as a combined standard. In the meantime the detailed tables of the 1944 edition will still be serviceable, and are obtainable at the reduced price of 7s. 6d. per copy, but the other parts of that edition are now superseded by the new Part 1.

Difficulties due to the small differences between the British and U.S. legal yards, and likewise between the legal pounds, have been overcome by the use in B.S. 350 of common units of length and mass defined by means of the following relationships : 1 yard equals 0·9144m ; 1 lb equals 0·453 592 37 kg.

These are the definitions adopted in 1959 by the National Standards Laboratories of Australia, Canada, New Zealand, South Africa, the United Kingdom, and the United States of America for use in science and technology.

CAST IRON ANGLE PLATES AND BOX ANGLE PLATES FOR WORKSHOP USE

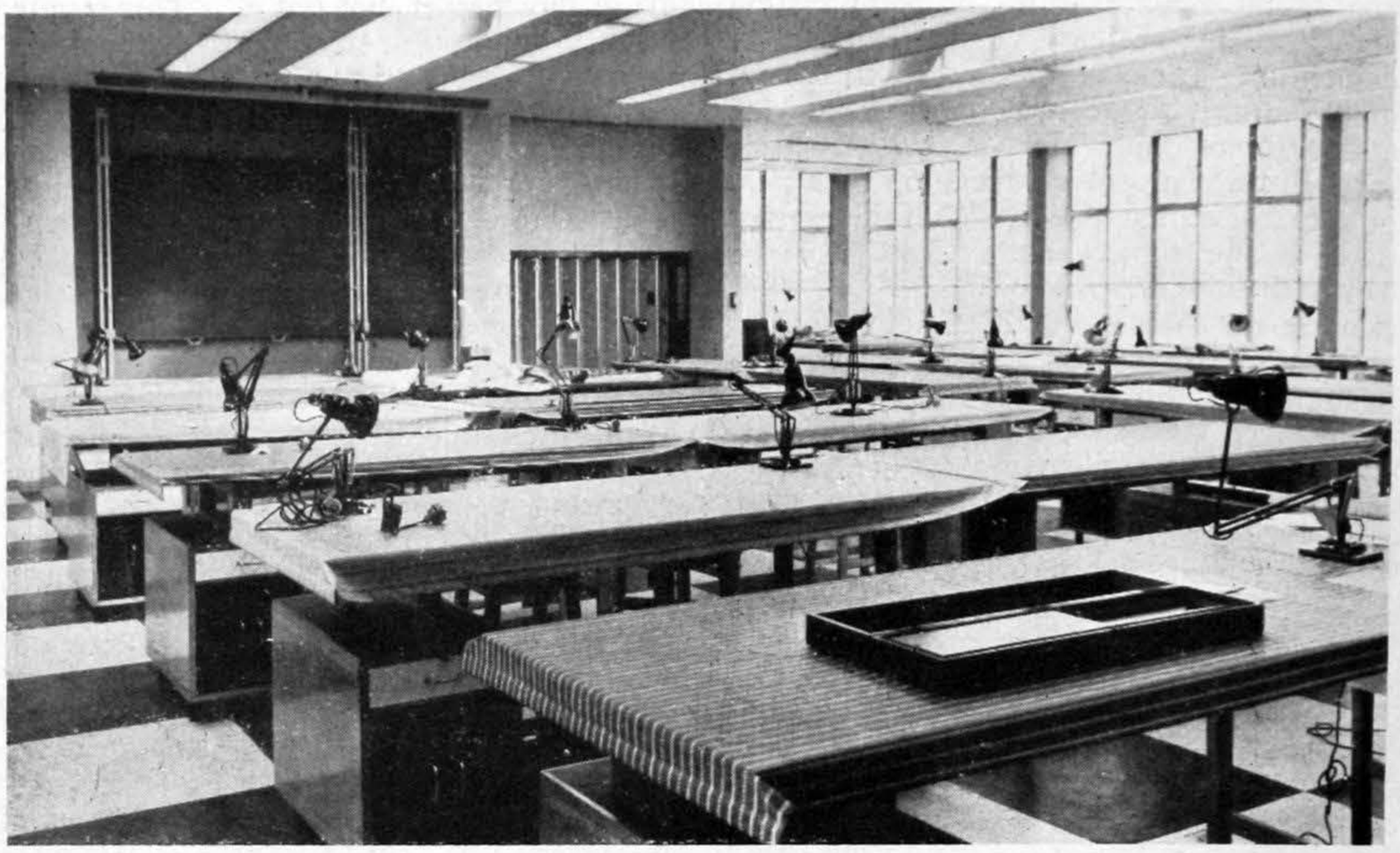
No. 3080 : 1959. Price 4s. 6d. Angle plates and box angle plates are among the most commonly used items of an engineer's equipment. They are to be found in workshops and inspection departments alike and are at present obtainable in a very wide variety of sizes. Because of the diversity of purposes for which these plates are required it was found impracticable to standardise one grade only. B.S. 3080 therefore provides for two grades of angle plates and box angle plates, suitable between them for all general workshop purposes. Higher grade plates for inspection use will be the subject of another standard. With regard to sizes, it appeared that there was very little in common between the various ranges available and there was no logical basis for a choice of any one range in preference to the others. It was therefore decided to establish a rational series of sizes and recommend them for adoption as existing stocks of plates become exhausted. In addition to these recommendations the standard specifies requirements for the two grades of accuracy and for material, stress relief and finish.

EARTHWORKS

Code 2003 : 1959. Price 25s. Code of Practice 2003, was prepared by a drafting committee convened by the Institution of Civil Engineers. It deals with civil engineering earthworks, but not with such specialised types as tunnels, dams, dykes, canals dredging and river training works. The recommendations in the 139-page code are set out in general terms. General advice is given on such matters as soil classification, weather conditions, and the economic aspects of earthwork design. There is full guidance on the design, drainage and construction of cuttings and embankments and of shallow cut-and-fill and compaction earthworks ; this is followed by a section on construction methods and the use of plant. A substantial section of the code is devoted to trenches, pits and shafts, covering such matters as site considerations, methods of excluding water, and the degree of support required in varying ground conditions. Excavation, timbering and back filling are fully dealt with, as are blasting and excavation in rock. Tables deal with such matters as the classification and characteristics of soils and the design of rock slopes ; and among the twenty-eight figures are many examples of accepted methods of timbering and of drilling for explosives. The code is based on conditions likely to be met in the British Isles, but a few references have been made to conditions overseas where this appeared desirable.

Glasgow University Engineering Building

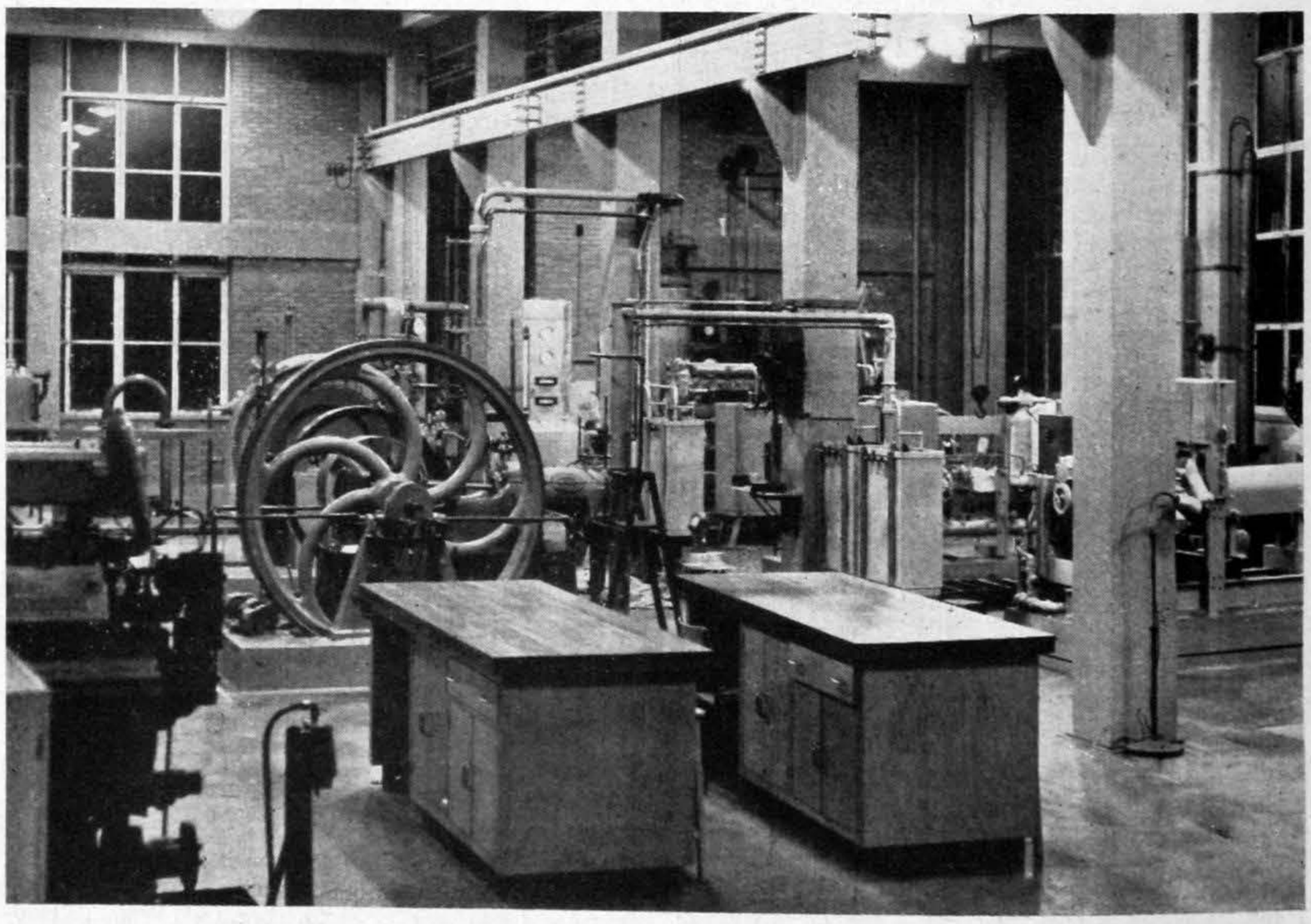
A new engineering building was inaugurated at Glasgow University on November 4 by Lord Montgomery, as noted in our last issue. It has been erected alongside an older building which is now being reconstructed. When that work is completed some time next year, the combined buildings will provide space for the departments of civil, mechanical, electrical and aeronautical engineering and of naval architecture. The new building has seven floors, with a total floor area of 102,850 square feet, about three times that of the older building close by, to which it is connected on two floors.





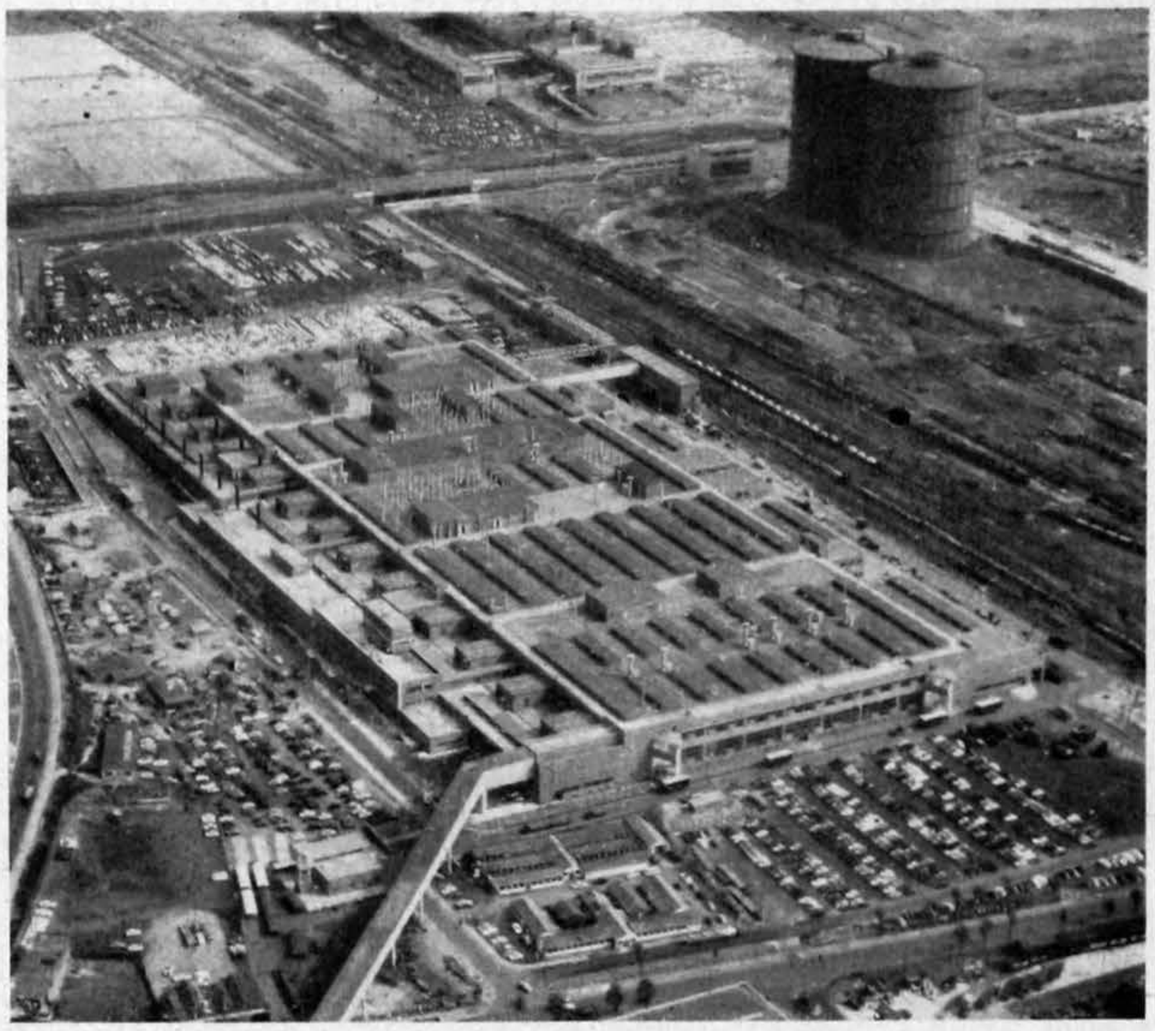
The upper floors are occupied by drawing-offices and laboratories for naval architecture and aeronautical engineering. A naval architecture drawing-office is shown in the illustration ABOVE. There is included in the building a large lecture theatre. A gift towards the cost of the building by the late Sir Daniel Stevenson is acknowledged by the naming of this theatre " John Stevenson Room " after the donor's father. Large laboratories for Heat Engines and for Electrical Engineering extend through two floors. These two laboratories are illustrated on the LEFT and BELOW.

The number of students admitted annually is at present 180. On this basis, the number of students of engineering in attendance at courses is likely to be 600. The cost of the new building and its new equipment has been met partly from state funds and partly from donations from many firms and individuals. Stone has been used for the external walls, as in the adjoining buildings, but large areas are of glass to light the laboratories and workshops. These glass curtain walls are suspended from the roof. The architects for the building are Keppie, Henderson and Partners, of Glasgow.



Motor-Car Factory at Dagenham

The £75,000,000 modernisation and expansion programme announced by Ford Motor Company, Ltd., in 1954 has now reached completion with the introduction of the new paint, trim and assembly building. The average daily production, (1220 vehicles in 1954) is 2000 this year, and is now being increased to bring the output of the "Anglia" alone up from 540 to 1000 a day.



SOME £10,000,000 have been spent by the Ford Motor Company, Ltd., in the construction and equipment of a new building for painting, trimming and assembling motor-cars at Dagenham. The new two-storey building is 1215ft long and 630ft wide and is served by a number of smaller ancillary plant buildings. It is linked by an enclosed conveyor bridge to the nearby body making plant and has the painting shop on the first floor with the trimming and assembling shops on the ground floor.

The two floors and the whole of the processing lines in the shops are linked by an automatic mechanical handling system, developed and installed by Geo. W. King, Ltd., of Stevenage, Herts. This system includes interconnected overhead and floor conveyors with a system of "indexers" automatically controlling movements involved in carrying the car bodies between sections of the plant and from the painting shop to the trimming and assembly shops below.

In the body making building bodies are loaded at pick-up stations on to a "Dual Duty" overhead conveyor system by what are termed "drop-sections." These drop sections are used at various points in the mechanical handling system where it is required to transfer bodies between floor and overhead conveyors or between floors. The bodies are attached to the drop sections by steel slings and in the initial operation each body after being raised is moved forwards into a six-bank "indexer" section where it is held ready for transfer on to the main transport conveyor. The "indexer" equipment is essentially a storage means arranged for stopping and starting load carrying trolleys without halting the conveyor line. It is employed for storing bodies on a live track until they are required in the paint shop. Should there be a hold up in the paint shop and the main conveyor stop, the bodies remain in this six-bank indexer, and interlocking devices prevent the drop sections operating in the body making lines.

As the bodies travelling over the conveyor bridge arrive in the new paint shop they are automatically transferred to two storage lines in alternate rotation, each line serving one of the two plant lines in the duplicated painting plant. One of these storage lines can be seen in Fig. 1. Should any variation in production cause a stoppage to one line, and the subsequent filling of the storage section, bodies will automatically pass to the line able to receive them. When that line is filled the main transport conveyor stops. Re-starting is automatic when the last indexer in either line becomes vacant.

Bodies are released for entry into the first of the process plants, a six-stage phosphating machine, by the arrival of an empty pusher dog on the return stand of the conveyor feeding this plant. Leaving the phosphating machine the bodies are passed into the dry-off oven. Here the "Dual-Duty" conveyor allows the automatic diversion of bodies from the ovens system on to overhead storage lines without losing sequence of flow at such times as meal breaks, end of shifts, &c.

In subsequent operations along the lines the bodies receive sealing treatment and have a priming coat of paint applied whilst still suspended by slings from overhead conveyors. Skids are then fitted to the undersides of the bodies and they are transferred to a floor conveyor system in which a two-strand roller chain provides a moving line for the skid mounted bodies. On these floor lines the other painting operations are completed at a series of spray booths, wet sanding stations and drying ovens.

At points in these lines powered transfer tables are installed where it is required to transfer bodies at the same level. These tables are automatic in operation, their movements being controlled by limit switches actuated by the body skids. When a body



Fig. 1—Bodies in line storage at the beginning of the process in the paint shop

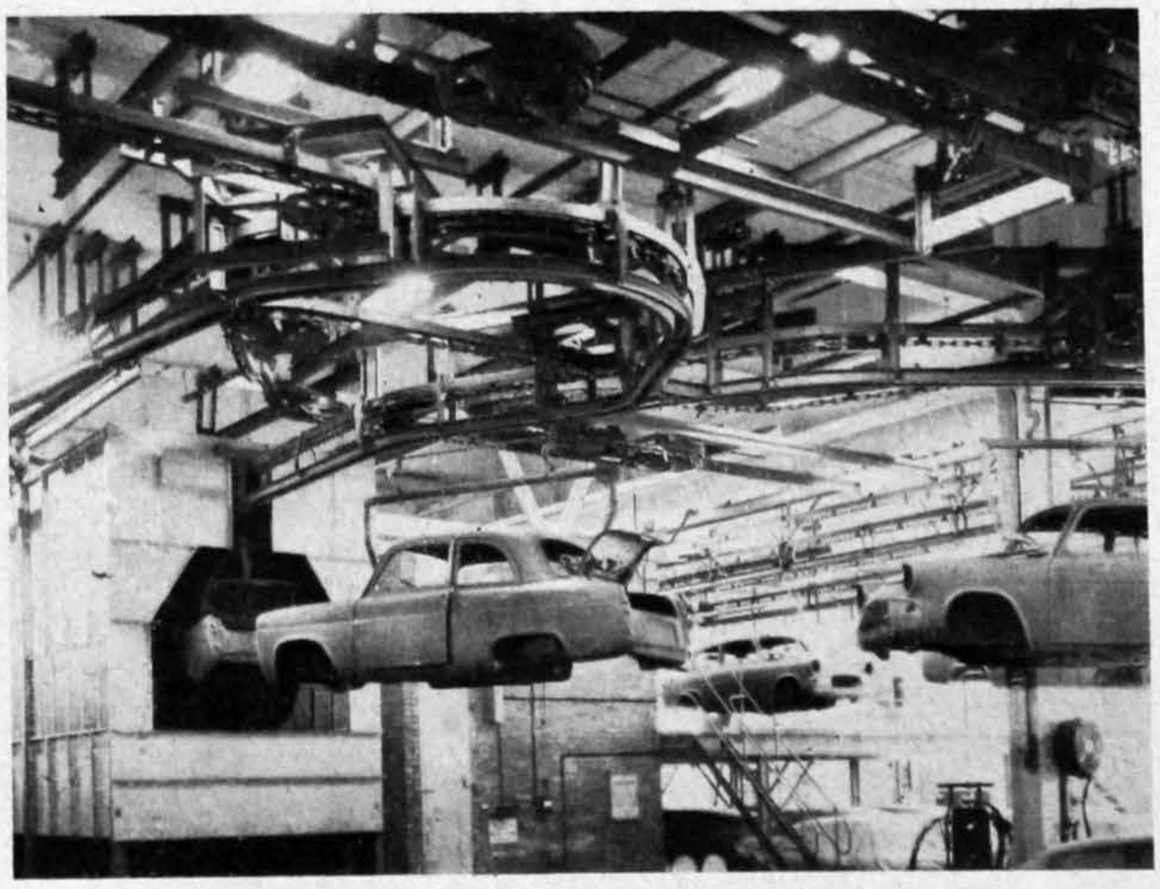


Fig. 2—A turn in the overhead conveyor and bodies entering the "Slipper-dip" for underside treatment

travelling along a conveyor reaches a predetermined position a limit switch is operated which lifts the table in the transfer conveyor on to which the body is then passed. Once the body is in position, the table lowers depositing the body on to the transverse moving chain. A further table lifts the body clear of the transverse chain and propels it on to the tail end of the receiving conveyor.

Each paint booth and oven has its own storage system into which bodies can be diverted during a close-down period. These storage or "stripping" lines consist of a series of gravity idlers carried between twin-strand chain in conjunction with transfer conveyors at right angles. Once selected by push-button, the stripping operation is completely automatic ; on restart the bodies are fed back into the main production flow to match up with those already in the system.

All small parts are separately treated in a similar phosphate and paint system equipped with a "Power-Pulled" conveyor. This system is a continuous flow through primary spray booth, two-pass oven, enamel booth, and three-pass oven. Completed parts are delivered to the trim floor by lift.

After painting the bodies wait in storage lines ready for transfer to the trim shops below through three body drop points, automatically sequenced according to the car models. One of these body drop stations can be seen in Fig. 3. The bodies are lowered on to power operated turntables where operators release the slings and on reaching a predetermined point on its upward movement an empty sling carrier operates a limit switch to rotate the turntable through 90 deg. to bring the body in line with the trim conveyor.

The trim shop comprises three separate systems of two-strand conveyors, the bodies being transferred from one line to the next by cross transfer conveyors and power operated lift tables. Where aisles have to be crossed the transfer conveyor is ramped down to floor level and up again to the next conveyor at operational height. This enables trim stock to be delivered direct to the line by fork lift trucks.

Trimmed bodies are either selected for water test, repair line or into final storage bank ready for delivery to the final assembly lines. Delivery to these lines is by closed hoist systems electrically interlocked with the assembly lines to ensure that a station is vacant before a body is brought into position. Sub-assemblies, wheels, tyres and seats, which have been prepared on slat conveyors at bench height elsewhere in the building, are delivered to the appropriate position by floor and overhead conveyors.

In order that the scheduled body is matched up, the delivery of sub-assemblies is regulated under a control system incorporating a teleprinter service which ensures that the right component is brought to the right body at the right time. Throughout both the paint and trim shops early warning stations are located to amend the overall schedule when certain bodies have been allocated for repair ; late warning stations are located at the storage banks prior to the body being hoisted to the final line where last minute adjustments to schedules are made. Such warnings are sent to all points so that similar adjustments can be made to supplies of seats, wheels and sub-assemblies.

All conveyor operations in this installation are channelled through main control rooms on the floors of the paint shop and trim shop. In each room is a control desk over which a "Master Mimic" diagram is installed with indication lamps to show conveyor movement. There is provided for every conveyor a variable speed potentiometer by which adjustment of speeds can be made to suit production requirements, in relation to neighbouring conveyors. Every change to conveyor movement, or interruption to the flow of bodies, is immediately indicated on the diagram.

This control gear was supplied by Heenan and Froude, Ltd., and "Dynamatic" eddy current couplings are included in the drives to afford control of speed by varying the excitation and hence the slip. Where positive synchronisation of conveyors is required, Magslips are fitted to each conveyor and the difference of the signal voltages used as the control signal. There are 175 separate conveyors in the system, which has an overall length of some 10 miles, and may at any time be carrying over 1500 bodies.

An interesting feature of the conception of the paint shop is the attention paid to water treatment, which stems from two principal problems.

The first was the possibility of a restriction in the supply of mains water coupled with a recent increase in water charges. No alternative source of supply was available and it was envisaged that the new building would require about 25,000 gallons hourly. Used on a once-through basis, this would entail, in a normal two-shift working day, a consumption of 400,000 gallons.

The second problem was posed by the fact that mains water—although pure from the point of view of domestic consumption—contains dissolved solids whose presence handicaps many industrial finishing processes. If mains water is allowed to dry on a vehicle body when it has been washed, following spray painting, the dissolved solids will deposit on the paint surface. Removal of the deposit is difficult and involves additional labour. If allowed to remain it will absorb moisture from subsequent washing—even through successive paint films—resulting in blistering of the finished work. The quality of water used during this stage of vehicle body production is, therefore, vitally important to the manufacturer.

The Permutit Company, Ltd., was requested to look into the question of water treatment which would overcome these difficulties economically. Permutit carried out a thorough investigation, including exhaustive laboratory tests, and produced a scheme which met the requirements completely.

This plant—arranged in two sections—recovers the waste water from the paint spray "Washmobile" section and wet sand deck, purifies it and recirculates it for re-use ; at the same time it produces demineralised water for the "Washmobile." Normal output from the plant is 23,000 gallons hourly of purified, reclaimed waste water and 6300 gallons hourly of demineralised water. The plant arrangement can be seen in the diagram below.



Fig. 3—Drop section transferring a body to the trim and assembly shop below

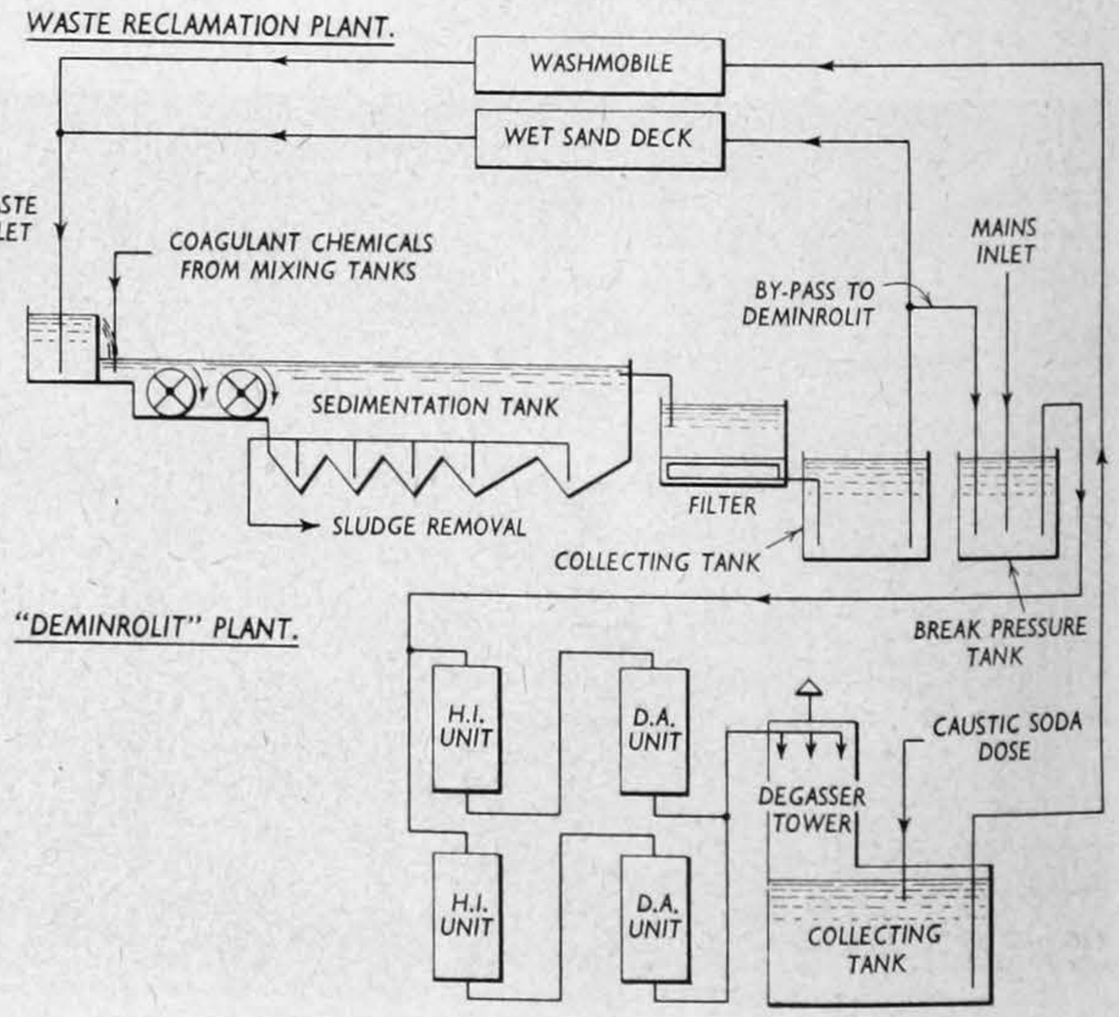


Fig. 4—Car factory water treatment system

Waste water reclamation involves a process of chemical treatment, flocculation, sedimentation and filtration which removes suspended solids from the recovered water and destroys harmful bacteria. Waste water is collected by a drain system and delivered to a tank, from where it flows over a weir and is dosed with chemicals. The chemicals used are lime suspension and a mixture of chlorine and ferrous sulphate. These chemicals sterilise the contaminated water and interact to form ferric hydroxide—a floc forming substance which coagulates suspended solids. Coagulation is assisted by two paddle wheels which agitate the flocculated water as it flows through a channel into sedimentation tanks. Here the heavier coagulated solids settle as sludge which is removed periodically from the bottom of the tanks and discharged to drain. Partially clarified and settled water collects at the top and flows to rapid gravity sand filters where residual suspended solids are removed. The filtrate is then recirculated for re-use by the wet sand deck, a proportion being by-passed through the " Deminrolit " plant *en route* to the " Washmobile."

This by-passed filtrate is blended with mains water in a break pressure tank. The mains water is introduced at this point for convenience and to make up losses resulting from periodical sludge removal and filter washing in the waste reclamation plant. The blended water flows through a two-stage " Deminrolit " plant comprising a pair of hydrogen-ion cat-ion exchange units and a pair of " De-Acidite " an-ion exchange units. These units are arranged as pairs in parallel and the water flows first through the h.i. units and then through the " De-Acidite " units. In the h.i. units dissolved salts are converted to their corresponding acids, which are then absorbed as the water passes through the " De-Acidite " units. CO_2 is liberated by the breakdown of the dissolved bicarbonate salts in the h.i. units. This is removed in a degassing tower where the water falls through an upstream of blown air which picks up the CO_2 and vents it to atmosphere. The de-gassed water collects in a tank at the base of the tower, where it is dosed with a small quantity of dilute caustic soda solution. This neutralises residual CO_2 and maintains correct pH conditions.

The final stages of the assembly process are particularly highly mechanised, in order that the more critical tasks shall be accurately performed with a minimum consumption of skilled man-hours. The cars pass along this end of the line running under their own power, the exhaust pipes being fitted with flexible hoses that run to and along an extractor duct, the extract system in common with the rest of the ventilation being the work of Andrew Air Conditioning, Ltd. Our illustration shows a " Consul " Mk. II in process of toe-in adjustment : it will be seen that the troughs guiding the car have narrowed down in way of the rear wheels, so that the car is constrained to face in the right direction. Each front wheel rests on a pair of rollers (those on the further line are visible) which are driven by electric motors. The large circular followers are advanced to make contact with the wheels, and magnetised circular plates take a slip-free grip. The angular attitude of each plate is metered and transmitted as a fluid pressure to a Solex manometer in the pit, by observing which the operator adjusts the two track rods (one behind each track control link). Any out-of-truth in hub or wheel will become apparent, since the measurement is on a revolving wheel.

The next station is devoted to adjustment

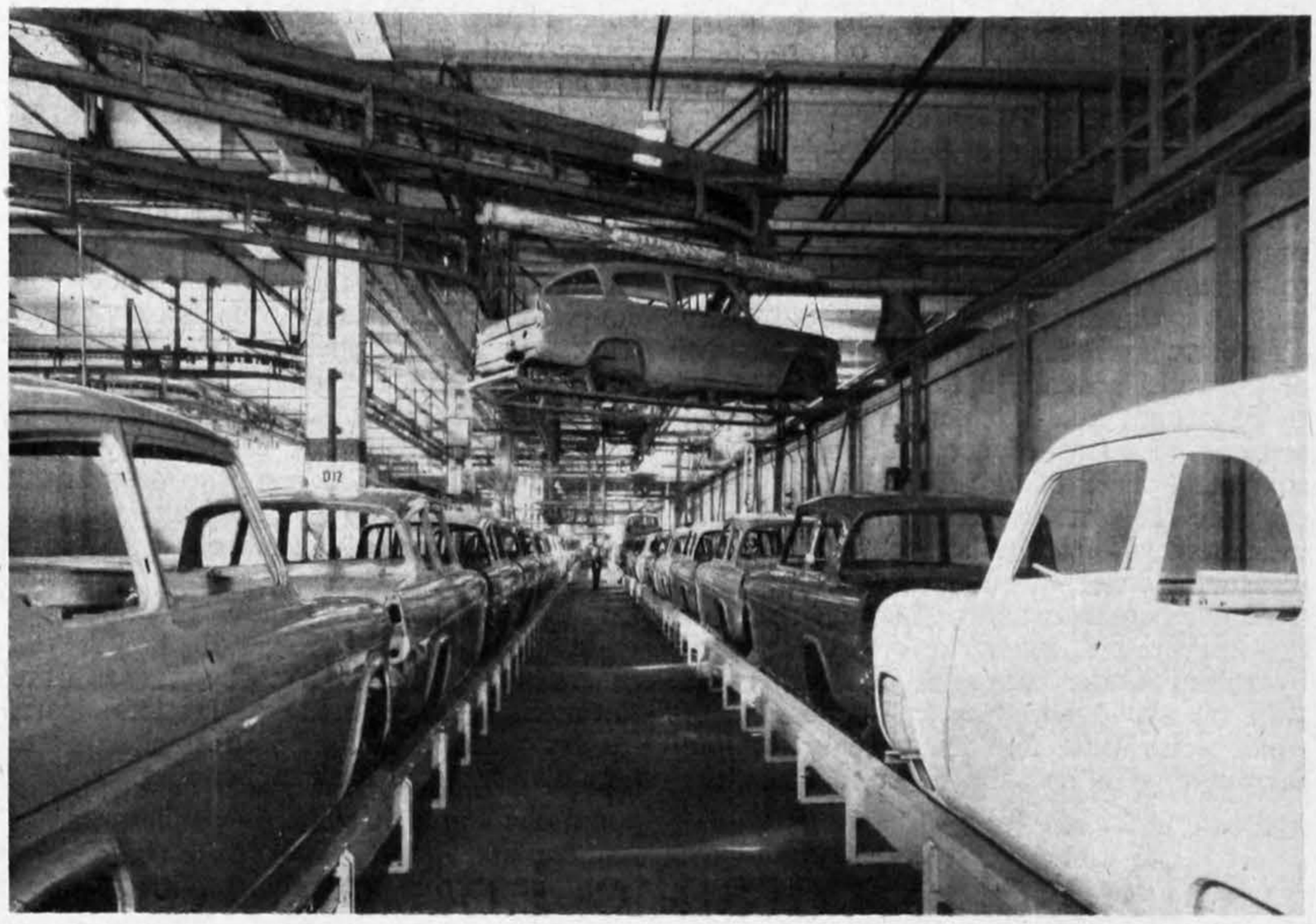


Fig. 5—Body shells mounted on skids for handling by floor conveyors. The closely cuboidal shape of the " Anglia " facilitates construction, the rear wings, for instance, being formed by folding a single pressing



Fig. 6—Toe-in is adjusted with the front wheels running



Fig. 7—The roller test plant can be controlled by a driver on either side of the car

of the steering lock : the car is halted with the front wheels on a pair of turntables, and the stops set to give the required clearance to the tyres at full lock.

The final station is a Schenke roller test machine, on which a road test—albeit in a tail wind equal to the road speed—can be simulated. The rear wheels rest on pairs of rollers and the front on one roller each, so that a separate test bed for cars of every different wheelbase is provided. The inertia of the rolls is matched to the car intended to be tested, and the performance can be assessed in terms of acceleration, the true equivalent speed being presented on a panel opposite the car : apart from the fact that measurement of speed is more reliable than measurement of torque this technique has the fundamental advantage that the behaviour of a carburetted engine can only be assessed by testing under transient conditions, i.e. with the speed changing. The absence of wind noise and the invariability of the surroundings allows the tester to study the noise of the car more satisfactorily than on a true road test and, of course, it is possible to have access to the engine while it is working under load. The machine is set for the road test by pulling the first of the three knobs seen near to the driver's window : since the front wheels are running, the car can be steered towards and away from the controls. Pulling the second knob uncouples the four sets of rollers for a brake test : the results appear on the four small dials visible on the panel and, since the effort on the pedal is not measured, it is the relative magnitudes of these readings that are checked. The results appear as the distance travelled by the periphery of each set of rolls from the time the knob was pulled, so that it does not merely represent the peak torque but reflects the effect of brake fade. The third knob brakes the rollers, so that the car can be driven off the test machine, and retracts the extractor plate.

Cars meeting the required standards are then driven out of the new building.

Diesel Hydraulic Locomotive "D.800"

A paper on the design, construction and performance of the Swindon-built diesel hydraulic locomotive "D800," now in service on the Western Region of British Railways, was presented to the Institution of Locomotive Engineers by Mr. G. E. Scholes on November 17 last. In this article we give abstracts of the paper which will be of particular interest to all concerned with diesel locomotive traction.

IN 1955, when British Railways were considering the type of traction most likely to meet the requirements of the newly-announced modernisation programme, experience on the Continent had already shown that for diesel locomotives of quite large powers hydraulic transmission could compete successfully with electric transmission. It was, therefore, decided that the possibilities in this direction should be explored and that the Western Region should take the initiative.

The 2100 h.p. "V.200" type BB locomotive already in service in Germany was an attractive proposition because of its high power-weight ratio of about 26 h.p. per ton, and the Western Region proposed that a few similar locomotives, in addition to two other types to be designed by the North British Locomotive Company, should be built for trial in this country.

Had the German Railways' load gauge been similar to that of the British Railways, a "V.200" type locomotive could have been purchased immediately and put into service. As it was, the "V.200" was 10in too high and 16in too wide for running in Great Britain and there was some lack of clearance on the underside as well. There was no alternative, therefore, to redesigning the locomotive and building in this country.

The "V.200" had been developed by the German Federal Railways' Central Offices at Munich, in co-operation with the Krauss-Maffei Locomotive Works at Munich-Allach, other locomotive builders in Germany also participating. Messrs. Krauss-Maffei had already built a number of locomotives of the class and a licensing agreement was therefore concluded with that firm.

The engines, transmissions and bogies, except for the wheel diameter, were to be exactly as on the German locomotive and it was decided to use a similar control system and similar compressed air brake equipment. The rest of the installation, including carriage warming boiler, cooling equipment and exhausters was to be of British manufacture.

It is not possible in a paper of this length to discuss in detail all the equipment installed in the locomotive, and therefore attention is confined, in the main, to those features which make the design different from all others on British Railways.

Fig. 1 shows a photograph of the Swindon-built version, designated the "D.800" class, of the German design. Two Maybach MD650 twelve-cylinder vee engines are installed, each developing 1135 b.h.p. at 1530 r.p.m. (except for locomotives "D.800" to "D.802," on which the engines are set to develop 1056 b.h.p. at 1400 r.p.m.). Power is transmitted to both axles of each four-wheeled bogie through a Mekydro K.104 transmission, as developed by Maybach, which transmission is secured to the underframe of the locomotive and occupies the centre portion of the pivotless bogie designed by Krauss-Maffei to accommodate such a transmission.

Underframe and Superstructure

In designing their "V.200" locomotives, the Germans adopted a lightweight construction technique whereby thin plate appropriately stiffened is enabled to withstand the loading imposed upon it. This technique, based on theoretical work by Timoshenko dating back to 1921, was developed after extensive research in the spheres of aircraft and steel building construction, and was later applied successfully to coach design.

In use, the technique involves a tentative method of approach, a structure having to be assumed in the first place and loads estimated. Shear force and polar bending moment diagrams are set out and for this purpose the weights of the main components are assumed to act at their centres of gravity, while the weights of the remaining auxiliary equipment and of the underframe and body are assumed to be equally distributed over the length of the locomotive. At any particular section of the locomotive the shear force and bending moment will depend upon the manner in which the structure is carried or lifted. The following cases have to be considered :

(*a*) Normal loading, that is with the body supported at the bogie centres.

(*b*) Lifting the whole locomotive, including the bogies, at the lifting points provided, which are symmetrical about the locomotive centre.

(*c*) Lifting the body and one bogie at a buffer beam with the bogie centre furthest from the beam acting as a fulcrum.

(*d*) Lifting the body and one bogie at a buffer beam with the lifting points furthest from the beam acting as a fulcrum.

(*e*) Lifting at both buffer beams.

Diagrams are drawn for all these conditions and, following this, a series of lengthy calculations is made for various sections along the locomotive to determine not only the strength of the section as a whole, but also the buckling strength of every unsupported area of plate forming part of the load-carrying skin of the superstructure. If, in the outcome, the proposed arrangement proves to be too weak or unnecessarily strong, it has to be modified to a second approximation and the calculations repeated.

For each section of the locomotive, the calculations follow the same pattern. First, the moments of inertia of each frame member section and each plate section including the body skin are determined, the sum of these



Fig. 1—Diesel hydraulic locomotive "D.800"

giving the moment of inertia of the whole cross-section. Using the highest of the bending moments resulting at this cross-section from the various methods of loading, the maximum tensile and compressive bending stresses are then calculated. The bending stresses due to normal loading are also derived and multiplied by a factor of 1·3 to allow for dynamic loading. The maximum shearing stress, and the compressive stress in the underframe alone due to a buffing load of 200 tons are also calculated.

The horizontal and vertical members of the body framing divide the skin into unsupported rectangular sections, which, in the calculation of the bending and shearing stresses for the whole cross-section, are assumed to be rigid. They must therefore be made and proved to be so. The technique involved is that previously referred to as having been developed in Germany. Formulæ are used which take into account the size of plate, ratio of length to width, and its thickness. For each rectangle of plate through which the particular section of the locomotive under consideration passes, a permissible buckling stress for the shear load and for the compressive load are calculated except for those plates in tension, for which it is only necessary to calculate a shear buckling stress. The actual shear and compressive buckling stresses are then calculated for each method of loading, and compared with the permissible ones. A formula involving the permissible and actual values of both kinds of buckling stress is then used to calculate a "Factor of Safety."

It is not possible in this paper to discuss in detail the theory upon which the design of this self-supporting shell structure is based and for further information the interested reader is referred to an article by Hans Zabel in the March, 1949, issue of the German journal *Glasers Annalen*. It is of interest to note in passing, however, that unlike columns in which loading in excess of the critical loading causes complete collapse, the shell construction permits of local buckling without total collapse because the immediate result of such buckling is limited to a shift of stresses from the part concerned to adjacent parts of the structure. The limiting "Factor of Safety" is therefore unity, and in fact some applications, although it is not recommended for rolling stock, may be less than one. An interesting sidelight on this is illustrated by a test carried out by Kraus-Maffei on a "V.200" locomotive when lifting at the buffer beams. One of the skin plate sections had a "Factor of Safety" of something less than one, and it is said that deformation of this particular plate could be observed under load but the plate returned to its normal shape on the load being released. Incidentally, this also serves to illustrate the soundness of the theory.

The buckling safey factors only apply if the buckling stresses do not exceed the elastic limit of the material, in this case mild steel. A maximum resultant buckling stress is therefore calculated for each plate and multiplied by the "Factor of Safety," the result being compared with the allowable stress for which a value of 13 tons per square inch has been used in the present case.

Finally, normal methods of calculation are applied to examine the strength as struts of various cantrail and body frame members.

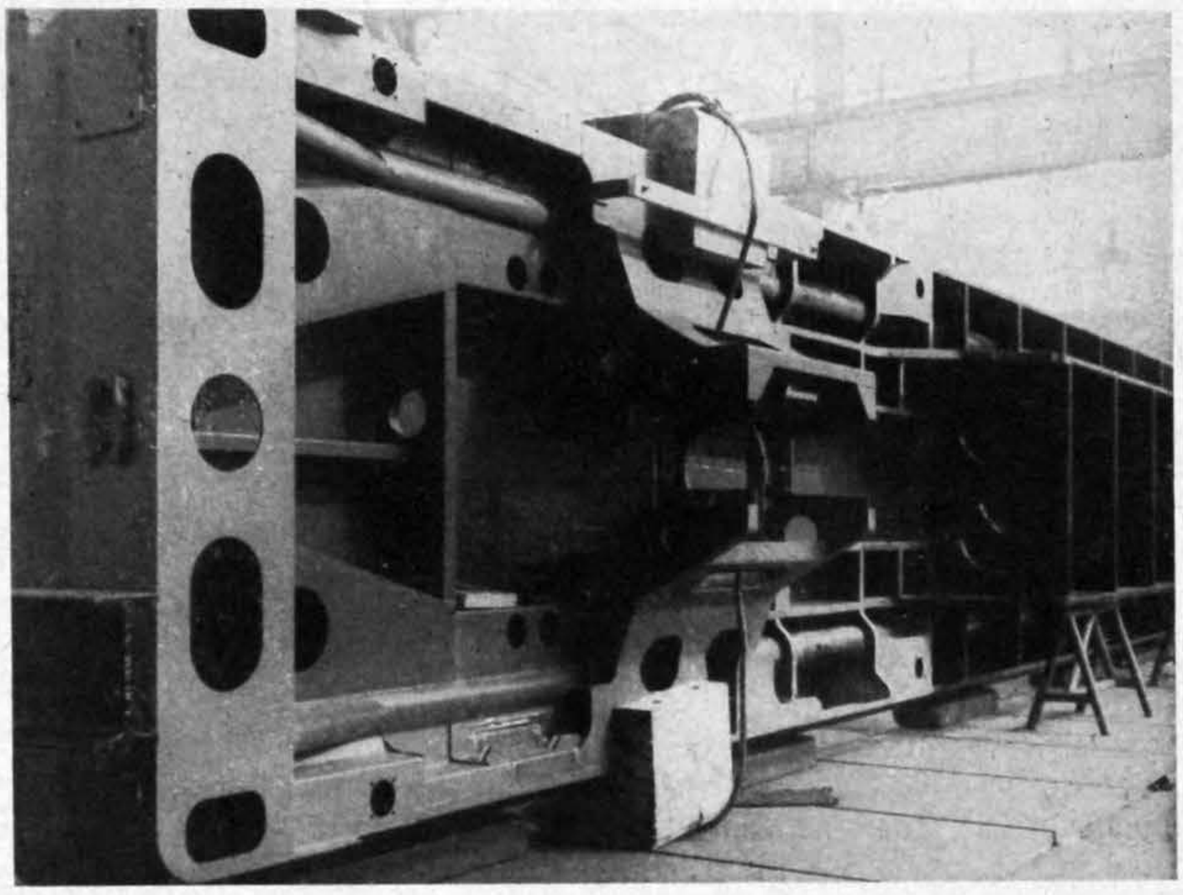


Fig. 2—Underframe during construction

Fig. 2 shows the appearance of the underframe in construction in the Swindon Works. The essential parts of the structure are two solid drawn steel tubes 6½in outside diameter and 0·192in thick running in one length from one end of the locomotive to the other, a number of lateral plate numbers $^{5}/_{32}$in thick threaded into these tubes and forming with longitudinal plates of the same thickness a honeycomb like underframe to which the $^{5}/_{32}$in thick decking plate is fixed, and the superstructure consisting of a light framework of 0·104in thick bent steel sections covered with 0·080in thick steel plate. The whole is welded together and thoroughly cleaned before painting with primer.

Bogies

The bogies of this locomotive are of considerable interest in that the normal axlebox-in-guide type of construction is not used and there is no bolster and no centre pivot. Fig. 3 shows the complete bogie and Fig. 4 has been prepared to make clear the principles of construction.

Referring to this figure, the weight of the superstructure is carried by the buckles of the laminated springs, *A*, through which it is transferred to the bogie frame by way of spring hangers *B*, coil springs *C*, and frame brackets *D*. The pads *E* resting on the tops of the coil springs are immediately beneath pads *F* affixed to the superstructure, but are separated therefrom by a distance of $\frac{15}{16}$in. The bogie frame is carried on four laminated springs *G*, which in turn transfer the weight to the four axlebox housings *H*, and thence through self-aligning Skefko roller bearings to the axles. The housings *H* are integral with arms *J*, which are pivoted at their inner ends to the main frame by long rubber-bushed bearings at *K*, thus eliminating the need for axlebox liners and horns and thereby avoiding the wear normally associated with such parts.

The bogie frame is constrained to pivot about its geometrical centre by the Krauss-Maffei patent linkage, consisting of two bellcranks *L* carried in brackets *M* on the bogie frame, a link *M* connecting the laterally disposed arms of the bellcranks, and two links *O* connecting the longitudinal arms to brackets *P* secured to the superstructure. Each of the eight pins in this linkage is carried in substantial rubber bearing bushes.

Traction and braking forces are transmitted from the bogie to the superstructure by way of thrust pads *S* on the bogie and *R* on the superstructure, the surface of each pad *S* being part of a cylinder and that of each pad *R* part of a sphere. These pads are of manganese steel. The final drive is shown in outline at *T* and the output flange of the Mekydro transmission at *U*. For the sake of clarity, the axlebox housing outline has been omitted from the left-hand side and the final drive outline and the other transmission output flange from the right-hand side.

The wheel diameter now is 3ft 3½in and this, with an axle load of 19 tons 13 cwt, gives an (axle load in tons/wheel diameter in feet) ratio, usually known as the *P*/*D* ratio, of 5·97. This is in excess of the ratio of 5, originally calculated on purely theoretical grounds as the limit beyond which Hertzian stresses would become troublesome, but in view of the almost insurmountable difficulties in this design of reducing the ratio to such a low value, the figure has been allowed to remain at 5·97. It is common knowledge that the limitations imposed by the track engineer are often contrary to the interests of the locomotive engineer, and in

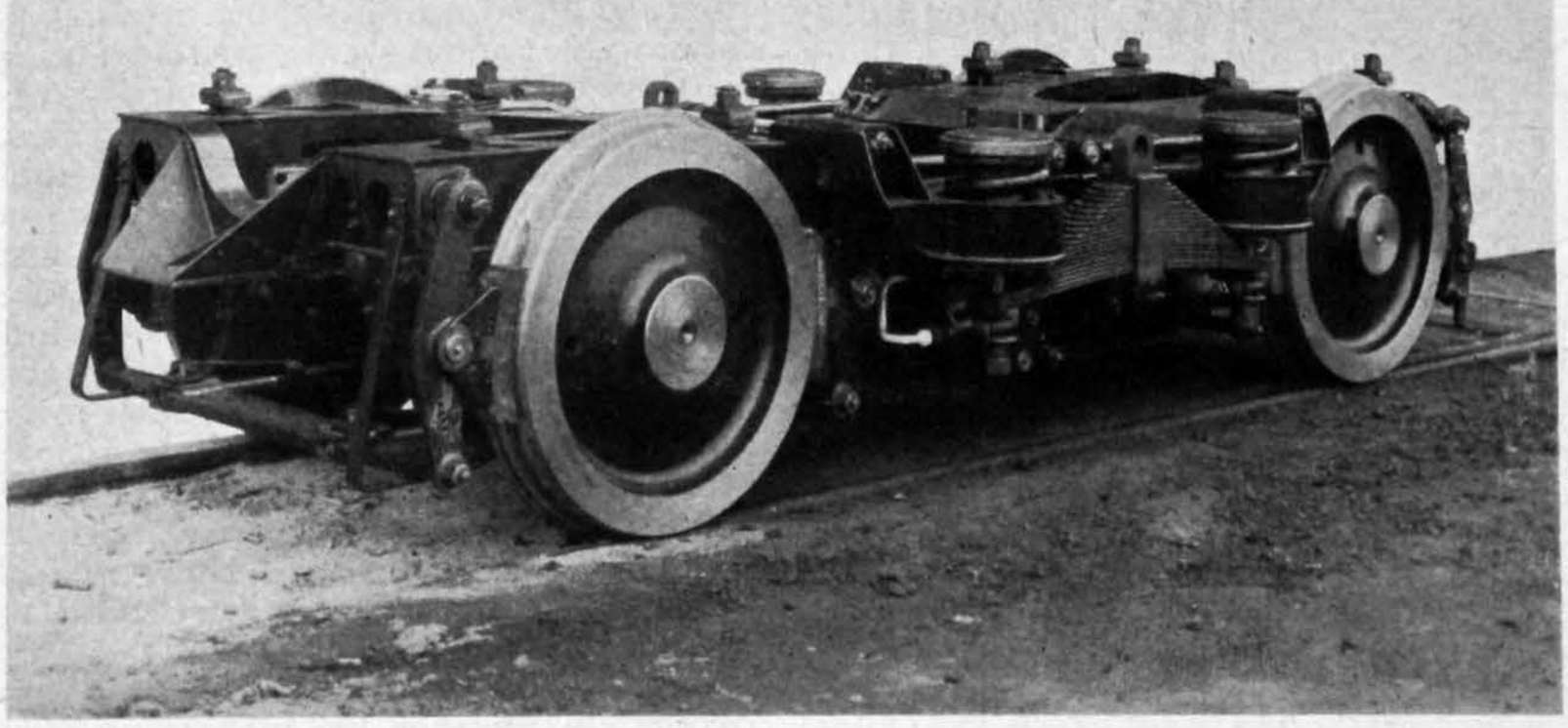


Fig. 3—Bogie complete

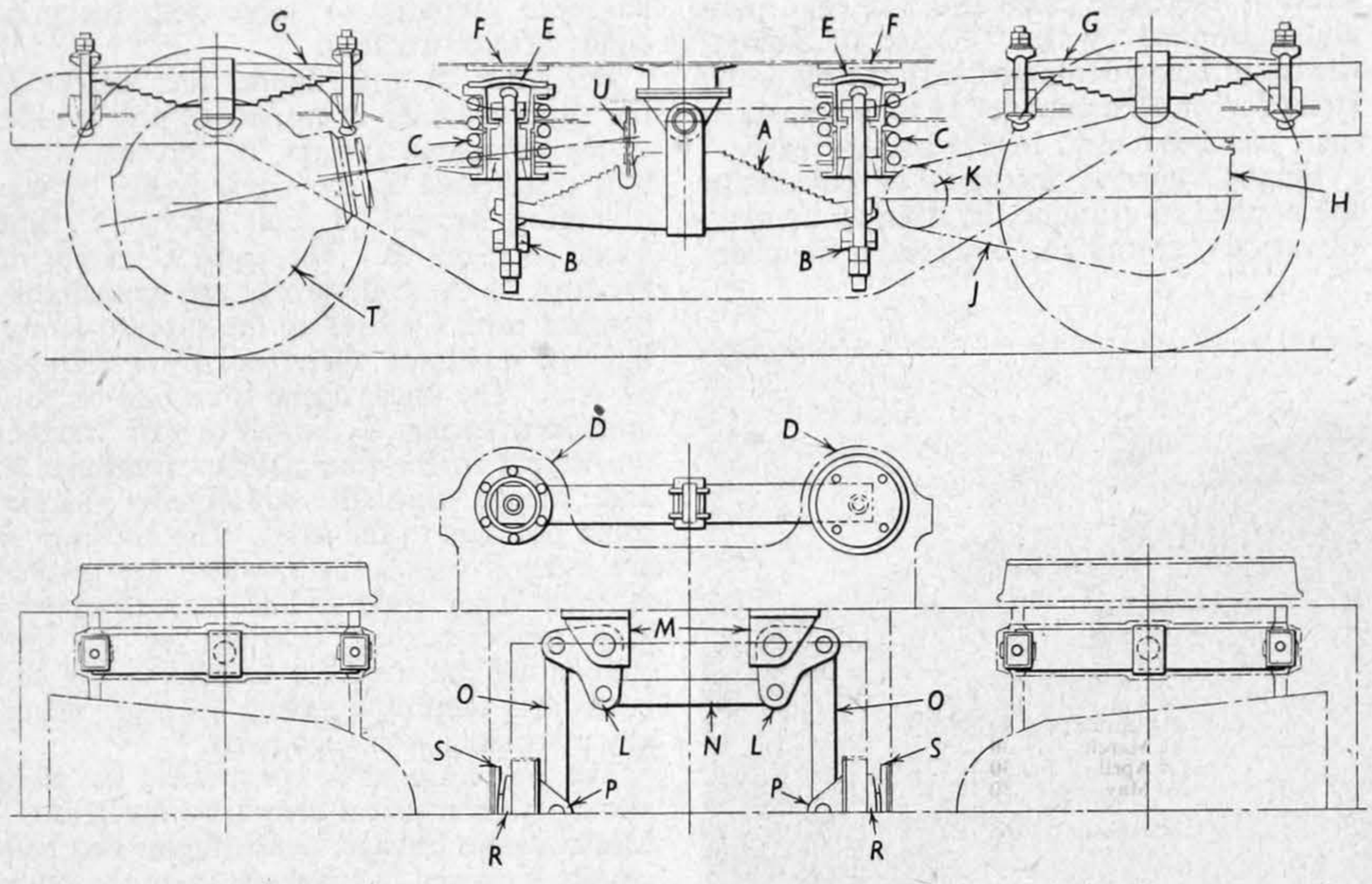


Fig. 4—Diagram of bogie

the matter of Hertzian stresses it may well be that even if a P/D ratio as low as 5 is necessary completely to safeguard the track, the imposition of such a figure would not in the long run prove to be an economical procedure.

[The author then describes the engines, transmission, electrical and control equipment, brakes, train heating equipment and styling of the locomotives in some detail.]

Performance

Traction performance and fuel consumption tests on the Controlled Road Testing System were undertaken in October, 1958, on Locomotive No. D.801 to establish the characteristic for the series. These tests were made over the main routes between Didcot and Bristol, the down route being via Bath and the up route via Badminton.

The locomotive was tested in all notches from 0 to 6, except for notch 1, each with the load which enabled the speed range to be covered. In notch 6 the maximum speed from which test data were obtained was 103 m.p.h.

Values of actual drawbar tractive effort exerted on the trailing load were plotted against speed, taken directly from the dynamometer car recording. The fair curve through these observations is transferred to Fig. 5, where it is marked p. Curve R_c (total resistance on level of trailing load) is the complement which, used in conjunction with curve p, produces a calculated speed-distance curve for the train and route which agrees with the speed-distance curve actually plotted from the data afforded by the test.

Curve p and the verified R_c curve enable the curve P (equivalent drawbar tractive effort at constant speed on the level) to be constructed.

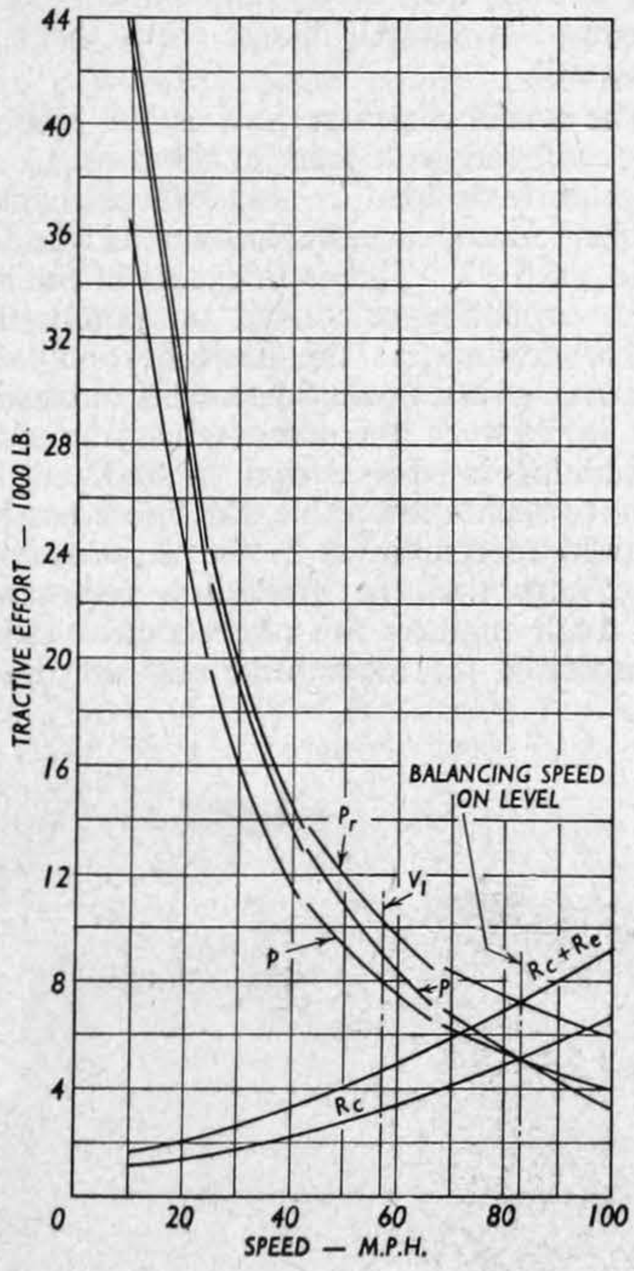
The rail tractive effort curve P_r is defined by the addition of the locomotive traction resistance R_e to the curve P. R_e was experimentally determined by drifting tests under a light power condition from high speed on suitable track, employing first the locomotive alone and then the locomotive and light train. When the power condition is identical in the two cases, locomotive resistance emerges from the differences in the net decelerating forces at the various speeds, the forces being those which by calculation produced speed-distance curves identical with those recorded.

Curve P_r was then constructed and subsequently verified by calculating again a speed-distance curve for the test as first described, using the total mass, resistance curves R_c and R_e and the rail tractive effort curve P_r. This speed-distance curve was identical with the curve derived from using the mass of the trailing load, the resistance of the trailing load R_c and the actual drawbar tractive effort on the trailing load, curve p. It is to be noted that the rail tractive effort curves thus established are independent of furnished information.

Fuel consumptions were measured and recorded by precision fuel meters and compared with consumptions relative to brake horsepower obtained for the same engines on the test bed. The mileage run between the two types of tests was very small.

Available power at the rail is representative of average running conditions, being affected slightly by the absorption of power by auxiliaries, which varies from time to time.

The overall mechanical efficiency of transmission and final drive reaches 82½ per cent between the gear changes, a figure only marginally lower than the overall efficiency of the electric transmission of Southern Region diesel electric locomotive No. 10203 previously tested by the Western Region. A noteworthy feature of the arrangements in the " D.800 " series is that high overall transmission efficiency is associated with the highest operating speeds.



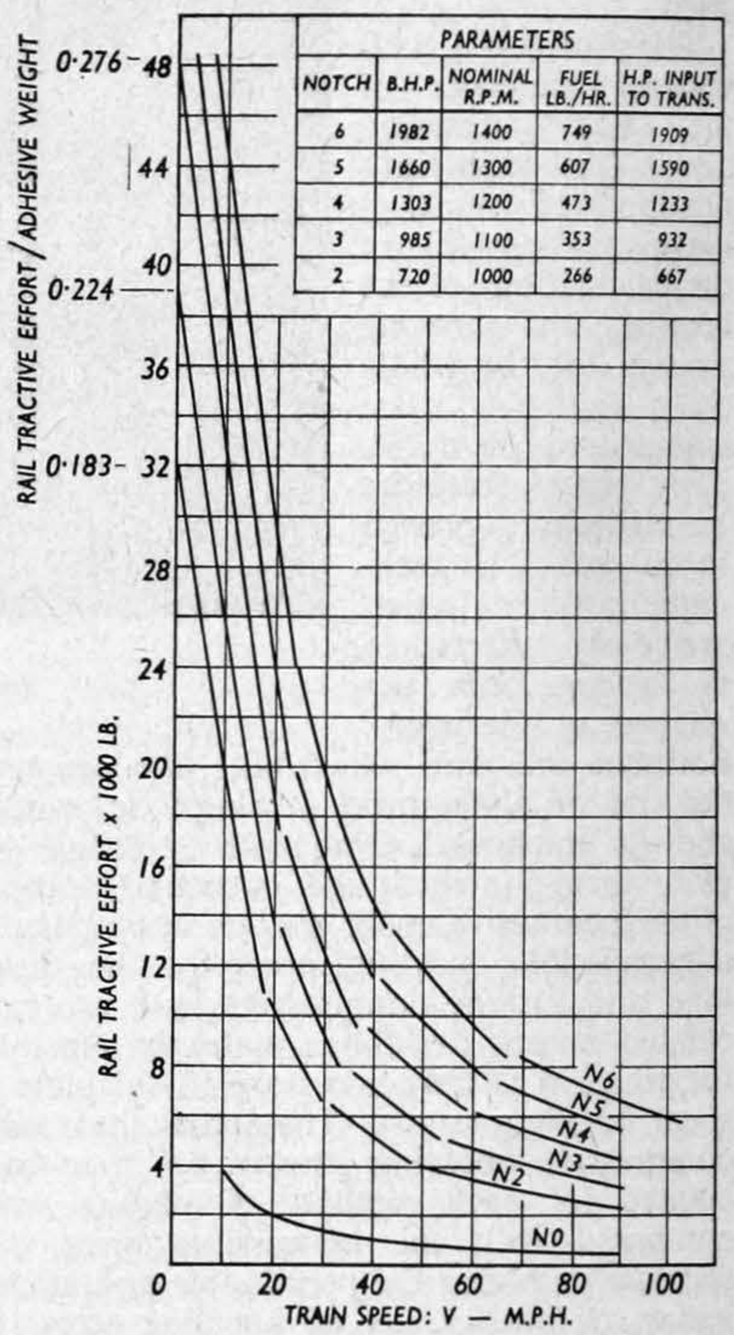
P_r = Rail TE.
P = Equivalent drawbar TE at constant speed on level.
p = Actual drawbar TE on trailing load.
R_e = Total resistance of locomotive.
R_c = Total resistance of trailing load.

At any speed V_1 where $p=p'$, $P=P'$, $P_r=P_r'$, $R_e=R_e'$ and
M_e = Equivalent mass of locomotive.
M_t = Equivalent mass of trailing load.

$$P'=p'+\frac{M_e}{M_t}(p'-R_e').$$

$$P_r'=P'+R_e'.$$

Fig. 5—Diagram showing method of testing



Rail tractive effort.
Test of Maybach Mekydro B–B type 4 locomotive " D.801. "

Fig. 6—Tractive effort/speed curves

The equivalent mass of the rotating parts of the coaching stock is 7 per cent of the actual mass, and the equivalent mass of the rotating parts of the 78-ton " D.801 " is 13 per cent of its actual mass.

The results of the traction performance and efficiency tests can be concisely expressed by the rail tractive effort-speed curves with tabulated parameters Fig. 6, taken in conjunction with the locomotive and coach resistance curves (Fig. 7). Fig. 6 is representative of the three locomotives " D.800 " to " D.802," except for possible slight variations which may be brought about by small differences in fuel and engine speed control settings.

The maximum test load was fifteen coaches and the minimum three coaches. All trains were started on a rising gradient of 1 in 74 in the appropriate notch positions without any difficulty whatsoever, although rail conditions varied between moist and dry. Nevertheless, separate tests on steeply graded routes in the West of England demonstrated that starting from signals on track graded steeper than 1 in 100 proved difficult when a rail tractive effort greater than 0·276 times the nominal adhesive weight was required

to start the load on a dry rail. Since conditions such as occur with hill fog and sea mist are not exceptional, rail tractive effort no greater than 0·24 times the nominal adhesive weight should be used for determining practical maximum loads in such situations.

Referring again to Fig. 6 it will be noted that starting conditions in Notch 4 correspond to a value of rail tractive effort/nominal adhesive weight of 0·276, whilst that of Notch 3 corresponds to 0·224 and Notch 2 to 0·183.

The notch spacings provided, therefore, appear to be too coarse for obtaining that fine balance which is desirable between starting rail tractive effort and adhesion over the practical range of adhesion conditions.

In view of this, arrangements have since been made to add one more notch to future "D.800" Class control equipment, the maximum addition possible without making radical modifications to the apparatus. Moreover, for future types of diesel hydraulic locomotives, it has been decided to adopt a pneumatic engine speed control system which is for all practical purposes infinitely variable.

During the tests of "D.801," test periods under extreme conditions were endured without overheating. Rail tractive effort curves, Fig. 6, may therefore be regarded as

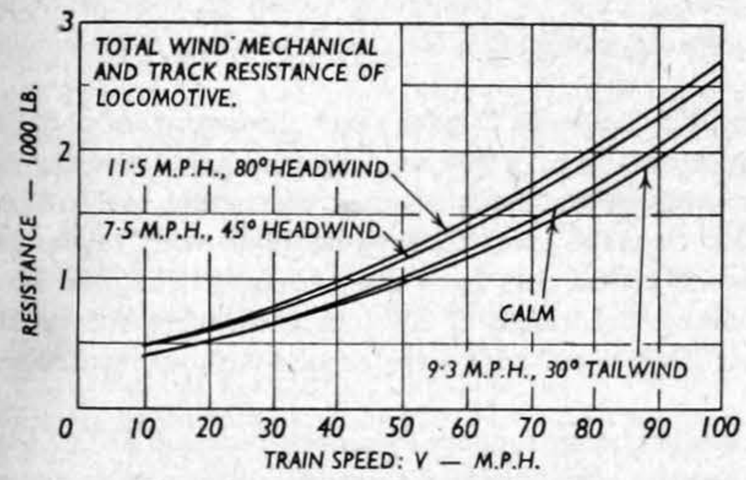


Fig. 7—Locomotive and coach resistance curves

applicable to continuous performance, but balancing speeds under 12 m.p.h. for any appreciable length of time must be avoided. Hence loads are determined not only by what the locomotive will start, but by the speed at which the load can be worked.

The fuel consumption per rail horsepower-hour corresponding to Fig. 5 is given in Fig. 8, a specific fuel consumption characteristic reasonably suited to normal locomotive working.

To conclude this section of the paper it should be stated that the performance on test of locomotive "D.801" was almost exactly that predicted for it from a consideration of the characteristics originally furnished by the engine and transmission manufacturers.

Experience in Service

The first cost of diesel locomotives, irrespective of the type of transmission, is very much greater than that of steam locomotives of corresponding power. If such a high first cost is to be justified, the new form of motive power must have a much higher availability than the old and, of equal importance, advantage must be taken of such high availability. Whilst experience with the "D.800" Class is as yet insufficient to enable a firm assessment to be made, trends are encouraging, as the following statistics for the first five months of 1959 will show :

Class	4 W.E.	Stock	Average miles per day per locomotive	Average hours in service per day per locomotive
Steam :				
"King"	24 January	30	165	5·3
	21 February	30	169	5·7
4–6–0	21 March	30	165	5·6
	18 April	30	159	5·9
	16 May	30	159	5·4
	24 January	165	158	7·3
"Castle"	21 February	163	153	7·6
	21 March	163	152	7·3
4–6–0	18 April	163	149	7·4
	16 May	163	152	7·2
	24 January	12	143	6·3
"Britannia"	21 February	12	179	7·6
	21 March	12	176	7·9
4–6–2	18 April	12	179	8·1
	16 May	12	183	8·2
Diesel :				
"D.800"	24 January	3	385	9·8
	21 February	3	458	13·0
	21 March	4	340	11·0
BB	18 April	4	357	11·0
	16 May	6	369	12·2

Care has been taken to make this comparison as reliable as possible. Because the "D.800" Class locomotives were new or nearly new and therefore spent no time under or awaiting factory repair, the same was assumed to be true for the steam locomotives, the average miles and hours per locomotive per day being calculated from the four-weekly returns by dividing the total miles and hours in service on weekdays by the number of locomotives multiplied by twenty-four in the case of the "D.800" Class and by the same figure less the locomotive-days under or awaiting factory repair in the case of the steam locomotives. Time for servicing and maintenance at depots is not reliably recorded and it is for this reason that average miles and hours per day, ignoring servicing and maintenance, have been given for comparison, the figures indicating clearly the improvements in these respects afforded by the diesel locomotives. There are at present no very reliable means of assessing whether or not the new locomotives are being used up to the limit of their availability, but the fact that they are doing about twice the daily mileage achieved by steam locomotives of corresponding power is of great significance. It is impossible to say how these figures will be affected as the locomotives grow older, because on the one hand availability may tend to fall as the time for a general overhaul approaches, whilst on the other hand it should tend to rise as initial teething troubles, inseparable from any new

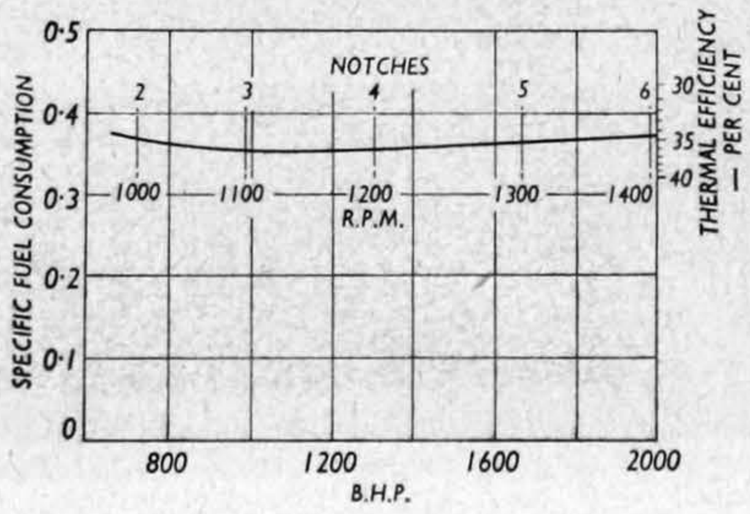


Fig. 8—Fuel consumption curve

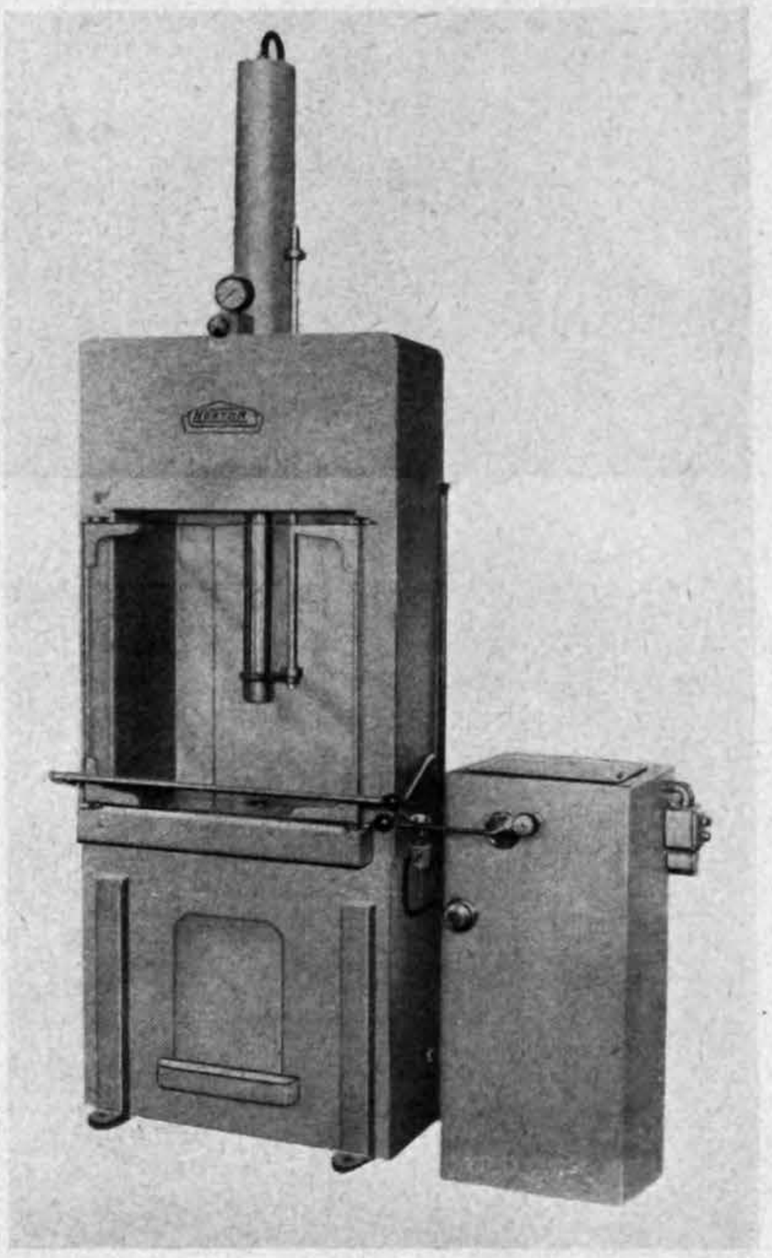
design, are overcome. Also, there is perhaps a tendency to put these first diesels to more intensive use than may be possible when they become available in large numbers, but this simply stresses the need to re-cast the timetables to ensure the best possible utilisation of the new form of motive power and to take the greatest care in diagramming the locomotive services.

Hydraulic Presses

A RANGE of bridge frame general purpose hydraulic presses in six models of from 12 tons to 100 tons capacity is now made by the Norton Tool Company, Ltd., and distributed by Frank Lewis and Co. (London), Ltd., 65, St. Paul's Churchyard, London, E.C.4. These presses incorporate many of the characteristics of the 7½-ton press made by the company and which was described in some detail in our issue of January 30, 1959. Their stroke length is infinitely variable with power return of the ram and they have three pressing and three fast approach speeds with provision for isolating the fast approach when not required. The power cabinet containing all the control gear can be situated any distance from the machine to facilitate remote operation when required.

Optional equipment available provides for pressure sensitive return of the ram, so that the ram movement is reversed immediately a preset pressure is attained, and there is provision for single or automatic cycling with pressure sensitive return. The ram can also be used with a vibrating action giving repeat strokes of any required frequency and length at each working cycle. Bottom ejector rams, die cushions, indexing tables, feed mechanisms, &c., can be fitted as units to a machine if required.

The typical 35 tons capacity press we illustrate



35-ton hydraulic press

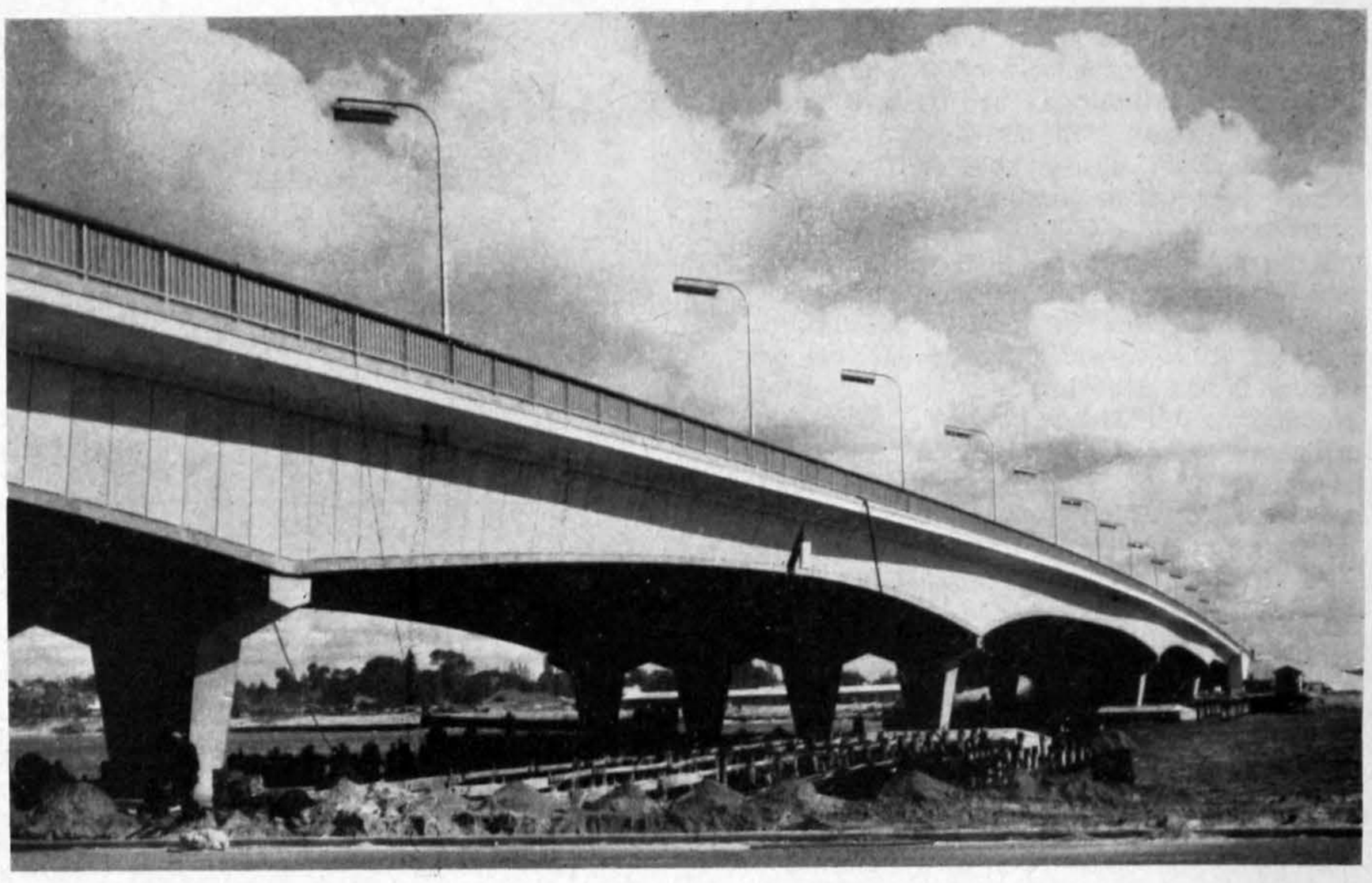
has a 24in stroke with a 24in square daylight in the frame. Its hydraulic pump is driven by a 5 h.p. motor and there are three pressing speeds of 16in, 32in and 48in per minute, with approach speeds of 22in, 46in and 70in per minute respectively, the return speeds being 40in, 80in and 120in per minute. In this and smaller capacity machines the ram speed is directly related to pressure, but in the larger presses the maximum tonnage is available at all speeds.

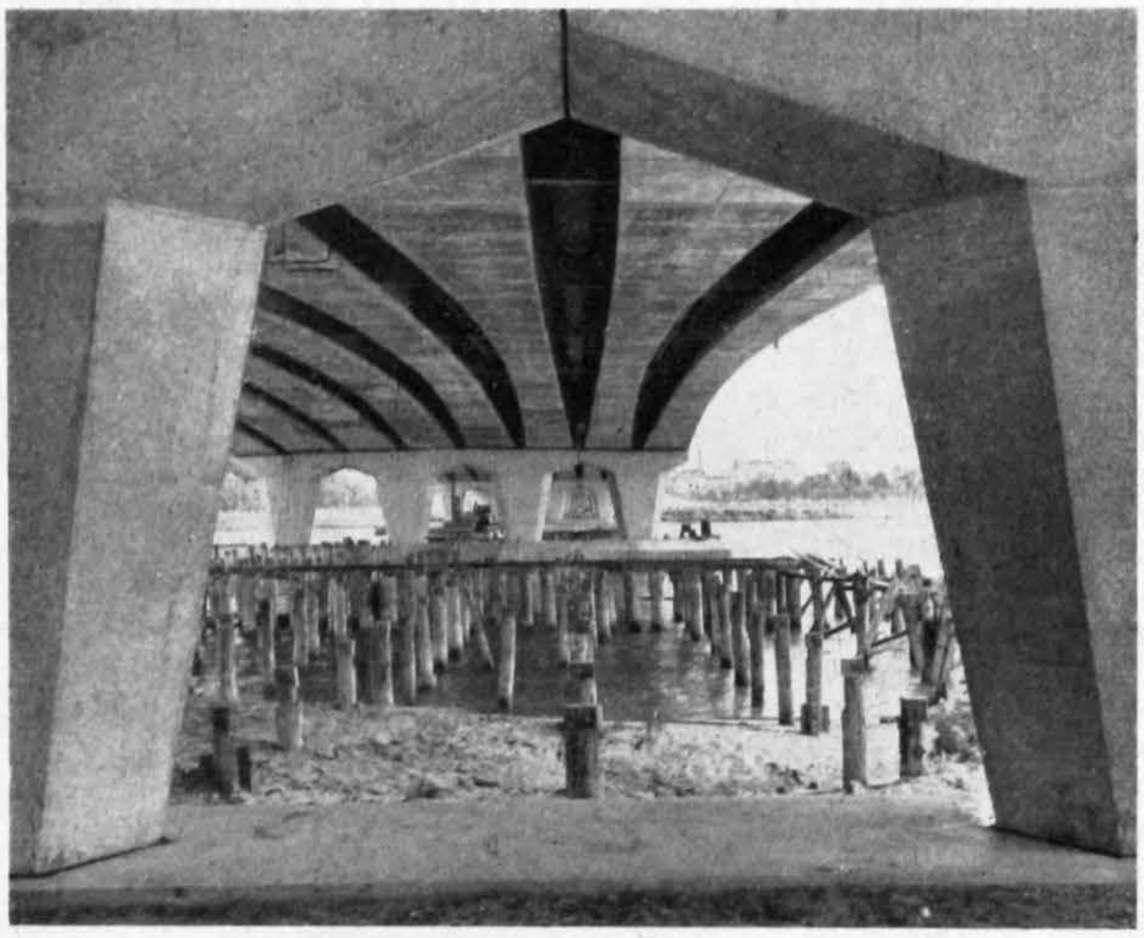
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Narrows Bridge, Perth

The park-like approaches and background of the Narrows Bridge at Perth, Western Australia (RIGHT and BELOW), determined the visual character of the bridge. The slenderness of the deck beams and the whiteness of the facing panels are intended to emphasise the horizontal line of the road, but the great width of the bridge and its low clearance have been played down, the alternation of tapering beams and dark voids breaking up the underside of the superstructure.

The length of the bridge, between faces of abutments, is 1100ft, and the carriageway is 70ft wide. There are 8ft wide footpaths and 2ft wide safety kerbs and fences on each side. The bridge is designed to carry 80 per cent of H.A. loading laid down in British Standard No. 153, and special vehicles of 75 tons, and has in addition to carry five 30in diameter service pipes. In all, the total superimposed load exceeds full H.A. loading plus normal services. The bridge has five spans—of 160ft, 230ft, 320ft, 230ft and 160ft—and is designed to be fully continuous under live load. It is anchored at the north abutment and all expansion movement is provided for at the south abutment. White concrete with exposed white aggregate is used for the facing panels in the spandrels, the abutments and the cantilevered footpaths. The balustrades are of aluminium set in granite.

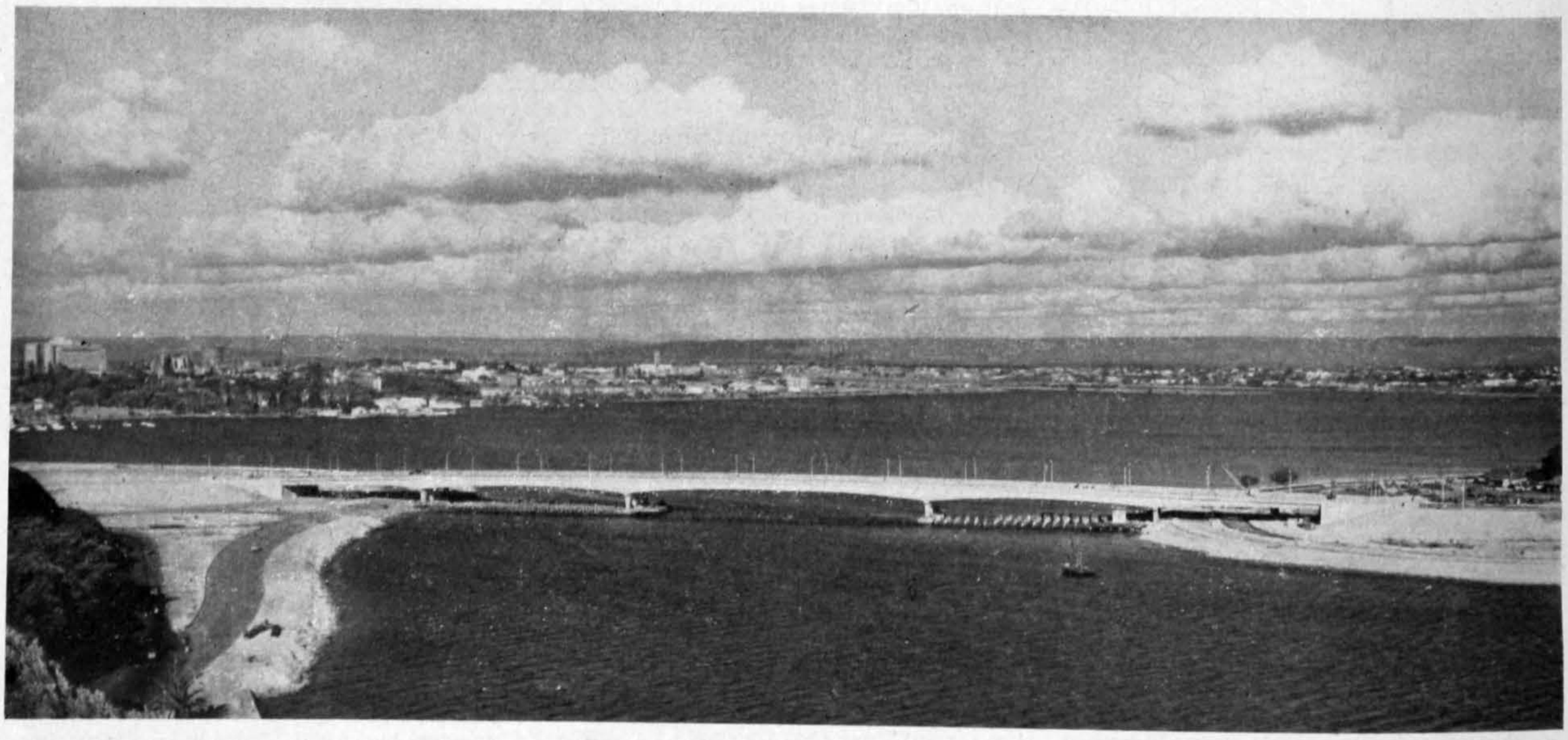




The bridge is carried on 180 "Gambia" piles, each consisting of a 31½in diameter steel tube driven internally by a 10-ton drop hammer delivering its blows on to a removable driving helmet lying on concrete in the toe. After driving to a set in very hard clay, the steel tubes were filled with reinforced concrete ; structural reliance is placed only upon the r.c. core. The piles have been designed to carry maximum dead loads of 200 tons each, increased to 250 tons by transient loads. Test loads of 400 tons were carried without measurable permanent deflection.

The reinforced concrete columns each support two deck beams (LEFT). The columns are set on curved bearing plates and are surmounted by similar plates, so that both top and bottom curves at each pier form part of a cylindrical surface. The columns thus become in effect parts of large roller bearings of diameter equal to the column height, to permit longitudinal movement of the bridge. Transverse movement occurs at nests of 7in diameter roller bearings set in boxes in the concrete under three of every four columns. All bearing surfaces, which have been left dry, are of stainless steel.

A description of the deck structure of the bridge is given on page 655.



Golden Jubilee of Aluminium Production at Dolgarrog

IN the first decade of this century there was a growing interest in the new metal aluminium, the production of which called for low cost water power. The mountainous region of North Wales offered possibilities for the development of both electric power and water supplies, and the water rights in the Dolgarrog area were acquired by the North Wales Power Company. This company sought a good base load for its power and the Aluminium Corporation, Ltd., which was formed in December, 1909, sought a source of cheap power, so a smelter was built at Dolgarrog to link the fortunes of both companies for many years.

Prior to the first world war alumina supplies came from Germany and the aluminium produced, together with surplus carbon anodes, were sold to that country. During the war a small rolling mill, of the modest capacity of 4 tons per week, was laid down and the Corporation became a roller of its own metal. Between the wars the company's financial position permitted a programme of development to be embarked upon and additions were made to the rolling plant and to the number of reduction furnaces, while some 100 houses were built for the employees. Unfortunately, the bursting of the dam on Llyn Eigian in 1925, which buried the works under many feet of debris and caused the loss of several lives, set back the programme. In 1926 the Corporation became associated with The International Aluminium Company, Ltd., and ingot metal for rolling was obtained from its Norwegian subsidiary on favourable terms. Three years later the hydro-electric plant was disposed of to the North Wales Power Company and an agreement entered into for a supply of power at a special rate for a period of twenty years. Meanwhile considerable expansion had taken place in the rolling facilities which raised the capacity to about 3000 tons per annum. This figure was increased to over 5000 tons per annum during the second world war. A major production change occurred in 1944 when large supplies of Canadian ingots became available at a price which made the production of ingot uneconomic due to the high cost of power, and so the furnace room was closed down.

Plans for modernisation of the plant and other improvements were put in hand when the British Aluminium Company, Ltd., became the parent company. However, to-day the Corporation forms part of the Tube Investments, Ltd., group which is associated with Reynolds Metal Company. The latest of the modernisation plans were initiated three years ago when it was decided to replace the old three-high hot breaking down mill, with its limited output, by a modern two-high reversing hot mill and associated handling and coiling equipment.

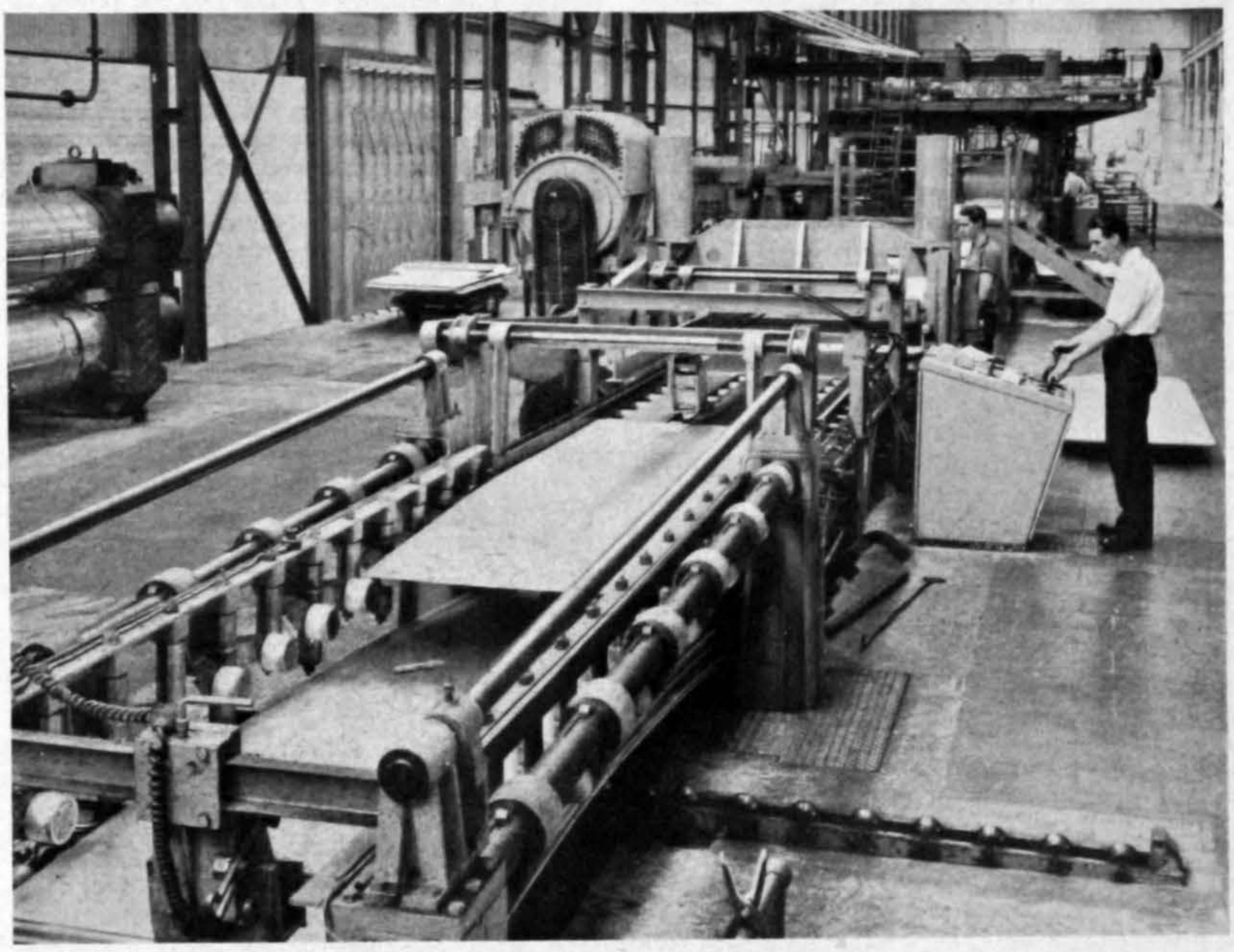
On the occasion of the Golden Jubilee of its founding we were able to visit the works of the Corporation, which occupy a floor space of 210,000 square feet on a site of 26 acres ideally situated in the Conway valley. The position is far removed from industrial atmospheres and the freedom from dust and air pollution helps towards the quality of the company's products.

W. H. A. Robertson and Co., Ltd., manufactured the new hot mill and the English Electric Company, Ltd., supplied the electrical equipment; the installation was completed in time for the celebrations.

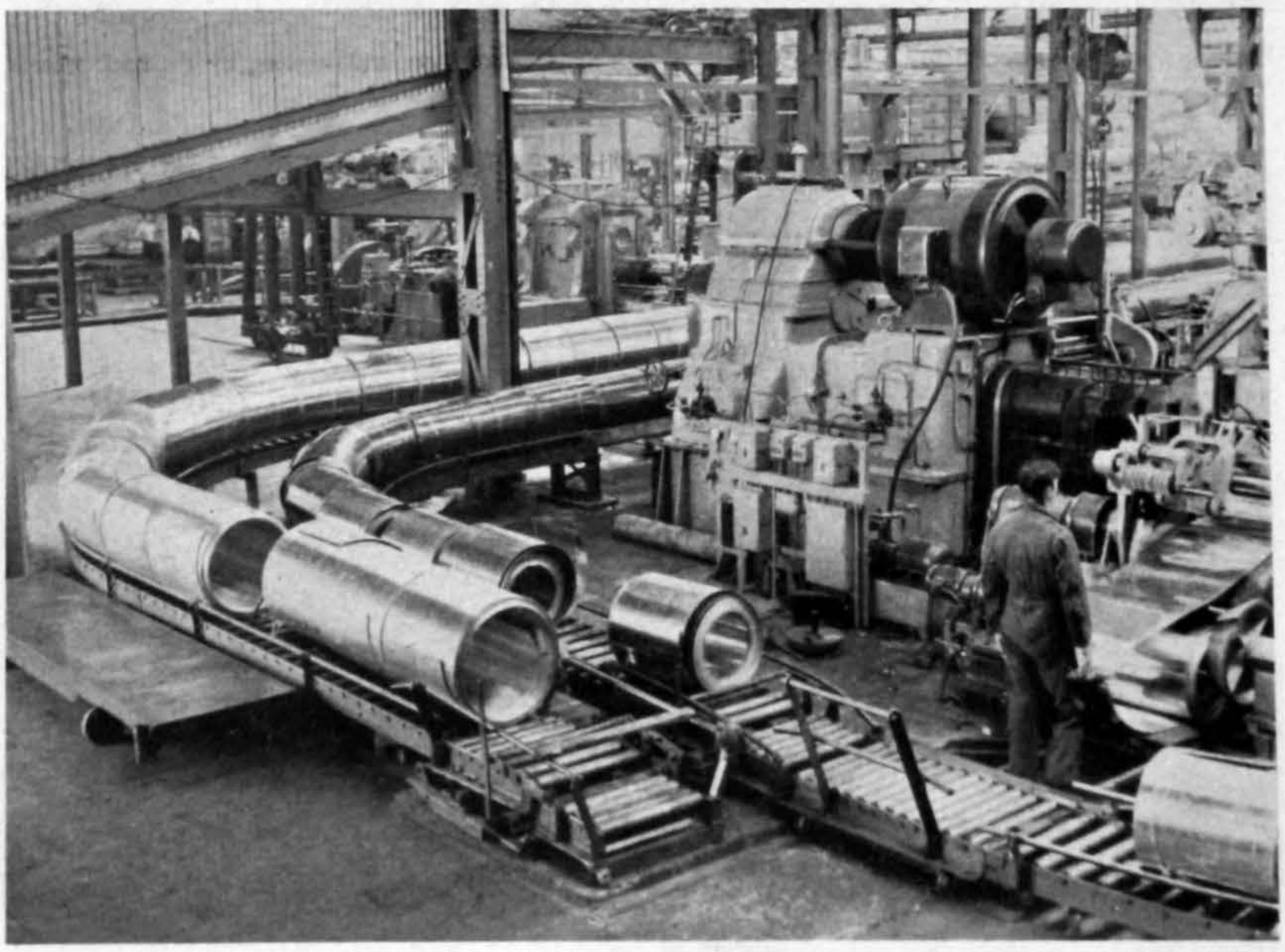
Most of the stock is in 50 lb ingots and a large percentage originates from the new Baie Comeau plant in Canada. The battery of melting and holding furnaces includes some raised on legs to enable the metal to be laundered. The billets weigh about 415 lb and are cast in water-cooled cast-iron chills, and can be rolled direct from the chills, or directed to a 20-ton holding furnace where they are maintained at 500 deg. Cent. ready for rolling. The new 60in by 28in mill has fabric bearings, a rolling speed of 350ft per minute, and a production of up to 5 tons of hot rolled strips an hour, and is equipped with a hydraulic roll changing rig which enables a roll to be changed in one and a half hours. There are also hydraulic manipulators for billet centring. There are run-out tables on each side of the mill, one for strip of 52in maximum width, and the other for sheet material. At the end of the strip table is a Bigwood cropping shear and a Robertson edge trimmer, slitter and drum coiler, while at the end of the sheet table is a Bigwood cropping shear, conveyor and piler. This end of the mill is shown in our illustration.

The main drive of the mill is by an 800 h.p. d.c. motor, having a speed range of 150 to 300 r.p.m., which is fed from an Ilgner set consisting of a 1000 h.p. motor working at 985 r.p.m. and a 670kW d.c. generator. Also supplied by the English Electric Company, Ltd., were the auxiliary drives for: the mill roll screw down gear; the mill tables and for the breast rolls which feed the billets into the main rolls; the shear tables and the piler tables. An extension from the main building houses the electrical drive, auxiliaries and switchboard and this space is air conditioned.

The coiled strip receives further working in a compactly arranged three-stage strip mill, part of which we illustrate, which deals with coils having a width up to a maximum of 28in, the usual width being 22in. The layout of the mill



Automatic piler handling hot rolled sheet blank from two-high hot mill



Ingoing side of the three-stand, two-high cold strip roughing mill

permits flexibility of working and the strip can be passed twice through No. 1 mill after which it is annealed and passed two or three times through No. 2 mill, again followed by annealing, and is then finished in No. 3 mill. The annealing furnaces were manufactured by the Electric Resistance Furnace Company, Ltd. The sheet mill is a three-stand, two-high line, part of which is being adapted to take a drive through gearing supplied by David Brown and Sons (Huddersfield), Ltd.

As is natural, the village of Dolgarrog is closely linked with the works and indeed most of the houses are owned by the Corporation and occupied by their employees. With the installation of the new mill and the virtual completion of the reorganisation of the works, the Aluminium Corporation, Ltd., backed as it is by the technical, commercial and financial resources of the Tube Investments, Reynolds, British Aluminium Group, is well equipped to satisfy market demands.

Wheeled Loading Shovels

WHAT are believed to be the first loading shovels moving on four driven wheels to be manufactured in Great Britain are now offered by F. E. Weatherill, Ltd., Welwyn Garden City, Herts. The shovels differ greatly in the details of their design, and in some cases use a patented shovel linkage for which unique advantages are claimed.

The smallest of the three new shovels is the "L-60," an enclosed machine which, as our illustration shows, resembles superficially the existing Weatherill Hydraulic equipment. However, the back instead of the front wheels are now steered, thus lessening the demand for power in the loaded case when most of the weight is on the front wheels. The power unit remains the Fordson "Power Major" of 62 h.p. at 2200 r.p.m., mated with a Brockhouse turbo-transmitter and power-operated two-speed-and-reverse gearbox : the Weatherill transfer box distributing the drive to the rear and, optionally, front axles can be given a ratio of 1·09 or 1·51 by assembling with alternative gears. The axles are Michigan products, with the final reduction by planetary clusters in the hubs : the front wheels have hydraulic brakes.



Loading shovel based on Fordson "Power Major," with all wheels driven and steering by the back wheels



Loading shovel with Rootes-Lister three-cylinder oil engine : notice the bucket linkage, which derives a crowding action from the initial motion of either pair of rams

The "L-62" and "L-64" are open cockpit machines with the operator sitting at the front amid the linkage ; cabs are optional extras. The two differ in size and in their operating characteristics, one having an air-cooled four-stroke engine, the Ruston 4YDA of 85 h.p. at 2000 r.p.m., and the other a liquid-cooled two-stroke, the Rootes-Lister TS-3 of 108 h.p. at 2000 r.p.m. Both have a Twin Disc 15in torque converter and a Weatherill transmission with two two-speed trains and a forward/reverse train, the close-ratio and the reversing change being "hot" by hydraulic power and the wide ratio change and front wheel drive selection being by toothed clutches manually engaged. The axles are Kirkstall on the smaller and Mack on the larger unit, and air brakes are fitted to all wheels.

Our illustration shows that the shovel linkage on the "L-64," which is common to the "L-62," differs significantly from that of the normal control model. Both are shown carrying material with the bucket fully crowded, but whereas on the "L-60" the scoop rams are fully compressed, implying that crowding was achieved by loading the rams in tension, on the second machine the scoop rams are half open. While the bucket could be levelled or depressed by extending the rams further, the intended method of operation is to fill the bucket with the rams fully closed and then crowd by opening the rams : loading the rams in tension is thus avoided, lessening the pressure needed for a given effort and reducing the duty of the seal on the exposed piston rod. The geometry is so arranged that when the bucket is lowered on to its stops and the scoop rams are closed, the bucket is set level at just below the tangent plane of the wheels, so that it will strip turf without digging in or climbing out. To dig deeper, it is possible, as mentioned above, to extend the scoop rams to and past the crowd position and tilt the bucket steeply, but the preferred technique is to withdraw the bottom stop for the lifting arms and lower the bucket bodily. When the bucket is filled by the correct method, crowding occurs automatically—i.e. without movement of the scoop rams—as the bucket is lifted to the carrying height : it is anticipated that with loose materials such as are found in stockpiles, the hydraulic crowd will not be necessary. Were the bucket to be lifted past the carrying height with the crowding bell-cranks depressed, the bucket would tilt backwards and possibly spill the load on the driver : a cam on the lifting arms is therefore arranged to force the "lift" selector forward as far as neutral when the carrying height is reached, this cam being withdrawn when the cranks have rotated to the crowd position. When the bucket is fully raised it is emptied by allowing the scoop rams to open fully, the sense of response of the scoop angle control changing as the crowding links move across the pivot of the bell-cranks. In general, the whole of the linkage is protected against damage due to the operator forcing it to the end of its travel.

As well as the buckets illustrated, the machines can be equipped with bulldozer blades, lifting forks, crane hooks, or snow ploughs. All the external working parts are provided with unprotected grease nipples.

Details of the specifications are tabulated below.

Model	"L-60"	"L-62"	"L 64"
Weight, lb	14,560	17,300	20,400
Safe working load, lb ..	3,400	4,000	5,000
Capacity of bucket, heaped cubic yards	1⅓	1½	2
Capacity of bucket, struck, cubic yards	1	1¼	1⅜
Maximum dumping height, feet	9½	9½	9¼
Maximum load-over height, feet	11½	11⅜	11½
Maximum reach, feet	5¼	4½	5
Tyres	12·00×24 8-ply	14·00×24 8-ply	14·00×24 16-ply
Top speed, m.p.h.	13½ or 9½	24	24
Hydraulic pump capacity, gallons per minute	21	33	40
Width, excluding bucket, feet	7¼	8¼	8¼

Electronic Telephone Exchange Experiments

AN experimental electronic telephone exchange incorporating some of the techniques already applied in subscriber trunk dialling is undergoing exhaustive tests at the Post Office Research Station, Dollis Hill, London. When these tests have been completed, equipment for about 1000 lines will probably be installed within two years for the public exchange at Highgate Wood, in North London.

The experimental exchange, which we inspected on November 10, is a result of co-operation



Fig. 1—Part of rack containing subscriber line units and associated switching equipment

between Post Office research and private industry. Before the inspection the Postmaster-General, Mr. Reginald Bevins, recalled that in 1956 the Post Office and five manufacturers had agreed to pool their resources in order to explore the possibilities of electronic techniques, together forming the Joint Electronic Research Committee. The work on which they were engaged offered the prospect of much smaller and less obtrusive telephone exchanges, which might even be situated underground.

Sir Lionel H. Harris, engineer-in-chief of the Post Office, said that the present electro-mechanical exchange equipment had reached a stage of near-perfection which precluded further important advance. Electronics were necessary for continuing development and were the means of conforming with the trend to higher frequencies and faster operation in communications. There might be greater integration between transmission equipment and the exchanges. There were already requirements for high-frequency cable circuits for data-processing, television signals and so on, and it was possible that higher frequencies in local communications would be useful.

The exchange equipment was then inspected in the laboratories. In this installation functional divisions have been used as the basis for the collaborative development. The multiplex and speech circuit equipment have been designed jointly by the Post Office and The General Electric Company, Ltd.; the supervisory equipment by Ericsson Telephones, Ltd.; the register equipment by Siemens Edison Swan, Ltd., and the translation, metering, line information and other equipment jointly by Automatic Telephone and Electric Company, Ltd., and Standard Telephones and Cables, Ltd. Similar divisions of responsibility and manufacture will occur in the Highgate Wood public exchange installation of which the Dollis Hill model is the laboratory version. The five companies together form a substantial industry employing over 800,000 persons and each is supported by a fully-equipped research organisation. Their range of manufacture in the telecommunications and allied fields is extensive, and all offer integrated communication systems for use in any part of the world.

A fundamental difference between the electro-mechanical and the electronic exchange is that in the former every call monopolises a direct electrical path through the exchange while it is in progress. In the electronic exchange, equipment is shared on a time-division multiplex system governed by a 1Mc/s crystal-controlled oscillator. The oscillator output is fed to pulse-shaping circuits and the resultant pulses control gate circuits so that a large number of conversations can use a common speech path by the opening and closing of the gates linking any two subscribers in a cycle occupying 100 microseconds, during which each speech circuit is connected for 1 microsecond. Thus 100 speech circuits are available for each multiple group, but many more can be connected in practice because not all will be using the telephone at the same time, and in a typical electronic exchange working in this manner up to 800 subscribers could be connected in one group. Further capacity could be provided by additional groups interconnected by gates.

There is a line unit (Fig. 1) for every subscriber. The lifting of a handset puts a loop on the subscriber's line and is detected at the exchange in the course of a continuous 28-millisecond scan of all subscribers. A pulse is then allotted by the channel selector and put into store. Dialling causes amplitude-modulation of the allotted pulse so that information on the number required is passed to the register.

Every line unit is allocated a particular area on the surface of a magnetic drum storage device (Fig. 2) which rotates continuously at some 2140 r.p.m. Part of this area records permanent information necessary for routing a call, and so the opening of the "gate" from the common highway in the exchange to the wanted subscriber's line is effected by co-operation between the register, the drum, and associated translator equipment.

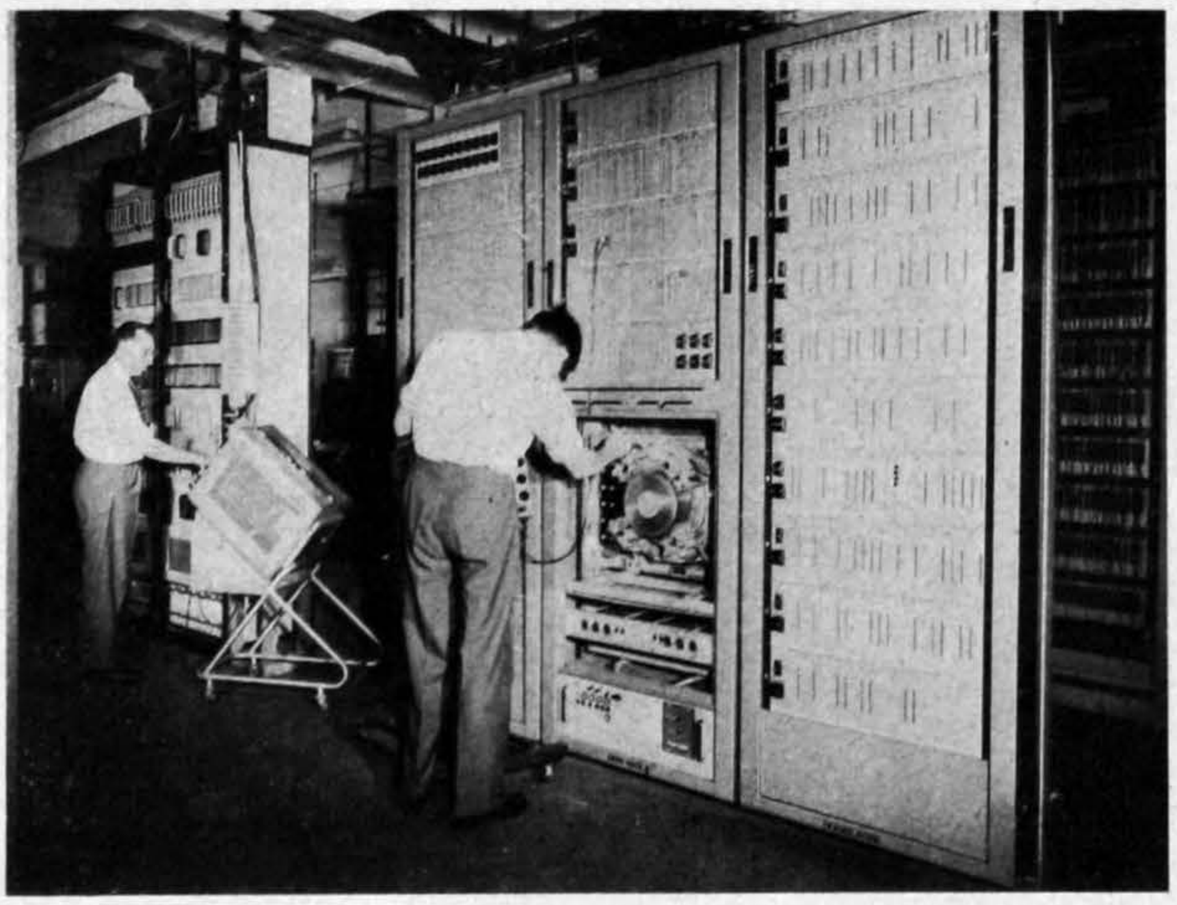


Fig. 2—The magnetic drum with associated translator equipment for routing calls and, in background, the register equipment into which wanted numbers are dialled

The "memory" features of the equipment can be classified as temporary and semi-permanent. Magneto-strictive delay lines are used as temporary memories for storing the pulses which have been allocated to the subscribers' gates for connection to the highway, and also for controlling the gates interconnecting the highways. They also form the registers which receive information dialled by subscribers. They count and store the dialled pulses, obtain any translations which are necessary to route calls to other exchanges and transmit digit pulses when outgoing routes are established. Delay-lines also control the supervision of connections after they have been established. They connect tones to the calling lines and ringing to the called lines at appropriate times, detect answering and clearing and arrange for the metering of successful calls.

The magnetic drum mentioned above constitutes a semi-permanent memory. It carries all the information relative to all subscribers' lines and junctions, acting in this respect as the exchange library. Another portion of the drum co-operates with the register as described by providing translation facilities for routing the call either to a local subscriber or to subscribers on other exchanges. Positions on the drum particular to each subscriber are used to record the accumulated total of unit fee registration debited against the subscriber and as such replace the individual electro-mechanical message registers provided per subscriber in existing systems. Such accumulated total can be read from the drum as and when required for subsequent automatic accounting for the final subscriber's account.

It is emphasised that the present experiments still have much ground to cover before widespread conversions to electronic switching could be contemplated. Apart from the electronic techniques themselves, functions such as handling pulses of a few microvolts through plug and jack connections have been found to raise considerable problems. The investigations at Dollis Hill are also looking beyond the exchange equipment itself to the possibilities of a time division multiplex system for economy in external line circuits.

Electronic Forum for Industry

PUBLICATION of a new bulletin by the Electronic Forum for Industry coincided with the forum's second open day held on November 11 at the premises of I.C.T., Ltd., 88, High Holborn, London, W.C.2. The first number of the *E.F.F.I. Bulletin* contains illustrated articles based on papers read at the forum's first open day earlier this year. A foreword by Lord Brabazon of Tara expresses confidence that the bulletin will do much to dispel the attitude of some industries that electronics is "interesting but not up their street." Further comment on the need to spread knowledge and understanding of electronics was made by the chairman of the forum, Mr. Clifford Metcalfe, in his address at the open day on November 11 to representatives of twelve industries which are users or potential users of electronic equipment. Mr. Metcalfe said an easier analogy must be found for explaining the working of electronics to busy people. Electronics, he continued, demanded a partnership between the producer and the user which must be much more complete than it was when mechanical equipment was the order of the day.

Subjects covered in the first issue of the *E.F.F.I. Bulletin* include industrial mathematics, the use of the computer "service centres" established by manufacturers and certain other bodies (a list of which is given), analogue computer aids to industry, and data reduction in the aircraft industry. The bulletin, which is to be published at irregular intervals, is obtainable from the Electronic Engineering Association, 11, Green Street, London, W.1.

SHORTER REPORTS

Institution of Engineers and Shipbuilders in Scotland

DURING the past summer alterations have been going on within the headquarters building of the Institution of Engineers and Shipbuilders in Scotland. The greater part of the first floor has been reconstructed and by that means a bigger meeting hall has been created. It has theatre-type seating and there is a projection box. This new hall will seat 160 people and will be used not only for the Institution's own meetings but also by a number of other societies. It is illustrated below and it is to be named the Weir Hall, in memory of the late Lord Weir, who had been an honorary member since 1921. A generous donation from Lord Weir made the present reconstruction possible. A new Council Room has also been formed—it is also illustrated below—and the opportunity has been taken to provide a more commodious kitchen. Mr. J. Bell, of Messrs. Frank Burnet and Boston, was the architect.

Traffic Engineering Study Group

THE Institution of Civil Engineers arranged a special meeting last March, when the question, "The Place of Traffic Engineering in the Institution," was discussed.* The outcome of this meeting has been the forming of a traffic engineering study group and membership of the group, which is open to members of the Institution and non-members professionally concerned with traffic engineering, is now 458, consisting of 340 members of the Institution and 118 non-members.

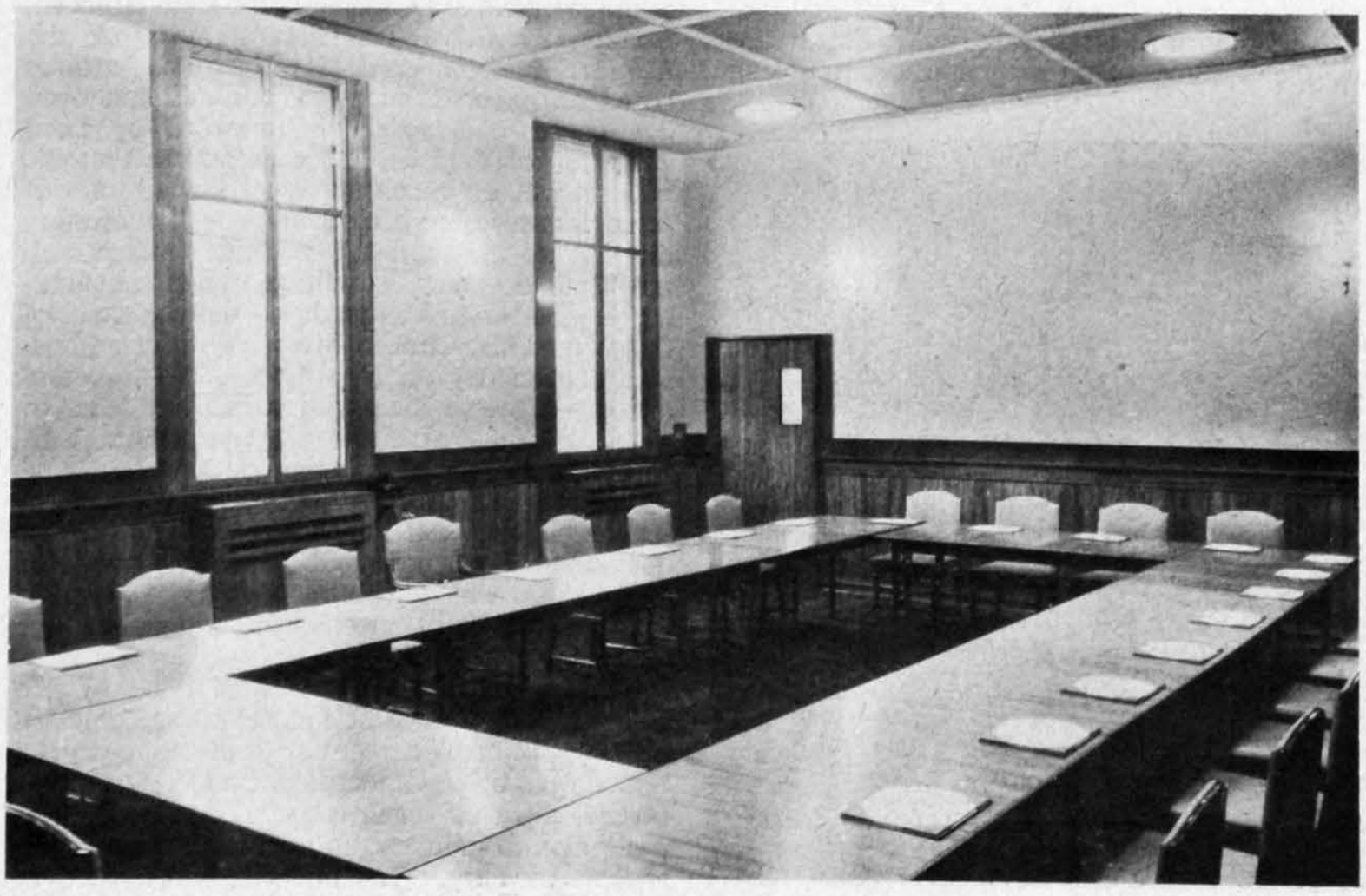
The objects of the group are given as : (1) to promote the general advancement of the science of traffic engineering ; (2) to foster papers and other communications for submission to the Institution, and to recommend suitable subjects or authors ; (3) to arrange visits ; (4) to provide a forum where members and others who are professionally interested may meet to discuss problems in traffic engineering.

During the present session, the group has arranged five meetings, as follows : November 19, "Urban intersections, with particular reference to the design of Highbury Corner," introduced by Joseph Rawlinson ; December 10, "Standards of design of rural roads," introduced by J. T. Duff ; January 21, "The development of traffic engineering in London," introduced by A. J. H. Clayton ; February 23, "Junction design on motorways," introduced by J. G. Smith ; March 29, "Parking," introduced by Rowland Nicholas.

* See THE ENGINEER, March 13, page 407.



The new meeting hall of the Institution of Engineers and Shipbuilders in Scotland has been named the Weir Hall, to commemorate the late Lord Weir



Reconstruction within the Institution Building has led to the creation of the new Council Room illustrated here

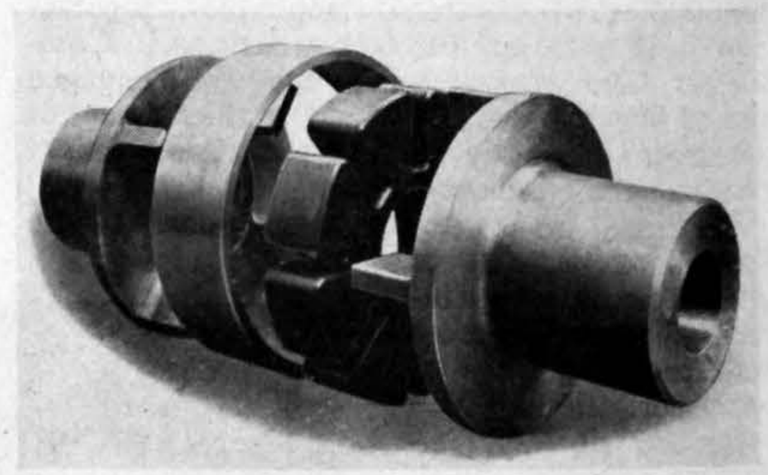
Student Exchanges

THE twelfth annual report of the International Association for the Exchange of Students for Technical Experience (I.A.E.S.T.E.) records that this year 5865 students have been exchanged between twenty-four member countries. The number of students is 471 higher than last year but it is below the record total of 5914 achieved in 1957. The report says that the increase this year has been due partly to Poland, which country, in its first year of participation in the scheme, has sent 190 students abroad and has received 159 students. But in part, of course, the increase reflects the improving economic situation in most of the member countries. Since the establishment of I.A.E.S.T.E., 45,861 students have participated in the exchanges. This year, 2910 industrial concerns have received students.

A report on the Association's work in Great Britain indicates that, during the recent summer vacation, 854 students were received from and 837 students were sent to countries overseas, the comparable figures for last year being 829 and 774 respectively. In this country, 366 industrial companies and organisations have co-operated this year in the Association's work.

Flexible Couplings

THE "Holset" rubber spider type coupling illustrated has been designed by the Holset Engineering Company, Ltd., Turnbridge, Huddersfield, for heavy duty coupling applications where the drive is by flange-mounted motor units. It is a development of the maker's standard rubber block coupling and in it the rubbers are moulded in the form of a spider,



Flexible coupling of rubber spider construction suitable for use with flange-mounted motor drives

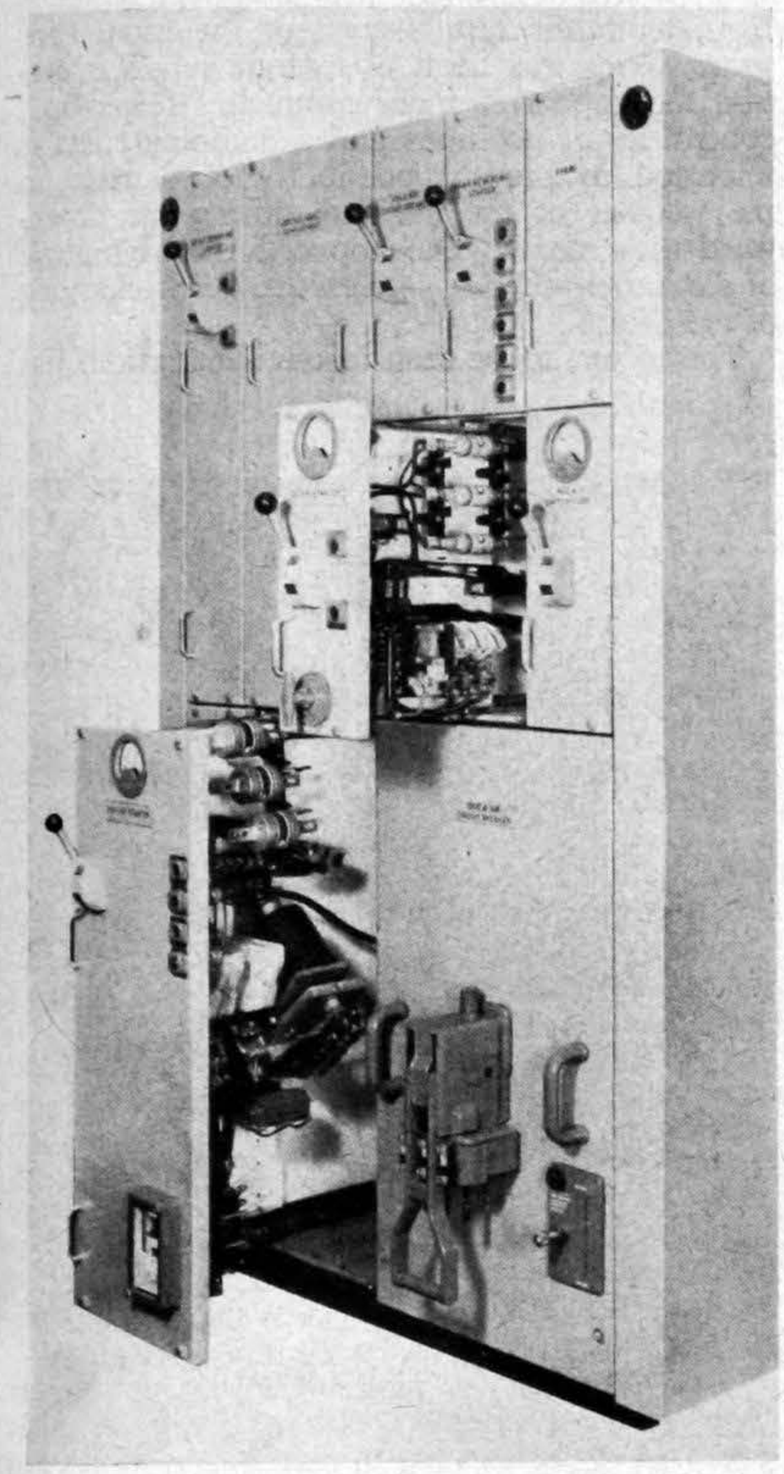
there being no bolted connection. Couplings to this design are available for up to 22 h.p. at 100 r.p.m.

This form of construction is particularly suitable for the blind assembly of a flanged motor to the housing of a driven machine, installation being effected by the axial movement only of one of the connected machines. The coupling uses rubber in compression and is claimed to have good shock absorbing properties and capacity for misalignment. The small overall size makes it useful for such applications as in rolling mill run-out table rollers where the coupling and motor may be under the floor. The fact that lubrication is not required is helpful in these and other drives where access is difficult.

[Reply Card No. E6524]

Multi-Motor Control Centre

WE illustrate a new multi-motor control centre which has been developed by the Motor and Control Gear Division of Associated Electrical Industries, Ltd., at Rugby, and has successfully completed tests under fault conditions



This multi-motor control centre provides for the grouped control of a number of circuits. It can house starters up to 250 h.p., switch fuses up to 400A and air-break circuit breakers up to 1600A

at an A.S.T.A. testing station. This multi-motor control centre (MMC series 1000) is designed to provide flexible means for the centralised control of medium voltage motors and distribution circuits up to 600V, three-phase ; it can accommodate starters up to 250 h.p., switch fuses up to 400A and air-circuit breakers up to 1600A. Each outgoing circuit is protected by a 440 A.C.5 h.r.c. cartridge fuse.

As can be seen from the illustration each individual control equipment is mounted on a tray in a separate compartment. The back of the cubicle provides access for cabling. Each tray is mounted on telescopic roller guides for easy withdrawal and the fixing holes in the tray supports are slotted. There are four standard sizes of equipment tray using a basic width module of 8in and they cover motor starting duties up to 250 h.p. per tray, switch fuse feeders up to 400A per tray, or air-circuit breakers up to 100A per tray. Air-circuit breakers rated between 100A and 1600A are mounted on withdrawable trucks. For duties such as rotor contactor panels a hinged door can be fitted over a section of the board, the required components being fitted on a fixed panel behind the door.

Any control connections to the equipment trays are brought out by flexible leads to split detachable connector blocks with spring loaded silver plated contacts in the outgoing terminal chamber.

Two sets of h.c. fully enclosed copper busbars are mounted centrally on the top of full-height equipment ; a single set of fully-enclosed busbars is mounted at the top of half-height equipment. The busbars carry caliper finger plugging contacts to mate with plugging stubs on the equipment trays. The caliper fingers are shrouded by moulded insulating covers and there is provision for padlocking the built-in shutter gear. A range of busbars is available with a maximum rating of 717A per phase.

The isolating switch is a slow-make quick-break equipment driven from the front of the panel by a lever operating handle which can be padlocked " On " or " Off." Mechanical interlocking of the switch mechanism prevents withdrawal of a tray when the switch is closed. To prevent the switch being opened by fault current forces the mechanism is toggle locked in the " On " position. The moving contact fingers of the switch mate with fixed contacts in a heat-resisting ceramic arc box fitted with phase barriers and the fingers form outgoing main current plug-and-socket connections from the tray. Isolation of the auxiliary circuits is effected by auxiliary switches driven from the isolating switch mechanism.

At the A.S.T.A. testing station the control centre was subjected to through fault tests on the different busbar arrangements available at various fault levels with a maximum of 49·7kA symmetrical R.M.S. for three seconds. Thus the board can be offered with a tested through fault rating of up to 55MVA at 660V for three seconds. Further tests with 440 A.C.5 fuse cartridges in the drawout equipment trays and with a fault simulated at the outgoing terminals were made when connected to a 440V system having a prospective fault current of 46kA.

[Reply Card No. E6531]

British-Built Outboard Motors

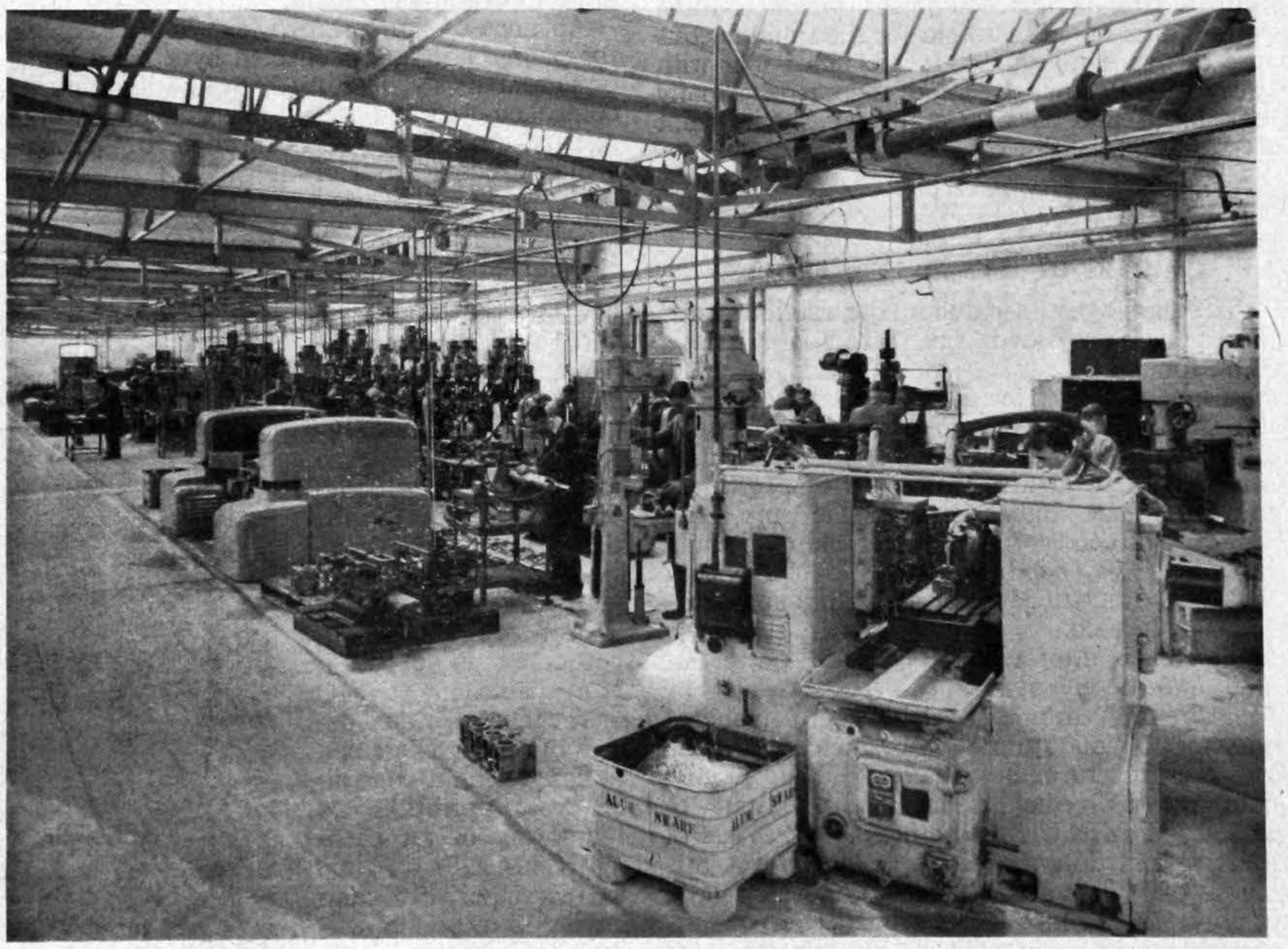
A PLANT for the manufacture of outboard motors has now been put into full production at a new factory acquired by Perkins Outboard Motors, Ltd., a subsidiary of F. Perkins, Ltd., at Peterborough. These outboard motors are to a design developed by the Oliver Corporation of the United States, and some time ago Perkins Outboard Motors, Ltd., acquired the full design and manufacturing rights together with the bulk of the tooling and production equipment from the American company. All motors of this design are now manufactured by the British company, and their marketing carried out under the world-wide sales organisation established by F. Perkins, Ltd., for its diesel engines.

A note on the motors was given in our issue of January 30 last. Briefly, they are made in three models of 6 h.p., 16 h.p. and 35 h.p., and are of water-cooled, two-cylinder, two-stroke design developing maximum horsepower at 4500 r.p.m. On the two smaller engines a reed valve is fitted in the power head but the 35 h.p. engine has poppet inlet valves to the crankcase. These poppet valves, in addition to ensuring a smooth flow of power at normal operating speeds regardless of varying atmospheric pressure are stated to be inherently quieter than reed valves and to increase initial acceleration. Power is transmitted to the propeller through a vertical shaft and a forward-neutral-reverse gearbox. In introducing the engines the makers point out that, although they are used in most cases for the propulsion of pleasure craft, their design and efficiency suits them for a wider range of application, in what might be termed light " working craft " such as those for passenger and cargo transport or fishing duties.

The new factory has a floor area of some 150,000 square feet and the plant at present in service has a capacity for the production of some 40,000 motors a year. A general impression of one of the machining lines is given in the photograph we reproduce. Under the system of flow production followed in the machining lines most of the machines are supplied with three sets of interchangeable tooling and fixtures to suit each of the three different models of motors made. The sales demands determine the length of time a particular model of engine is maintained in production on the machine lines, it taking about two days to change over progressively all the machines from one model to another. In addition to a number of standard in-line machines of British manufacture which have been installed a number of special purpose machines were acquired from the United States, completely tooled up for the production of parts.

After machining and inspection, parts are transferred straight across the shop floor to the assembly section where special fixtures have been installed to facilitate unit assembly and the subsequent building-up of the motors. When completed, each motor undergoes dynamometer and running tests in a separate water-tank shop before release to the despatch stores. With the system and equipment at present installed 150 motors can be completed in an eight-hour shift by 150 operators and there is sufficient floor space available for the introduction of new plant to increase considerably this output as demand for the motors expands. It is of some interest to note that although the firm has been building these motors for only a little over a year a substantial reduction in their price has already been effected with the attainment of full production.

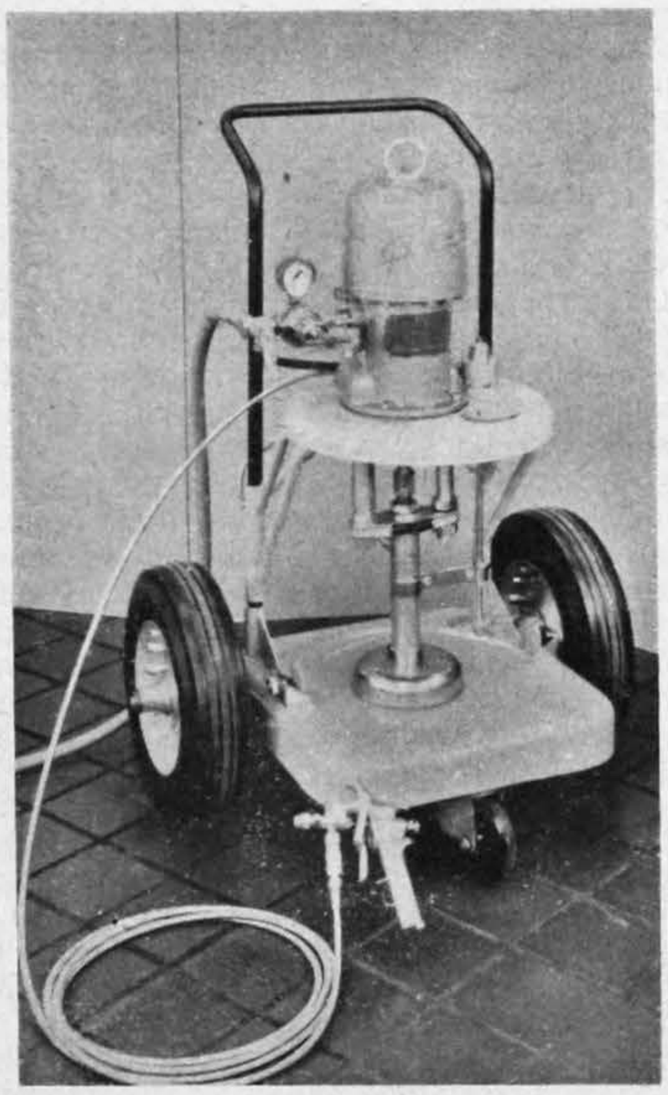
[Reply Card No. E6532]



Engine block machining line

Paint Spraying Equipment

IT was recently announced that the firm of Alfred Bullows and Sons, Ltd., Long Street, Walsall, had been appointed distributor in the United Kingdom for the American "Hydra-Spray" painting equipment. With this equipment paint under very high pressure is delivered directly from a gun, and compressed air is not used to atomise the paint as is the usual practice. A truck-mounted equipment now being made is shown in the illustration below.



Truck-mounted "Hydra-Spray" set

A hydrostatic pressure of some 1600 lb per square inch is attained in this particular set by the coupling of a double-acting air motor to a reciprocating double-acting pump. This pressure is confined to the pump and a 20ft length of stainless steel wire braid-reinforced plastic tubing coupled to the spray gun. The gun itself has a tungsten carbide nozzle to resist the erosion effect of abrasive paint when under high pressure. The paint container, which contains an agitator, is not at any time subjected to pressure.

If required, up to 80ft of paint hose can used with a gun on this equipment, which is fitted with a dual outlet manifold for the simultaneous use of two spray guns. It is claimed that with this form of paint spraying over-spray is virtually eliminated and a considerable saving in paint is attained.

[Reply Card No. E6541]

Launch of T.S.S. "Oriana"

THE passenger liner under construction at the Barrow-in-Furness works of Vickers-Armstrongs, Ltd., for the Orient Line was named "Oriana" and launched by Her Royal Highness Princess Alexandra on Tuesday, November 3. A total of 638 first-class and 1496 tourist-class passengers will be carried at a service speed of 27½ knots, and the main dimensions of the ship are: length between perpendiculars 740ft, breadth moulded 97ft, depth moulded to "E" deck 41ft 9in, draught 31ft 6in and gross registered tonnage 40,000. Denny-Brown stabilising equipment is fitted and the electrical power for ship and hotel services will be provided by four 1750kW turbine-driven generators, one of which is a standby unit. For air conditioning purposes four turbine-driven centrifugal "Freon" compressors having a maximum output of 22,000,000 B.Th.U. will be fitted. Two sets of double reduction geared triple expansion turbines, of "Pametrada" design, developing a total of 65,000 s.h.p. at 147 propeller revolutions per minute in service will propel the ship and be capable of 80,000 maximum shaft horsepower at 157·5 propeller revolutions per minute. Steam will be generated at 960 deg. Fah. and 750 lb per square inch gauge at the superheater outlet by four Foster-Wheeler watertube boilers burning oil fuel under balanced draught. The machinery includes a Weir closed feed system and a Weir double effect sea water evaporating plant.

Small Centreless Grinder

A SMALL precision centreless grinding machine having a nominal capacity from 0·020in to ⅝in diameter has been introduced by Arthur Scrivener, Ltd., Tyburn Road, Birmingham. It has been designated the Wickman-Scrivener No. 0, and is illustrated below. The machine has a maximum wheel opening of 1⅜in and takes a 12in by 3in grinding wheel and a 7in by 3in control wheel. The grinding wheel is driven by a 5 h.p. motor and runs at 1806 r.p.m., whilst the control wheel, driven by a 0·75 h.p. motor, has three working speeds of 23, 30 and 39 r.p.m.

The base of the machine is of cast iron, and the grinding wheel head is integral with the superimposed heavy bed, as are the workrest seating, the main slideways, and the grinding wheel truing-slide base. The grinding and control-wheel spindles of nitralloy steel run in plain hard-bronze bearings and are protected by a safety device which automatically stops the main motor if the oil supply to the bearings should fail.

The normal main-slide construction includes long dovetail ways to guide and support the control-head slide, but is an anti-friction main slide incorporating ball-slides optionally available. A microsizer unit, when fitted, conveniently provides push-button incremental advance of the control head by tenths up to 0·0005in.

Separate hydraulically-operated power-truing attachments are provided for each wheel, enabling any desired profile (straight, taper, or form) to be obtained by fitting the necessary former plate. On the grinding wheel side, the attachment is ball-bearing-mounted to enable steep slopes to be climbed with ease, and to permit accurate following of extreme forms. On the control-wheel side, the attachment is fitted to the fixed member of the control-head slide, so that truing slide and diamond always move in a horizontal plane substantially parallel to the grinding wheel. Provision is made for the stepless variation of the traverse rate of both diamonds and this, as well as the direction of traverse, is under centralised hydraulic control by a single valve conveniently situated at the operator's left hand.

Advance of the control wheel and workpiece for plunge grinding is effected by a hand lever, or automatically, if desired, by the addition of controlled-cycle equipment. The universal workrest is used for straight-through or plunge-grinding, change-over of the workplate itself being quickly effected. By use of a workrest coupling the workrest can instantly be connected with, or disconnected from, the control-head slide. This facilitates adjustment of the workrest from time to time to follow up grinding-wheel wear. Whilst the main in-feed handwheel is graduated in increments of 0·001in, a fine-feed attachment graduated in 0·0001in is available.

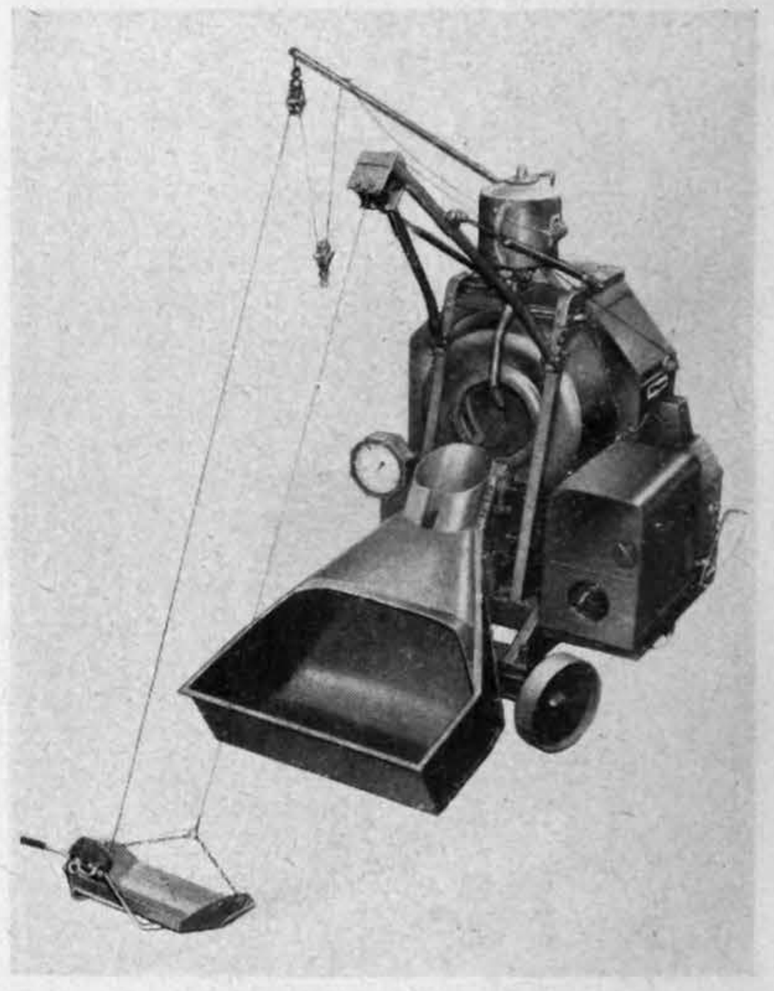
The hand-operated design of this machine can be converted to controlled-cycle operation by the fitting of an automatic in-feed cam slide to the upper bed, and having a separate self-contained power unit console connected to the machine by hydraulic hoses and plug-in flexible electrical connections.

[Reply Card No. E6543]

Concrete Mixer

A NON-TILTING reversing drum concrete mixer of ½ square yard capacity, made by Winget, Ltd., Rochester, Kent, has a hopper actuated by a hydraulic ram instead of the usual rope gear. With this form of hydraulic ram operation the hopper is under complete "finger-tip" control at all positions and a damping effect is imparted to prevent possibility of damage to the weigher of the machine during the downward movement. The hopper has a high angle of discharge—55 deg.—to ensure quick charging of the drum.

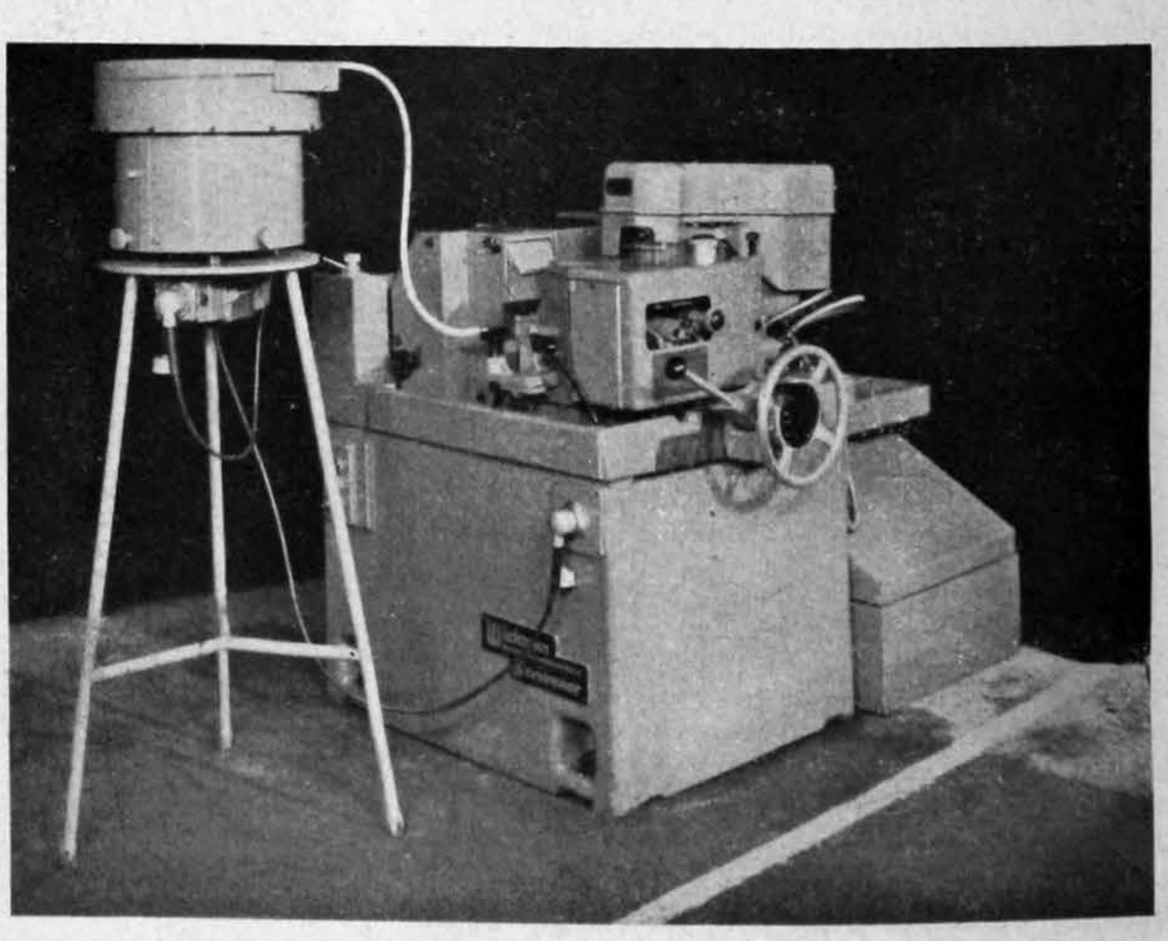
The mixer, to be seen in our illustration, has



½ cubic yard concrete mixer with its hopper operated by hydraulic ram

a drum discharge height of 4ft 6in and is stated to be suitable for discharge into any form of normal placing equipment on reversal of the direction of drum drive. A batch weigher is built into the machine and a dragfeeding shovel facilitates and speeds hopper loading operation. The water tank incorporates a positive action water valve and is arranged to enable, when required, a partial discharge of a measured volume of water before a dry batch is introduced into the drum.

[Reply Card No. E6544]



Small centreless grinder equipped for through-feed grinding and hopper feed

Deck Structure of the Narrows Bridge, Perth

THE beams of the deck structure of the Narrows Bridge at Perth in Western Australia, which we describe and illustrate generally on page 648, are made of precast concrete units, which were jointed and stressed together in place. The main beams were designed as double-cantilever beams with suspended spans for the dead load condition during erection but are continuous for all subsequent superimposed loads. The unusual features of the deck structure are the external cables, vertical shear cables, the method of casting the precast concrete units, and the method of obtaining continuity.

One of the requirements of an efficient concrete cross section is that the webs and flanges should be as thin as practicable. This was found to be incompatible with the space needed for the cables, so the longitudinal prestressing force was applied with external cables. The thickness of webs and flanges is thus 8in, containing only the vertical prestressing cables and mild steel reinforcement.

To achieve the maximum eccentricity, and therefore the maximum economy, the external cables needed to be as small as possible. Experiments made by the designer in association with the Somerset Wire Company, Ltd., and Udalls Prestressed Concrete, Ltd., led to the production of a nineteen-wire Seale's construction strand of 0·7in diameter to be used with a split wedge anchor grip. At the positions where the cables change direction the strands pass over lubricated machined steel saddles with a frictional resistance such that the loss of prestress from this cause was only 4 per cent, or one-fifth of the value usually associated with long curved cables in ducts. The prestressing forces were accurately measured with load cells reading on mirror galvanometers. After completion of tensioning, the cables were surrounded with fine concrete to protect them from corrosion, and to bond them to the beam through mild steel shear bars passing through holes in the webs.

Vertical prestressing cables were used to reduce the principal tensile stresses due to shear in the thin webs, but these cables were not sufficient alone to resist the total shear tensions at ultimate load, so additional mild steel reinforcement was added. Because of the total lack of fundamental information on the behaviour of prestressed concrete beams in combined bending and shear, a one-third scale test model was made to verify the assumptions that had been made. The test beam failed at the load predicted on the assumption that the shear forces would work as in a lattice beam, and that the main cable was fully bonded. The load factor was 1·95 on dead load plus superimposed load.

Because, in the designer's opinion, beams of this cross section are unsuitable for *in situ* construction, the bridge was built with short precast units with separate diaphragms. To simplify the construction, the bottom flange and lower section of the web were cast first. A few days later, the remainder of the section was cast in a second mould, which was bolted to the lower part of the web. The second mould has a standard shape, the variable depth of web and width of bottom flange being accommodated in the first casting stage. The units were transported from the precasting yard to the bridge on a light railway from which they were lifted by a Goliath travelling crane on to a piled staging.

A complete section of units on the staging was adjusted for line and level with small screw jacks. The 3in wide joints between the sections were filled with fine concrete compacted with immersion vibrators. The primary strands of the main cables of the double cantilever beams were then threaded and stressed. The suspended spans were constructed above their final position to give access to the beam ends for cable tensioning. After completion they were jacked down until the halved ends of the anchor blocks rested on neoprene strips placed on the upper face of the halved blocks of the double cantilever beams. The temporary props which had been left beneath the centres of the beams were then removed. and the secondary main cables were tensioned. These cables have their anchorages in the top flange of the main beam.

After the *in situ* concrete deck splicing strips had been placed, and the transverse cables had been tensioned, the facing panels were erected, and the cantilever footway slab was concreted.

The final operation to complete the superstructure was to make the beams continuous by fixing the temporary hinges. This was done by caulking the vertical joints between the anchor block faces with cement mortar and then clamping them together by tensioning short cables passing through ducts formed in the anchor blocks. These cables, which are standard G.U.12/0·276in, were tensioned using the short-wire technique. They lap with the main strand cables and thus give complete continuity. The principal figures for stresses in the bridge are :

Concrete :	
Bending compression :	
Initial, lb per square inch	2500
Service, lb per square inch	2300
Bending tension	Nil
Principal tensile stress due to shear, lb per square inch	150
Specified minimum 28-day strength of 6in test cubes, lb per square inch	6500
Approximate strength obtained, lb per square inch	8500
Standard deviation, lb per square inch	500±
Steel :	
Initial stress in strands, tons per square inch	83
Load per strand, tons	26·5
Final stress in strands, tons per square inch	63
Load per strand, tons	20

The consultant for the deck was E. W. H. Gifford

[Reply Card No. E6551]

Axial Vibration Resonance Changer

COMMANDER A. J. H. GOODWIN R.N. (Retd.) read a paper entitled " The Design of a Resonance Changer to Overcome Excessive Axial Vibration of Propeller Shafting " before the Institute of Marine Engineers on November 10. This paper was prepared to give details of experience in the field of axial vibration in propeller shafting subsequent to that given in a paper given by C. P. Rigby in 1948. The paper deals mainly with the performance and design of resonance changers which were adopted by the Admiralty as a solution for the axial vibration problems in H.M.S. " Eagle " in 1950. The resonance changer is described as a tuned damper using hydraulic means for mass and stiffness as well as for damping and having the advantage of being readily and cheaply fitted to existing systems. The use of this device obviates the necessity for adopting unorthodox positioning of thrust blocks, or departing from the most suitable number of propeller blades. The paper includes a condensed version of Rigby's paper followed by an account of the trials, which indicated that the use of multi-bladed propellers did not always constitute a satisfactory cure for excessive vibration. A mathematical explanation is given of the action of the resonance changer and also a recommended design procedure for the shafting system in new construction.

Data Processing System

DETAILS have been received from I.B.M. United Kingdom, Ltd., 101, Wigmore Street, London, W.1, of a new data processing system for scientific and engineering work, using transistorised equipment which occupies little more space than the average desk. The system, known as the " IBM 1620," consists of a central processing unit and a paper tape reader and punch. In addition to paper tape, there is also direct input-output by an electric typewriter incorporated in the console of the central processing unit.

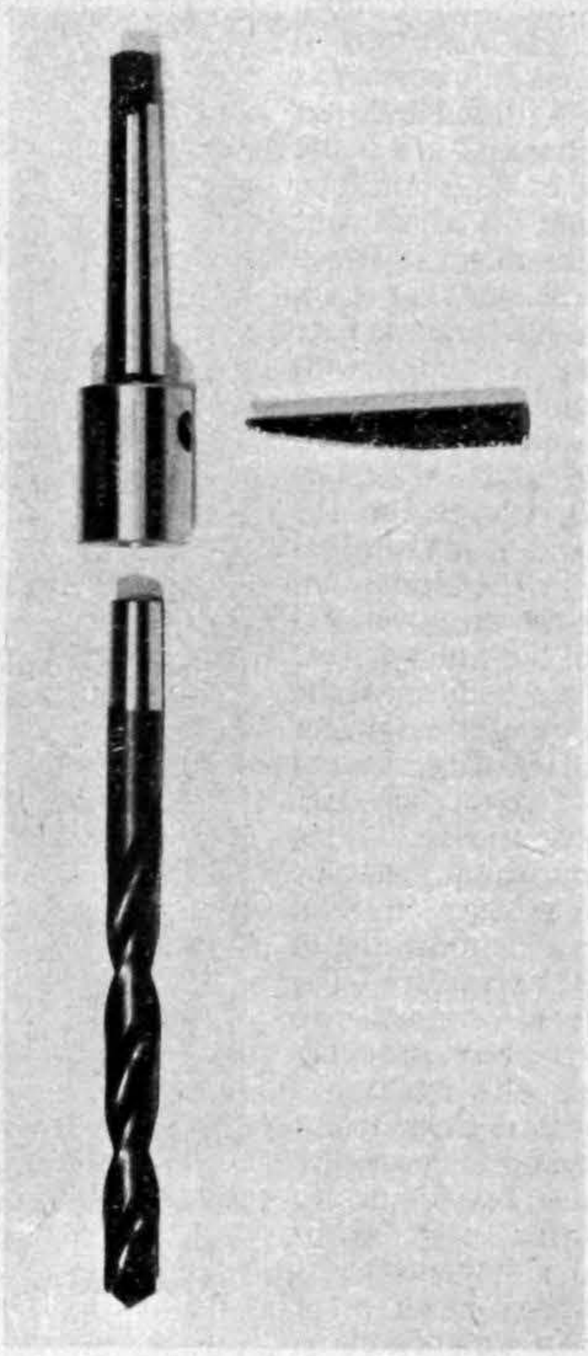
The paper tape reader has an input rate of 150 characters per second. Calculating rates include : additions and subtractions (five-digit factors), 1780 per second ; multiplications (five-digit factors), 200 per second ; and comparisons (five-digit factors), 1780 to 5000 per second.

The storage consists of 20,000 decimal digits on magnetic cores. Data and instructions may be entered manually by means of the typewriter keyboard, and this machine provides automatic printing of the computer output at the rate of fifteen characters per second.

[Reply Card No. E6553]

Taper Shank Drills

A NEW design of drill and holder has been developed by Clarkson (Engineers), Ltd., of Nuneaton, to provide an economic replacement for the conventional taper shank drill without loss of its inherent accuracy or ease in fitting in machines. This " Taperfast " tool, as it is known, is shown in the accompanying illustration ; it consists of a hardened and ground precision taper holder with which there is used a replaceable straight shank drill having a short length of taper ground on its shank. The taper on the drill is a precision fit in the bore of the holder and when such a drill is worn down or broken it can be easily removed from the holder by the insertion and light tapping of a drift which is provided. These replacement drills only cost a fraction more than equivalent standard straight shank drills. The makers state that the cost of a holder is recovered on use of the third or fourth replacement drill when compared with the price



Taper shank holder and drill

which would have to be paid in replacing more expensive taper shank drills. The fact that both the holders and the drills are precision ground ensures that these tools have the same degree of accuracy in use as standard taper shank drills.

When inserting a replacement drill in its holder, a sharp tap of the tang of the holder on a metal surface fixes the drill firmly in the taper bore. A full grip to resist drilling torque is obtained subsequently by a small initial twisting movement imparted at the start of a drilling operation, there being no risk of the soft shank of the drill harming the hardened holder by the twisting movement. In the course of a recent demonstration, we were shown the efficiency of the new tool when a ⅜in drill, driven at 1120 r.p.m., with a feed rate of 0·012in per revolution, was used to drill mild steel. After a number of holes had been drilled at this rate, the drill was removed from its holder by a single sharp tap on the drift. The drill was then replaced in a few seconds and the drilling operation resumed.

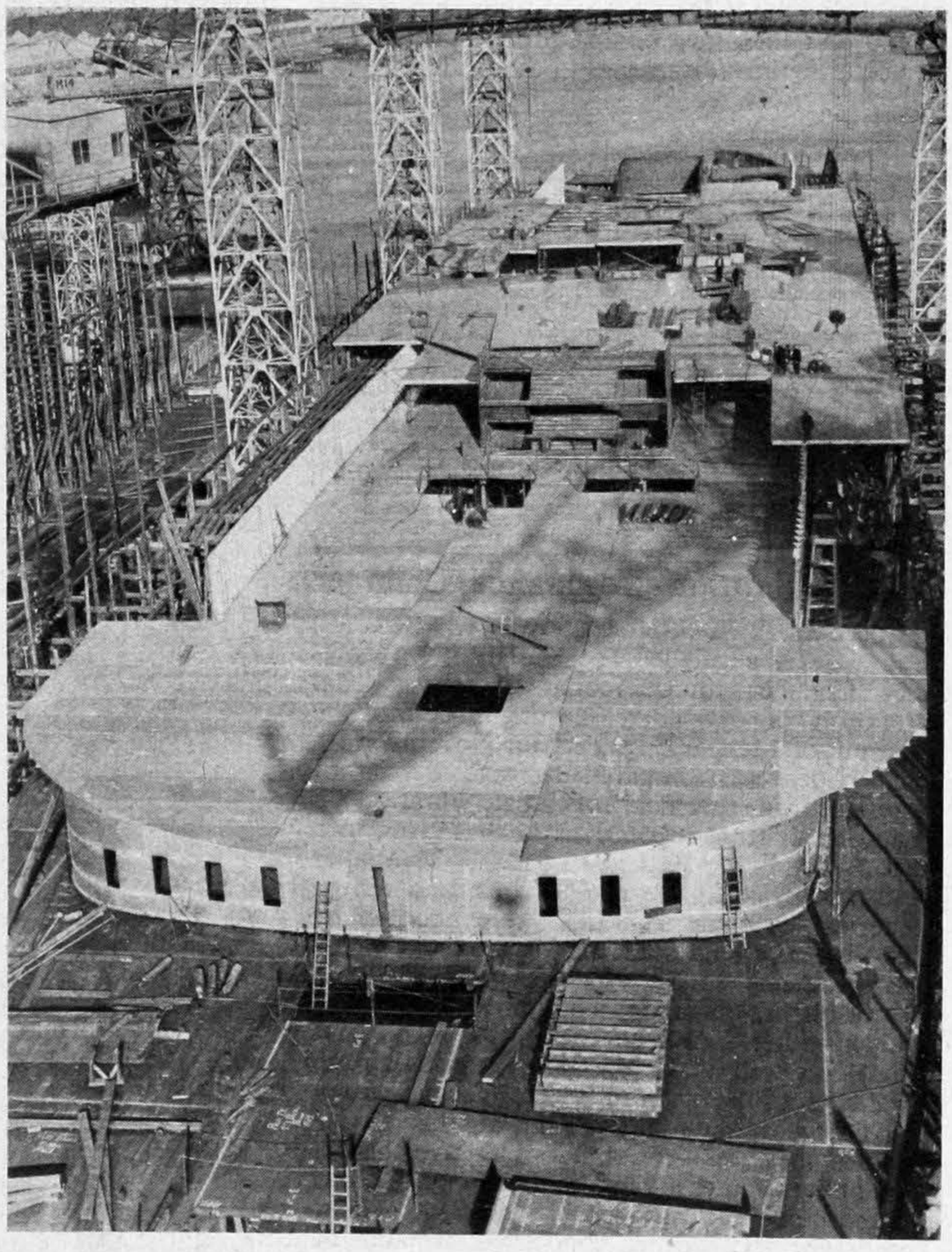
At present the holders are available with Nos. 1, 2 and 3 Morse shanks. For these shanks there are available drills from ⅛in to 1¼in diameter ; in number sizes from 1 to 31 ; and in letter sizes from A to Z. Each holder throughout the range takes a series of drill sizes.

[Reply Card No. E6554]

Building of the 45,000-Ton Liner "Canberra"

At the invitation of the P. and O. Company we were able to visit Belfast to see the progress made in the construction of the liner being built by Harland and Wolff, Ltd., and which will be named "Canberra" when the ship is launched on March 1 by Dame Pattie Menzies. As designed, the liner has a length between perpendiculars of 740ft, a beam of 102ft, a depth to "E" deck of 41ft 6in, and a load draught of 32ft 6in. A total of 600 first-class and 1650 tourist-class passengers will be carried and the ship will be propelled at 27½ knots by turbo-electric machinery developing a total of 85,000 s.h.p.

The ship is taking shape rapidly on the stocks, as can be seen from our illustration, and it was interesting to note that full bossing is not being fitted and that the tail shafts are being carried by shaft brackets, in which the shaft runs in white metal bearings with oil seals at each end, and intermediate brackets lined with "Tufnol." Riveting is used to fasten the frames to the shell which is welded, except for the bilge and shear strakes, while in the aluminium superstructure over 300 tons of light alloys have been worked into the ship out of the total of about 1000 tons. Also in place were the fin boxes to house the stabilisers, four of which are to be fitted to give a total righting moment of 18,000 tons-feet. The transverse tunnel to house the bow propeller is lined off; the tunnel itself has a diameter of 6ft 7in and the propeller will have two blades to allow for easy withdrawal, a diameter of 6ft 6½in, and a mean pitch of 5ft 9in, and be able to exert a thrust of 8½ tons at 300 r.p.m. The power is supplied by a 800 b.h.p. three-phase, 3300V, 60 c/s electric motor driving through a Hindmarch-Modern Wheel Drive gearbox and bevel gears.



Aluminium superstructures in course of erection above the promenade deck

Apart from seeing the progress in the berth, there was a small exhibition of contractors' equipment which gave a preview of some of the special design items to be incorporated in the liner. A model demonstrated the Collis baggage transport arrangements which includes side loading by means of slat conveyors, supported by a gantry, to the baggage room on "F" deck or by a special design of vertical conveyor to the various passenger decks. Also noted in the exhibition was a model of the Victor system for treating oily ballast water; this indicated that two deep tanks would be used for this purpose, one to treat lightly contaminated ballast at about 1500 tons per hour and the other to deal with dirty ballast at a low rate of discharge. In the system a perforated grille is fitted at half-height in the tank and the contaminated ballast is pumped into this compartment, the oil being allowed to rise through a slotted grille to discharge while the water sinks through the perforated grille into the lower chamber and is withdrawn under a weir placed at the bottom of the tank. To assist in expediting the deballasting and fuelling operations, James Gordon Valves, Ltd., has developed the "Pilgrim" valve which is completely pressure balanced and is operated by pneumatic controls from a centrally placed console.

As was mentioned in our issue of last week, design studies of the machinery were undertaken by the Yarrow-Admiralty Research Department and the steam conditions adopted are 750 lb per square inch at the stop valve and 960 deg. Fah. The boilers supplying the steam are of Foster-Wheeler "E.S.D." design and consist of three units of 260,000 lb and one of 50,000 lb per hour evaporation rating. Propulsion of the ship will be by turbo-electric machinery designed for 68,000 s.h.p. at 136·5 propeller r.p.m. for normal service and a maximum of 85,000 s.h.p. at 147 propeller r.p.m., and built by the British Thomson-Houston Company, Ltd. This consists of two double-unit 6000V three-phase motors of 42,500 maximum s.h.p. at 147 propeller r.p.m. and two 32,200kVA three-phase alternators each driven by a seventeen-stage unidirectional single cylinder turbine which is fitted with supervisory equipment. Arrangements permit one alternator to supply both propeller motors at 40,000 s.h.p. maximum. For auxiliary purposes, the Heavy Plant Division of Associated Electrical Industries, Ltd., is also constructing four 1500kW geared pass-out turbo-alternator sets, while the English Electric Company, Ltd., is supplying the main a.c. distribution switchboard and transformers which cover a range from 20kVA to 75kVA.

Air-Break Cam-Operated Master Controllers

A new range of air-break, cam-operated master controllers has been introduced by Allen West and Co., Ltd., Brighton, 7, Sussex. These equipments have a plug-in double-break contact system and have been specially developed for frequent operation in drives such as rolling mills, chargers and heavy-duty cranes. The design provides for easy withdrawal of the controller unit (as illustrated here) through the top of the case, without disconnecting any leads.

Three forms are available. The first, type PMC, is a conventional single unit with twin contact bars; it has a maximum of seven notches. The second, type PUMC, is similar but is arranged to control two motions (for example, hoist-lower and slew right or left); there are two controllers mounted one above the other, the driving shaft for the lower controller being concentric with the camshaft of the upper controller. Both motions are controlled by a single operating lever which can be moved either fore and aft or left and right, the drive to the appropriate camshaft being transmitted through gearing, part of which can be seen in the illustration. The third controller, type PNMC, is a single unit with a single contact bar to give reduced overall width of the equipment. In all three forms of controller the main operating shaft carries machine-cut moulded cams which actuate the contact unit or units.

The contact system is a single assembly which, as illustrated, is independent of the main camshaft. Two screws only secure the contact assembly and it can be removed without disturbing any connections. In the contact system each moving contact lever is operated by the action of the associated cam against the lever roller. The contacts are double-break and silver-faced to reduce contact resistance and they close under heavy spring pressure. Insulating barriers separate adjacent contact assemblies. Each assembly is connected with its associated main terminal by a silver-tipped spring-loaded contact.

To allow for quick removal of the complete controller assembly without disconnecting any wiring, there are contacts at the bottom of the controller and they plug into corresponding spring-loaded contacts in the terminal block. The controller can, therefore, be withdrawn merely by slackening two retaining screws.

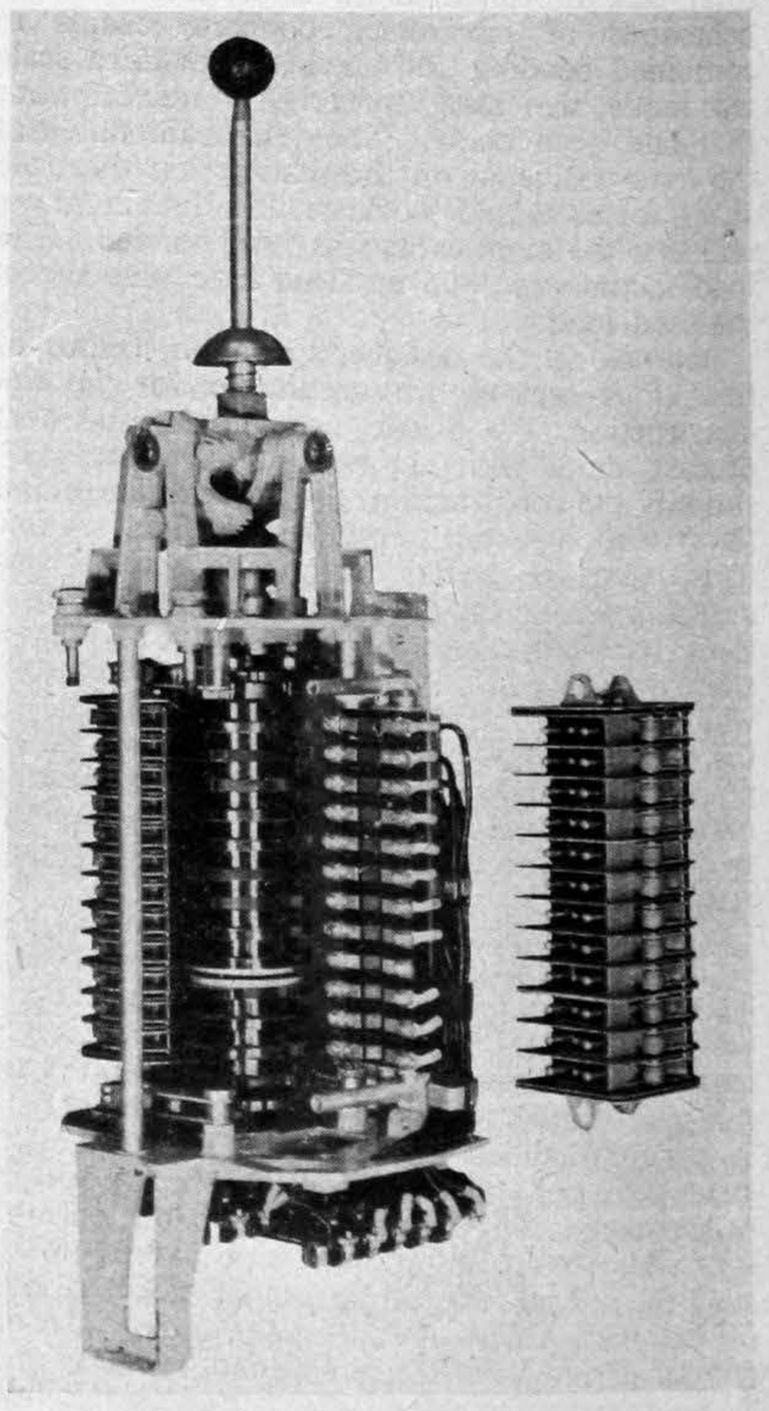
The controller ratings are tabulated below.

Ratings for Control Circuit Applications

Voltage	Breaking capacity, amperes D.C.	A.C.
120	1·25	7·5
250	0·60	7·5
500	0·25	7·5
650	0·18	7·5

Normally the controller is enclosed in a sheet steel case with a removable top cover which is fitted with a rubber grommet to exclude dust and moisture. Alternatively, a number of controllers can be assembled in a self-contained control desk.

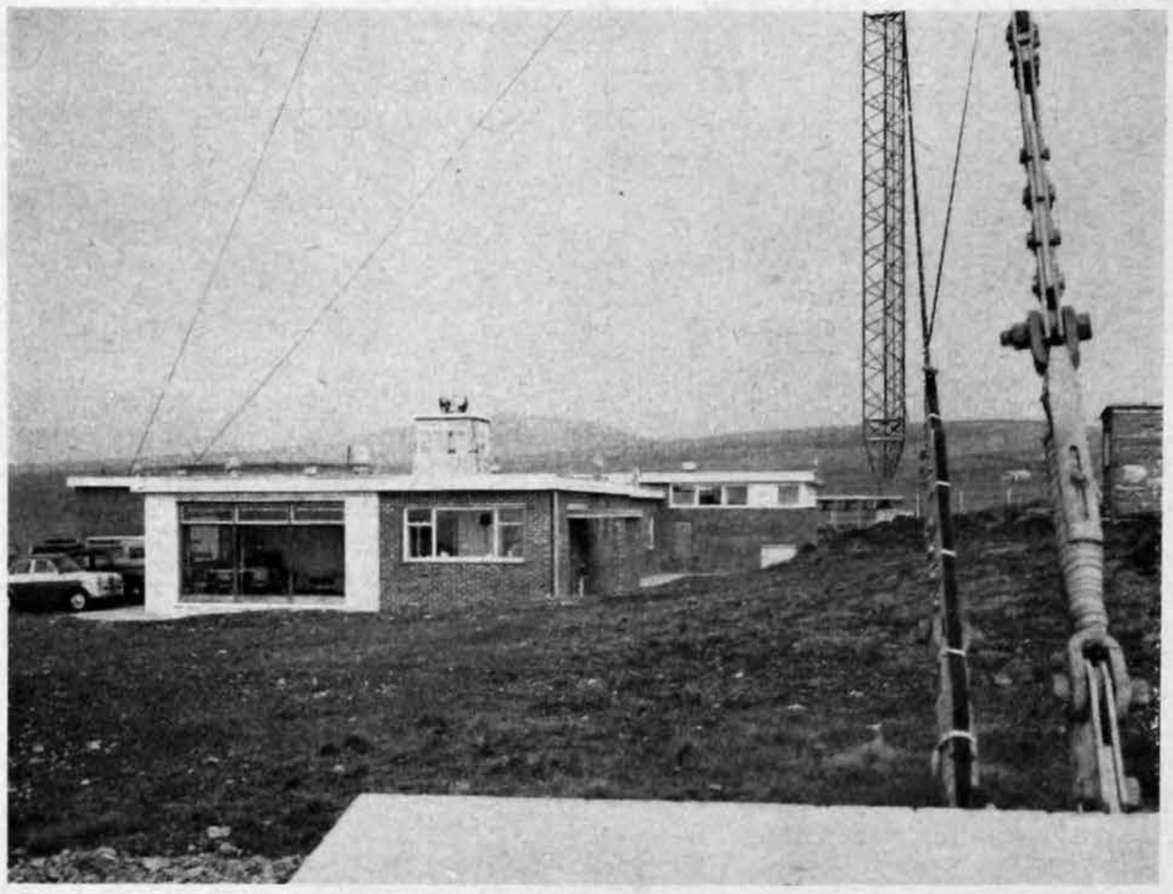
[Reply Card No. E6562]



Air-break cam-operated controller withdrawn from tank. The contact system is a single assembly as shown on the right



Transmitter hall at Black Mountain with two 4kW vision transmitters, two 1kW sound transmitters and combining units



The Black Mountain transmitter building and base of the 750ft triangular lattice steel aerial mast

I.T.A. Transmitter in Northern Ireland

VISION transmitting equipment at the new Black Mountain station (near Belfast) of the Independent Television Authority is of a new design in which a reduction in the number of valves used has simplified the layout and allowed the incorporation of a cooling system needing no sub-floor ducting. In this way the installation approaches the conception of a "packaged" equipment for a high-power television station.

All the main transmitting equipment and the greater proportion of the associated studio equipment for this station, which began programme service on October 31, was supplied and installed by Marconi's Wireless Telegraph Company, Ltd., Chelmsford. The installation includes two "BD.366" 4kW vision transmitters and two "BD.270A" sound transmitters, together with combining units, programme input equipment, flying spot caption scanner, control desk and test equipment. The duplication of transmitters follows established practice; in this instance, one vision and one sound transmitter carries the programme service, with the remaining pair immediately available as stand-by, although, if the requirement ever arose, the vision transmitters could be operated in parallel (as also could the sound transmitters) to double their respective output powers.

The radiated signals are horizontally polarised. The aerial system consists of two eight-stack quadrant aerials, one above the other, the whole being used as a single sixteen-stack directional array. With this arrangement, the aerial gain gives a peak effective radiated (vision) power of approximately 100kW in the direction of maximum propagation. The station is 987ft above sea level and the triangular lattice steel mast is 750ft high. The mean height of the aerial system is 1687ft above sea level. The station operates in Channel 9 at a vision frequency of 194·74325 Mc/s and a sound frequency of 191·230 Mc/s. British standards of transmission are employed.

The control rooms and studios in Belfast were designed by Marconi's Wireless Telegraph Company, Ltd., in conjunction with the technical advisers of Ulster Television, Ltd. Two Marconi broadcast vidicon cameras, a smaller vidicon camera (in the announcer's studio) and telecine equipment are installed.

A microwave radio link, engineered and operated by the General Post Office, has been established between Carlisle and Ballygomartin in order to integrate the station with the rest of the I.T.A. network. There are three repeater stations, at Riddings Hill (near Dumfries), Canbrec Hill (near Newton Stewart) and Enoch Hill (Portpatrick), on the overland section of this 130-mile route. Beyond Ballygomartin the television signals are transmitted at video frequency over coaxial cable links to the G.P.O. switching centre at Belfast.

The 4000 Mc/s microwave equipment for the link has been supplied by Standard Telephones and Cables, Ltd., Connaught House, Aldwych, London, W.C.2. Space diversity equipment similar to that described in our September 4 issue in connection with the company's equipment installed between St. John's, Newfoundland, and Sydney, Nova Scotia, has been provided at Ballygomartin to counteract the effects of fading on the oversea path. The link provides a both-way channel for 600-circuit telephony, a one-way channel for television, and a both-way stand-by channel for telephony or television. A departure from previous microwave practice in the United Kingdom is the use of common telephony/television terminal equipment. At present the link is being used for television signals only, but it is planned to add telephone service in 1960, when space diversity equipment will also be installed at Enoch Hill.

All locations on the link have been equipped with "Austinlite" fully-automatic no-break power plant supplied by Austinlite, Ltd., 28, St. James's Square, London, S.W.1. The all-electric no-break sets installed at all stations comprise an a.c. motor, a d.c. motor and alternator coupled in line and arranged so that on a mains failure the d.c. machine takes its power from a battery and drives the alternator until a stand-by diesel set is up to speed and voltage. The d.c. motor is then disconnected from the battery.

"Austinlite" 400/440V, three-phase, 50 c/s automatic diesel-alternator stand-by sets are installed at the repeater stations. Each comprises a Dorman "LB" series 1500 r.p.m. diesel-engine direct-coupled to an alternator. Should a partial or complete failure of mains supply be detected, the engine is started automatically by a C.A.V. 24V geared axial starter.

Facilities are provided in the control equipment for direct supply of essential loads from the mains in the event of a fault in the all-electric no-break plant. Should co-incident faults occur on the mains supply and a diesel-alternator stand-by set, the all-electric no-break plant will continue to operate from the battery via the d.c. motor. Batteries have been provided by the Post Office but the charging rectifier cubicles were included in the equipment supplied by Austinlite, Ltd.

[Reply Card No. E6571]

Portable Contamination Monitor

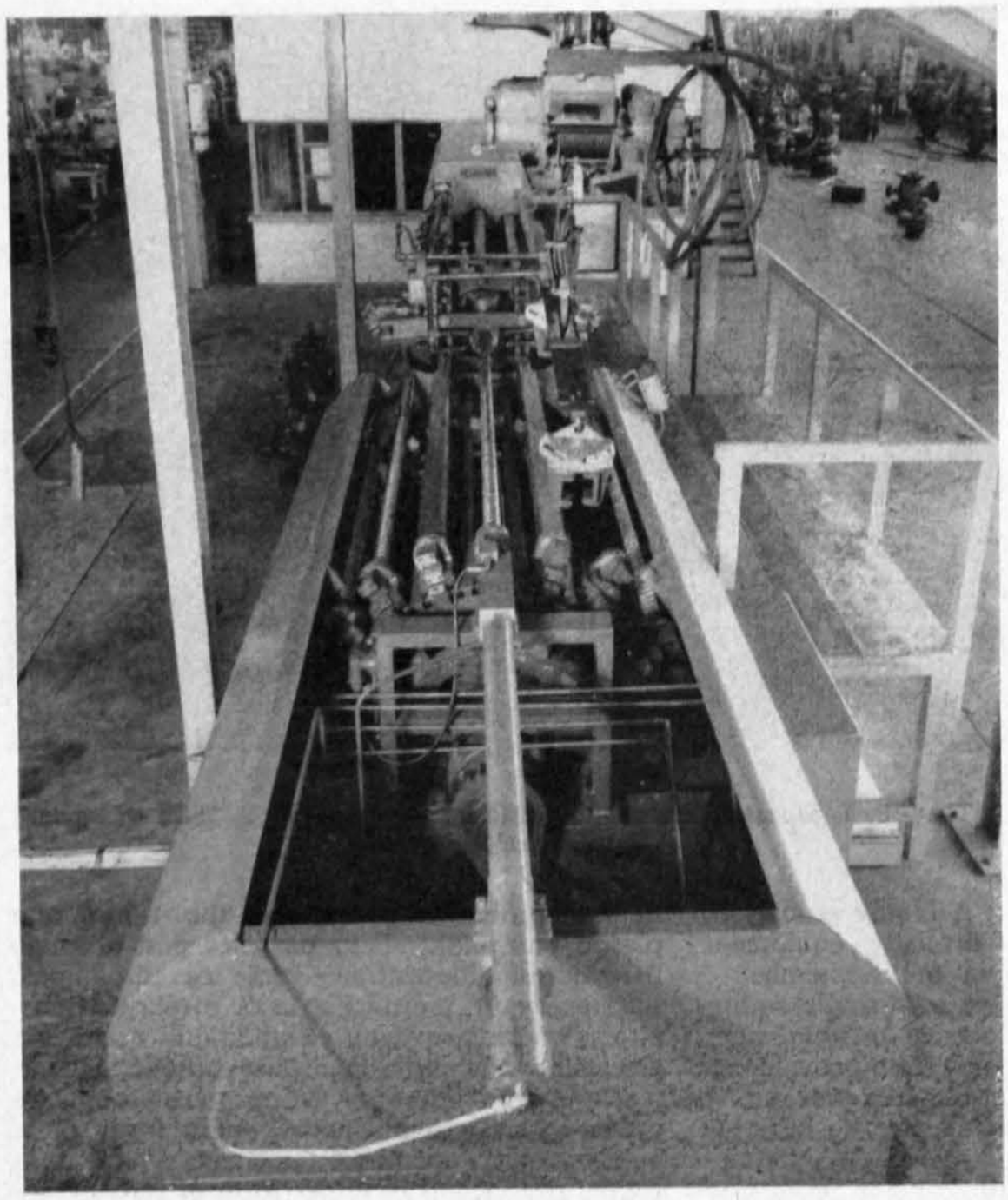
USING transistors and printed board circuits throughout, E.M.I. Electronics, Ltd., Hayes, Middlesex, has produced a portable contamination monitor capable of operation for long periods from twelve "U2" batteries carried in the case. The monitor (Type "P.C.M.1") detects alpha and beta contamination simultaneously if required by means of an E.M.I. dual phosphor technique. This uses two phosphor layers in the probe, a layer of zinc sulphide being superimposed on a plastic phosphor base. Alpha particles produce light scintillations on being stopped in the zinc sulphide layer, and these are seen by the photo-multiplier in the probe head through the transparent plastic phosphor. Beta particles pass through the zinc sulphide with negligible loss to dissipate their energy in the thicker layer of plastic phosphor, where the light scintillations are again detected by the photo-multiplier cathode. Signals reaching the monitor from the probe are presented as two distinctive audio tones on a built-in 2½in loudspeaker and measurement in counts per second of either form of radiation—or of the sum—takes place on a 3in meter with a 270 deg. logarithmic scale and a special cursor which may be used as the MPL setting. The range of measurement is from 0 to 5000 counts per second. The loudspeaker signal may be attenuated and headphones used if preferred. Low alpha counts (below six per second) may be switched into an electromechanical register. A panel switch selects monitoring of alpha plus beta, alpha or beta only, and register indication of low-count alpha. Probes for individual alpha and beta measurement are available, and the beta probe is provided with a shutter enabling gamma only to be measured.

The unit is housed in a case of high-impact Polystyrene and contains a power supply unit in its own casing which may be either a Polystyrene battery container or a mains unit for inputs of 200/240V or 50V, 50 c/s, or 90/130V, 60 c/s. Overall dimensions of the unit are 11½in by 8in by 8½in, its weight approximately 11 lb, and power consumption ¾W. The equipment is stated to operate satisfactorily in temperatures from 0 deg. to +45 deg. Cent.

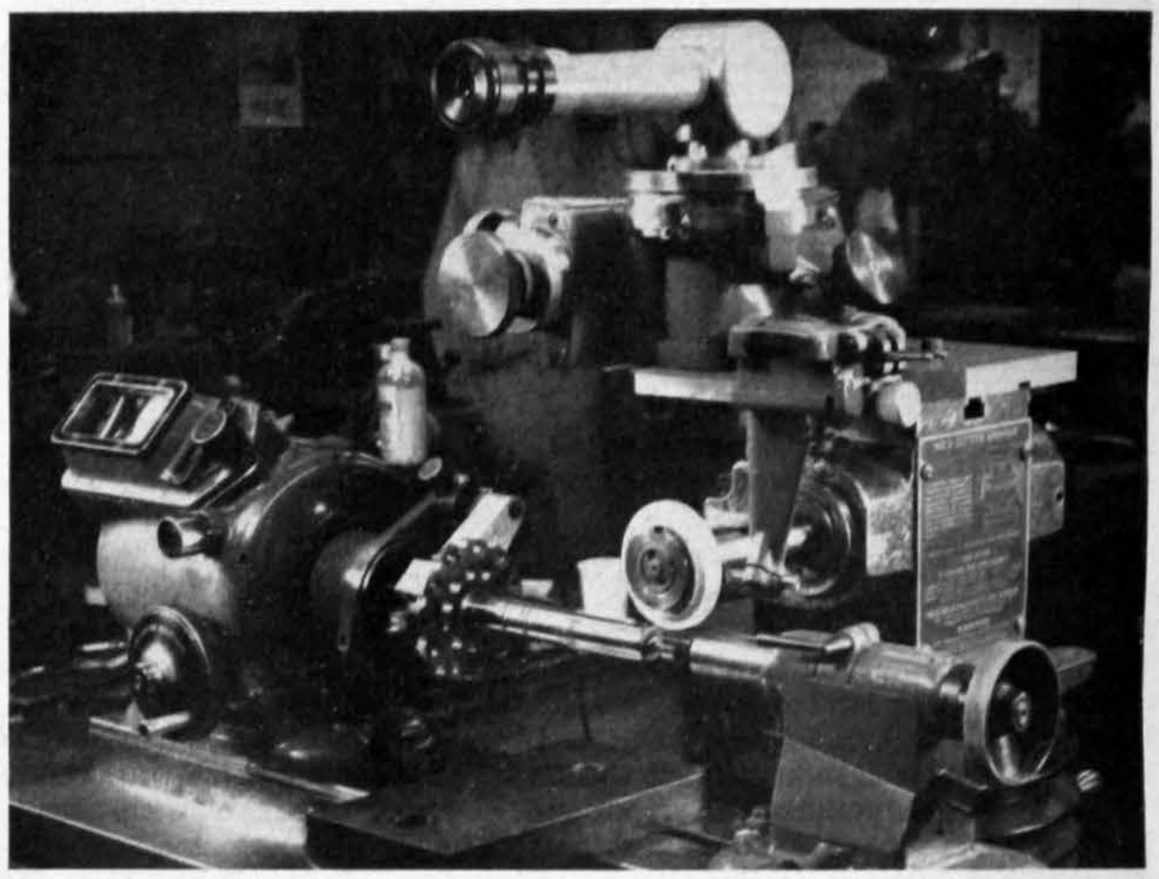
[Reply Card No. E6572]



Monitor and dual-phosphor probe for simultaneous detection of alpha and beta radiation



Nineteen-station turret broaching machine with a 60-ton pull and 100in stroke



Equipment for grinding wheel form dressing without use of master templates

Turret Horizontal Broaching Machine

A LARGE horizontal broaching machine with a nineteen-station turret which was recently supplied to a valve manufacturing company by the Lapointe Machine Tool Company, Ltd., of Watford, is illustrated above. This machine has a 60-ton pull and a stroke of 100in, its overall length exceeding 37ft.

The turret is 4½ft in diameter and set horizontally in front of the faceplate below floor level to bring the broaches it holds into line with the pull-head of the machine. Normally eighteen 80in long broaches are fitted on the machine to produce holes up to 2⅜in by 5½in by 12¼in, an open station being left for conventional hole broaching purposes. Push-button controls are used to index the turret and control movements of the pull-head, electrical interlocks being provided to allow the correct sequencing of ten movements in a broaching cycle.

The broaching speeds on this machine are steplessly variable up to a maximum of 12ft per minute and the broach return speeds are adjustable up to 80ft per minute. The turret design gives easy access to the broaches for maintenance and it is stated that a tool can be changed in about five minutes when necessary. The machine is not particularly designed for special application and can readily be adapted for single or multiple broaching operations.

We are informed that the associated American company of this firm has built a turret vertical broaching machine with a twenty-one station turret. This machine also has a 60-ton pull with a 78in stroke, its overall height being 36ft.

[Reply Card No. E6581]

Grinding Wheel Form Dressing Equipment

To allow the form dressing of grinding wheels without the use of master templates, a new instrument known as the " Optidress " has been developed by Precision Grinding, Ltd., Mill Green Road, Mitcham Junction, Surrey, as an auxiliary to the firm's " Profiloscope." With this equipment, which can be fixed permanently to a machine, one radial and two straight line motions can be carried out in one setting. It also enables wheel form to be checked after the dressing operation.

The equipment is shown in use on the machine in the accompanying illustration. It has a built-in microscope which facilitates centring and positioning of the diamond and through it the wheel and diamond can be kept under constant observation while blending a radius into a tangential run-off. A graticule incorporated in the microscope carries radius markings from 0·025in to 0·375in in increments of 0·01in, a graduated scale enabling intermediate radii to be approximated. The arm which carries the diamond is adjustable in relation to the radius shown in the microscope.

The slide which is used for dressing to straight lines has a total movement of 1in and it is traversed by hand through a rack and pinion. This slide can be set to any angle between 0 and 180 deg. with reference to an engraved dial and using adjustable stops ; its zero line is parallel with the wheel axis. The same slide is also used for radial dressing operations by arresting it between two centralising stops which are adjusted initially to bring the diamond into axis with the centre of the microscope. With this design, when using the equipment to dress on the wheel, a straight line followed by a radius and a further straight line, it is only necessary to set the angular stops and swing one of the centralising stops out of position when changing from radial to straight line movement.

The microscope and the dressing equipment are mounted on co-ordinate slides to enable them to be positioned to suit wheel diameter, and to facilitate co-ordinating various operations to dress a profile 1½in long.

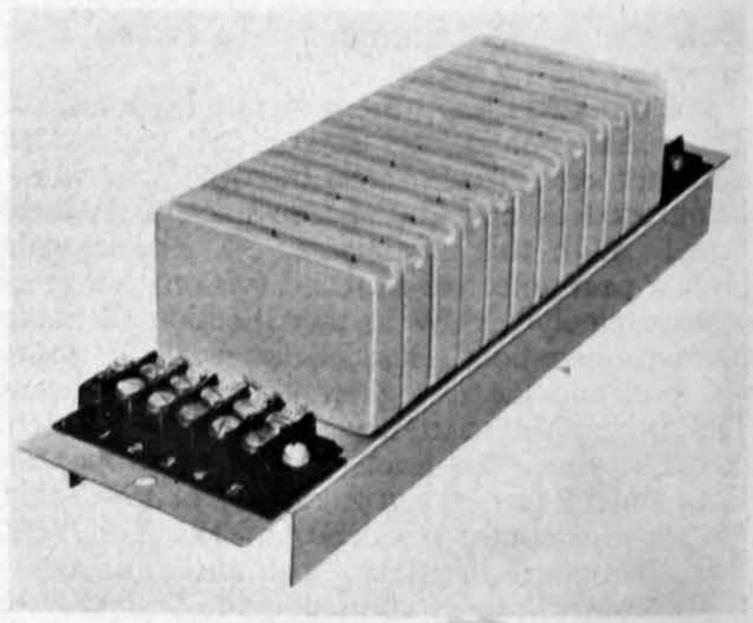
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Electronic " Building Bricks "

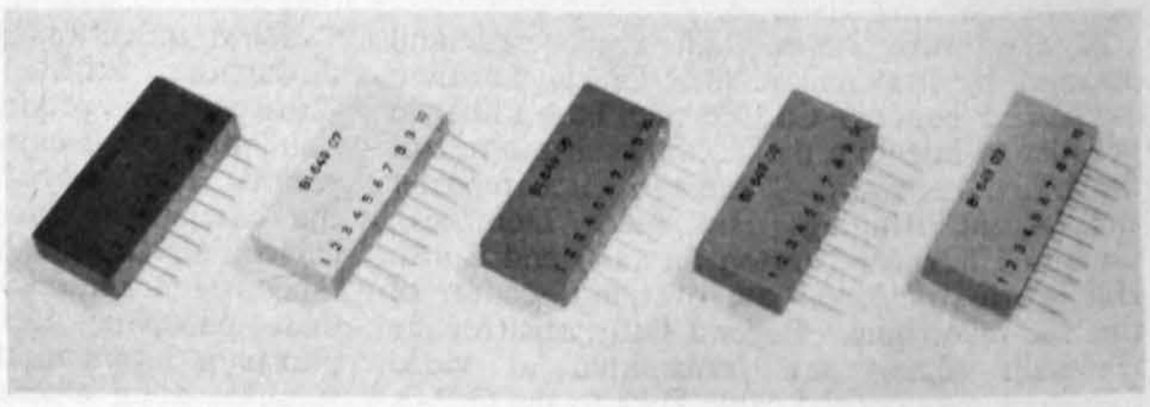
WE have received details from Mullard Equipment, Ltd., Mullard House, Torrington Place, London, W.C.1, of two series of electronic sub-assemblies designed as standard " building bricks " for the construction of industrial control systems, digital computing elements, data processing equipment, measuring systems and other equipments based on digital circuit techniques. The two series are known respectively as " Norbits " and " Combi-Elements." Both are fully transistorised and accommodated in compact plastic cases.

"Norbits" are designed specifically so that the entire planning and construction of an industrial sequence control system can be carried out by a plant engineer having only a general knowledge of electronics. The units have long flying leads so that intermediate connections may be made without intermediate tag panels or additional wiring, using solderless clinched joints. Channel units, equipped with terminal blocks for input and output connections, are provided on which a number of " Norbits " may be mounted by single-screw fixings.

The basic " Norbit " unit is a transistor switching element designed for use as an " And " or an " Or " circuit (corresponding to series and parallel connection of relay contacts) depending on the manner of connection. On receipt of information from limit-switches or other input sources, this switching unit performs the necessary logic operations and delivers signals in the correct sequence to an output unit, which in turn activates the transducers governing or monitoring the functions of the machine. The basic unit measures 2½in by 1 $\frac{9}{16}$in by ½in, and twelve can be accommodated on a single channel (as illustrated). A number of output units of various ratings up to 150W are available for



Twelve " Norbit " transistor switching elements, interconnected by flying leads, mounted on channel with input and output terminal blocks



Circuit elements (multivibrators, pulse-shapers, &c.) in plastic cases for mounting on printed circuit boards

operating contactors, electromagnetic clutches, solenoids, &c.; other units include a counter, and a timer with a range of 0–60 seconds.

The range of "Combi-Elements" includes flip-flops and other multivibrator circuits, pulse shapers, gate circuits, amplifiers, and emitter follower circuits. Each circuit is hermetically sealed in a small plastic case, identified by its colour, measuring 2·1in by 0·94in by 0·39in and designed for mounting on a printed circuit board using the techniques normally employed for mounting resistors and capacitors (see lower illustration). Single elements or complete boards may thus be interchanged readily. The range of circuits has been based on the principle of d.c. gating, and in general the signal transfer from element to element is at d.c. levels. The flip-flops and other multivibrators can be triggered either by a d.c. signal or a voltage step (a.c. signal), and depending on the application the units can be used for non-synchronous or synchronous logic, the latter using clock pulses.

[Reply Card No. E6583]

Extensions to a Heavy Machine Tool Factory

A PROGRAMME of development and reorganisation which has been in progress at the works of Hugh Smith (Possil), Ltd., Glasgow, for some five years was recently completed with the opening of a new bay 260ft long by 55ft wide for the assembly of heavy machine tools. This firm, established in 1875, has for many years specialised in the design and manufacture of heavy machines for the shipbuilding and other industries. To mark the occasion of the opening of the new bay, the firm arranged an exhibition of some of its machines of recent design and we reproduce a photograph of the shop taken at that time.

One of the largest machines shown was a 2000 tons vertical plate bending press with a nominal capacity for forming plates up to 10ft wide by 2¾in thick. The action of this design of machine is fully automatic and the firm has built similar presses with capacities from 1200 to 3000 tons. The machines are hydraulically operated with a fluid working pressure of 4500 lb per square inch, and that shown had a stroke which could be adjusted from 1½in up to 9in. The plate, which is normally supported on rollers on the floor, is automatically fed in steps through the forming rolls, the feed being synchronised with the bending action. A machine of this design was described in our issue of May 14, 1954.

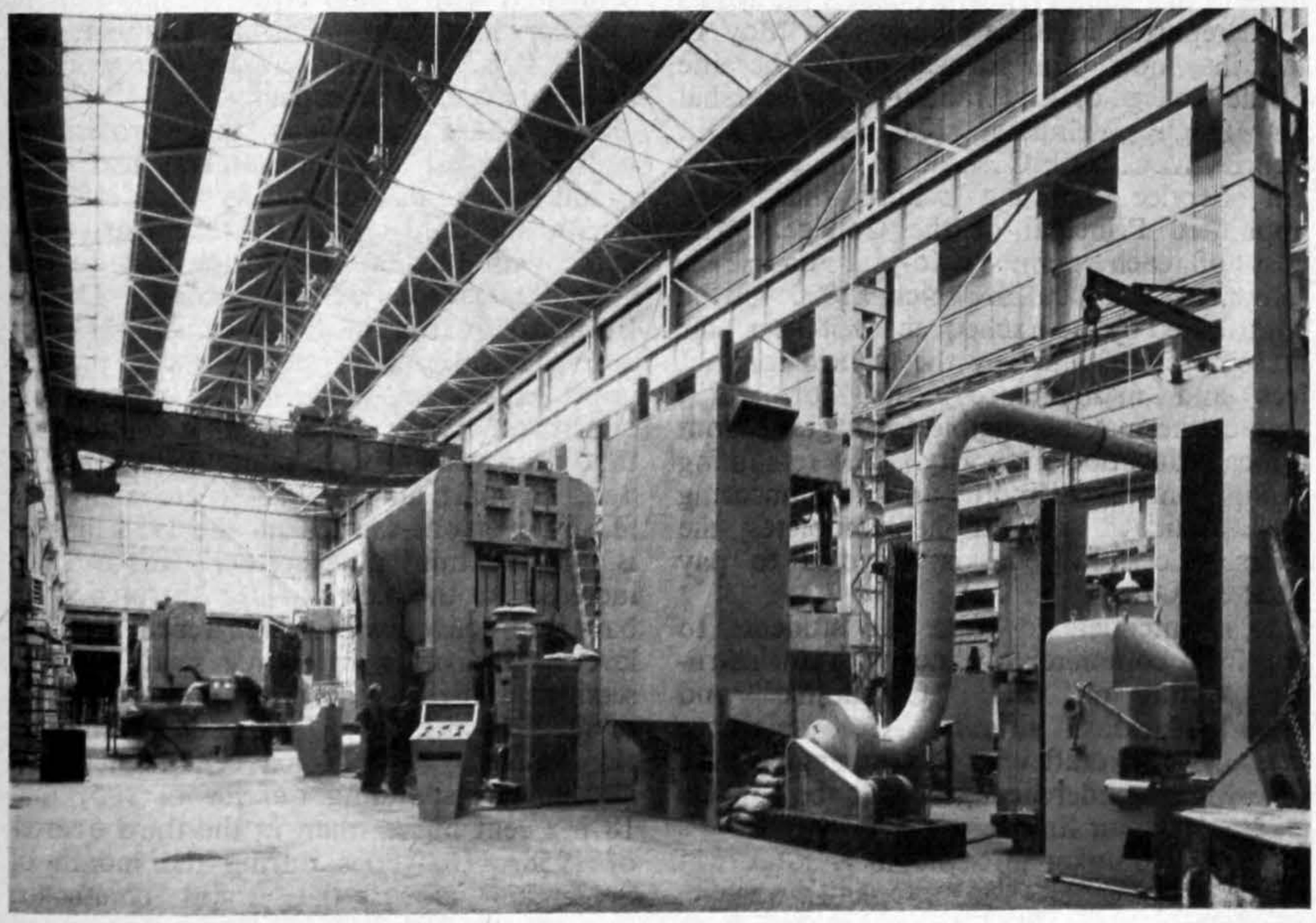
Typical of the firm's gap presses with powers up to 1000 tons, widely used for general pressing and flanging work in shipyards, was a 250 tons capacity machine which has a gap of 30in and a daylight of 41in with a stroke of 18in. By this machine there was one for the cold bending of ship's frames. This bender is capable of exerting 400 tons pressure in either direction and its open front gives free access to a workpiece for reference to templates. It can be used for handling bulb flats up to 17in deep in pairs to ensure symmetry of port and starboard frames. In operation, two outer clamping arms grip the beam and pull, with a power of up to 77 tons, against a fixed central clamp.

A 35ft plate edge planer shown in operation is equipped, in addition to the toolbox, with a shearing head capable of shearing plates up to ⅝in thick. The toolbox is used for bevelling plate edges and can be set at any required angle. A variable range of cutting speeds between 20ft and 60ft per minute is available for machining purposes. The machine can be supplied with either a moving beam plate clamp or a fixed beam with clamping jacks. A mechanical handling gear for loading and feeding plate into the rear of the machine gives plate feed speeds of ½in and 2in per second.

Some prototype machines in course of development at this works include a descaling machine for plates up to 10ft wide by 1¾in thick which is about to undergo shop trials. Plates standing vertically on edge are fed into the machine and as they pass through, shot, fed into the casing at various points, is projected against both sides to remove mill scale. Another prototype machine of particular interest exhibited was a "Hydro-level" rolls for straightening plates up to 12ft wide, from ⅜in to 1½in thick. This design of five-roller machine for heavy, wide plates has two bottom and three top rollers. The two bottom rollers only are driven to give a plate speed of up to 30ft per minute. The top rollers are actuated by hydraulic cylinders, the central one being capable of exerting a pressure of 900 tons, and each of the side rollers 300 tons. A smaller capacity prototype machine of this design handles plates up to 9ft wide by ⅝in thick, and is already undergoing trials in service. Both of these machines have been ordered by Barclay Curle and Co., Ltd.

Amongst the new equipment installed in the new bay to increase the manufacturing capacity for larger and heavier plant for shipyards and heavy metal fabricating firms is an Asquith No. 6 travelling head, ram type milling, facing, boring and drilling machine. This machine has a table area of 50ft by 20ft and is capable of milling and boring work up to 12ft high. To provide for the larger and heavier classes of plant which will be manufactured for industry in the future, the new bay has a height of 40ft below the crane hook and is served by two Babcock and Wilcox cranes to handle lifts up to 100 tons.

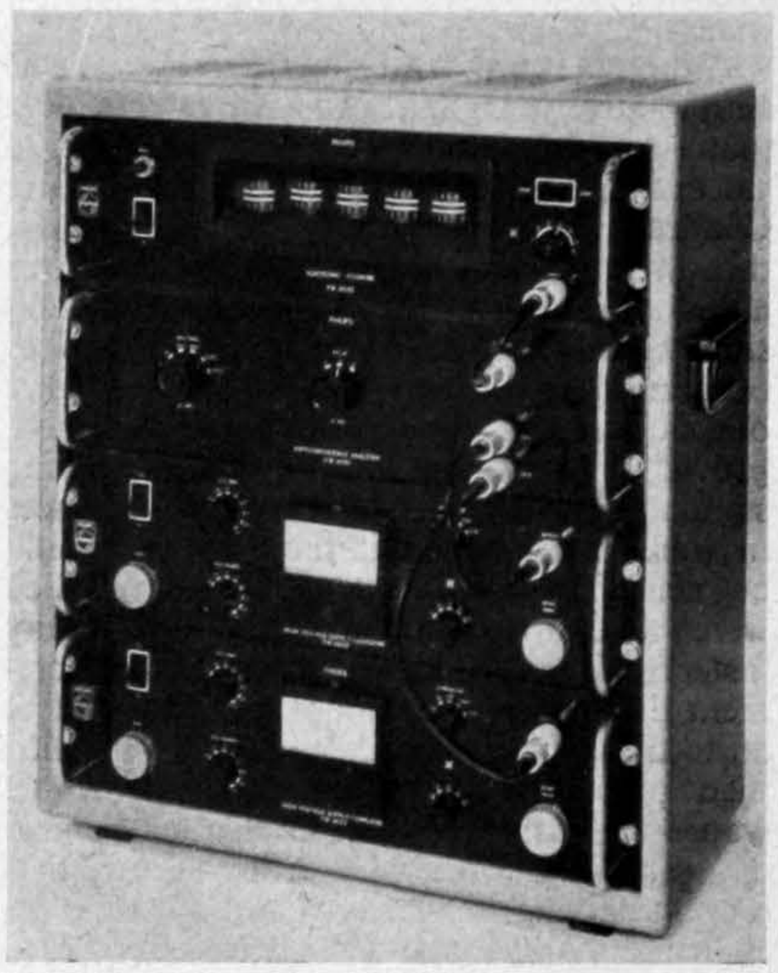
[Reply Card No. E6591]



New shop at the works of Hugh Smith (Possil), Ltd. On the right, there can be seen the prototype plate cleaning machine

Low-Level Beta Counting

WE have received details from Research and Control Instruments, Ltd., Instrument House, 207, King's Cross Road, London, W.C.1, of a new Philips anti-coincidence analyser which the company is now marketing for use in low-level beta counting systems. The analyser is known as the PW.4092 anti-coincidence unit and is seen in the illustration assembled with a PW.4032 electronic counter and two PW.4022 high-voltage supply/amplifier units (all of which are



Assembly of instruments for counting beta radiation and suppressing background interference

Philips standard rack-mounting instruments) to form a complete assembly for low-level beta counting in conjunction with the Philips PW.4127/02 guard counter and beta counter.

To measure low specific beta activities, the background level must be reduced as much as possible. Among the most important components of the background are the cosmic ray mesons, and in order to eliminate their effect it has been customary to surround the beta counter with a ring of cosmic ray counters connected in anti-coincidence (i.e. arranged to block the beta channel when responding to interference). The two counter systems required massive shielding from environmental gamma radiation. In order to reduce the bulk of the equipment, Philips introduced a PW.4127/02 halogen-quenched cosmic ray guard counter in which the guard counter electrodes are concentric hemispheres with a gas space between them. The interior surface of the inner electrode is the guard anode, and this electrode merges into a cylinder inside which the beta counter is placed. Thus every meson striking the beta counter has first traversed the gas space of the single guard counter which surrounds it completely. The arrangement weighs 550 lb and occupies a floor space less than 3ft square.

Pulses at the guard counter anode are passed to the guard channel of the anti-coincidence analyser, which consists of a pulse amplifier and two pulse shapers (the output pulse length being variable). Pulses from the beta counter are fed to a count channel consisting of a pulse amplifier and three pulse shapers and supplying pulses of three microseconds duration. Both outputs are applied to a diode circuit which is blocked during guard pulses so that only beta pulses which have not coincided with cosmic interference are passed to the scaler. Separate outputs are also provided from the guard and count channels so that background count rate and sample plus background count rate may be observed.

[Reply Card No. E6592]

Industrial and Labour Notes

Wages, Profits and Prices

The Chancellor of the Exchequer, Mr. Heathcoat Amory, addressed a meeting of the National Production Advisory Council last Friday, the first meeting of the council to be held since the general election. In his speech, the Chancellor emphasised that maintenance of the present buoyant level of industrial activity depended on the continuance of price stability. The country, he said, was adding rapidly to its ability to produce more and to produce more efficiently.

Although manufacturing investment was still relatively high, it was lower this year than last and sample forecasts had indicated a lower level again next year. The Chancellor expressed the hope, however, that the reintroduction of investment allowances and the growing confidence in expansion would lead to an upward revision of programmes during the winter. Higher output per man, the Chancellor commented, provided the source both of higher living standards at home and competitive prices in world markets. But those things would be achieved only if the industries which were able to increase their productivity faster than average put some of the increment into the national pool. If they took it all to themselves, in higher wages or profits, then prices in the economy as a whole would be pushed up. It could not be said with assurance, the Chancellor stated, that the underlying upward trend in prices of eighteen months ago had been eliminated, though it had recently been much more moderate. The reason for that was that wage rates and earnings had been rising much more moderately than in some earlier years. Profit incomes showed a larger percentage increase than employment incomes in the first half of this year over a year earlier ; the first half of 1958, however, was, relatively speaking, depressed and company profits were then falling.

Railway Workshops

Some criticism of the Government's attitude to the future of the country's railway workshops was expressed by Mr. Noel-Baker, the member for Swindon, in an adjournment debate in the House of Commons last week. Those employed in British Railway workshops, he said, were worried because they believed that, even under present conditions, many thousands of pounds worth of work which they could and should have been doing had gone to private firms.

The Joint Parliamentary Secretary to the Ministry of Transport, Mr. John Hay, spoke for the Government. He pointed out that " the railways should be appreciated to be a commercial concern engaged in a competitive transport industry." The Government had frequently made it plain, Mr. Hay said, that a direction would not be used to the British Transport Commission requiring it to put any proportion of its building or repair work to any particular workshop. Nor would the Minister of Transport require that the Commission should use its own facilities in preference to those of any private firm or company. The Commission was a commercial undertaking engaged in a competitive enterprise and the Minister did not propose to interfere with its commercial judgment in the matter.

In May, Mr. Hay continued, the Commission made it clear (THE ENGINEER, May 22) that the railway workshops would continue for the manufacture of the equipment for which they were suitable and would also continue for the repair of all equipment. It was also made plain that the reduction in workshop capacity which must go on would be by a carefully phased programme. The trade unions, Mr. Hay added, had been consulted throughout. In May, an agreement was reached between the Commission and the unions which provided that, if men had to be transferred to other work at a lower rate of pay than that which they were previously receiving, for three years after that time they would continue to receive their standard time-work rate of pay. Furthermore, if anyone had to be discharged because he was genuinely redundant and could not be absorbed elsewhere in the Commission's activities, then a lump sum payment of compensation would be made if the man had been employed for three years or more.

Overseas Trade

The recorded value of United Kingdom exports in October, has been calculated provisionally at £306,000,000. Imports were valued at £360,200,000 and re-exports at £14,600,000. The Board of Trade says that, after eliminating normal seasonal variation, the United Kingdom's exports in the three months August to October were $3\frac{1}{2}$ per cent higher in value than in the preceding three-month period and that, over the first ten months of this year, the average was 4 per cent above the monthly average for 1958. On the same basis, imports were 4 per cent higher in August–October than in the preceding three months, the average over the first ten months of the year being 5 per cent above the monthly average for 1958.

Training of Air Line Pilots

It has been announced that the flying school to meet the need for pilots of the air lines in this country, the proposals for which were reported in these columns on May 15 last, has now been formed under the title of the College of Air Training. Air Marshal Sir Hugh Walmsley, K.C.B., K.C.I.E., C.B.E., M.C., D.F.C., head of the erstwhile Air Service Training school, has been appointed Principal of the College. The cost of each pupil's two-year course is estimated at £4000, of which £1000 will be contributed by the Exchequer : £380 per year must be contributed by the trainee to meet fees and maintenance costs, for which amount he may be eligible for a grant from a local education authority. The remaining sum is contributed by the air line sponsoring the candidate, and if he completes the course successfully he is expected to pay back £1000.

It is intended to train the students to acquire a commercial licence with an instrument rating on D.H. " Chipmunk " and Avro " Anson " aircraft. Conversion to pressurised aircraft with turbine engines and nose-wheel undercarriages will be undertaken by the air lines.

The first intake, in September, 1960, will be of fifty cadets for B.O.A.C., and in subsequent years it is expected that both B.O.A.C. and B.E.A. will enter at least forty cadets. Applications for the first entry are due at the end of November : candidates must be at least eighteen but under twenty, or twenty-four in the case of graduates.

Engineering Industry's Prospects

At the annual luncheon of the British Engineers' Association, which was held in London on Thursday of last week, the president, Sir Edward Thompson, suggested that it was now possible to sense the growing dependence of the whole country upon the products of the engineering industry. He felt that the industry could expect to keep above the country's average in the export field, though he emphasised that this country's opportunity to maintain its place in international competition rested more than ever on its rate of technological advance.

The principal guest at the luncheon was Sir Ewart Smith. In his speech, he reaffirmed that British industrial supremacy had been built up by the ingenuity of its engineers as well as by the ability of its business men. But, he said, a change could be detected. Historians of the present time, Sir Ewart asserted, would be struck by one word—research—for it had come to be synonymous with progress. But knowledge by itself, whilst interesting, achieved nothing; knowledge must be available quickly, anywhere and for everybody " who was ready to go and get it and was willing to apply it." In the matter of the application of knowledge, this country, Sir Ewart thought, still had a long way to go. That, he said, was why it was essential to secure more and better technical education.

Iron and Steel

The Iron and Steel Board has announced that, in October, pig iron production averaged 269,800 tons a week which represented an annual output rate of 14,029,000 tons, compared with 12,579,000 tons a year earlier. Steel production in October averaged 441,400 tons a week and was thus at an annual rate of 22,953,000 tons, compared with a rate of 18,902,000 tons in October last year. During October, the Board says, the steel industry was working to 92 per cent of its capacity.

The Board says also that provisional figures suggest that consumers' and merchants' stocks of steel fell by about 150,000 tons in the third quarter of this year, compared with 180,000 tons in the first quarter and 190,000 tons in the second. During the third quarter of the year, deliveries of most descriptions of steel show a marked improvement on those of the comparable quarter of 1958. The main exceptions to that improvement were plate, colliery arches and, in particular, rails where deliveries fell by over one-third from the 1958 figures. But in the third quarter there was a sharp increase in the demand for ferro-concrete bars, the deliveries of which reached record levels. Deliveries of heavy sections, light sections and bars also improved. Deliveries of sheet from the wide strip mills during the third quarter were 24 per cent higher than in the corresponding quarter of 1957 and 18 per cent higher than in the third quarter of 1958. Deliveries during the month of September alone, the Board comments, improved to about 30 per cent over those of a year earlier, thus reflecting the continued increase in capacity.

Marine Diesel Engines Trial

DURING a demonstration on October 27 at its Augsburg works, the Maschinenfabrik Augsburg-Nürnberg (M.A.N.). showed two new designs of ships' diesel engines. Both are developments of the " KZ " type in the direction of increased output. Our illustration (Fig. 1) represents the two engines on the test bed.

The " K6Z 78/155 " is a development of the " KZ 78/140 " engine, retaining the old bore of 780mm but increasing the stroke from 1400mm to 1550mm. This increases the output per cylinder to 1350 b.h.p. at 35 per cent supercharge. Such a figure does not, it is stated, represent the limit, a maximum output per cylinder of 1800 b.h.p. being possible.

The second motor, the " K3Z 84/160," has a continuous rating per cylinder of 1700 h.p. at 115 r.p.m., and a specific consumption of about 150 grammes per metric brake horsepower per hour. The bore is 840mm, and the stroke 1600mm. A ten-cylinder engine of this type is being built under licence by Howaldtswerke, Kiel, for a 47,300-ton tanker, and a nine-cylinder version is being produced by another licensee, Yokohama shipyard, for a 40,000-ton tanker, while a twelve-cylinder engine of 22,000 h.p. has been ordered from the same firm for a 65,000-ton tanker for the Olympus Shipping and Trading Corporation, New York.

In the production of heavy ships' diesel engines the Augsburg plant occupies a leading position, having produced annually during the last few years sixty-five to seventy-two engines of over 500mm bore and 1500 h.p.–12,000 h.p. and over. Since 1950, when the manufacture of ships' engines was resumed after the war, 500 large engines with a total horsepower of over 2,000,000 b.h.p. have been delivered. The construction of supercharged engines which had been taken up before and again during the last war was resumed in 1952, and the first post-war supercharged engine of 9000 b.h.p. was delivered in 1955 to the Hamburg-America Line. Since then until the middle of the current year, sixty supercharged two-stroke engines totalling 382,000 h.p. were delivered from Augsburg, while German and foreign licensees supplied a further 110 engines aggregating 866,000 h.p.

Of the " KZ 78/140 " design which was first introduced in 1950, M.A.N. and its licensees have built approximately 260 units with 1900 cylinders. The original output of 900 h.p. per cylinder was raised by supercharging to 1200 h.p. The present version is identical with the earlier engines except for modifications arising from the lengthening of the stroke and the increase in power. The six-cylinder unit now on the test bed is to be used for extended trials and research.

The engine was exhaust turbo-charged according to the impulse system, since the crank displacement of the six cylinders permitted a very favourable grouping of the turbo-sets, with one set for every three cylinders. It is possible, for purposes of the trial, by simple means to convert one, two, or three cylinders so that the piston underside supplies scavenge air in parallel with the turbo-sets. All parts have been strengthened to cope with a firing pressure of 60 kg per square centimetre. The piston shape has also been redesigned so as to reduce the temperature at the rings, the new piston having only a slightly dished crown. While the temperature of the centre remains the same it is 100 deg. Cent. lower at the rim. In order to ensure proper scavenging with the new stroke ratio of nearly 2 : 1, the ports had also to be modified.

In the trials, it is stated, the exhaust temperature in front of the turbine was 380 deg. Cent. For a service output of 1350 h.p. the specific consumption was found to be 150 grammes per metric horsepower per hour, and the exhaust temperature in front of the turbine, 350 deg. Cent. (Fig. 2 (*a*)). At a mean effective pressure of 8·8 kg per square centimetre, the 150 gramme limit of consumption was reached. The results are claimed to show that with the loop scavenging system, performances can be obtained which correspond to the best results with engines with uni-

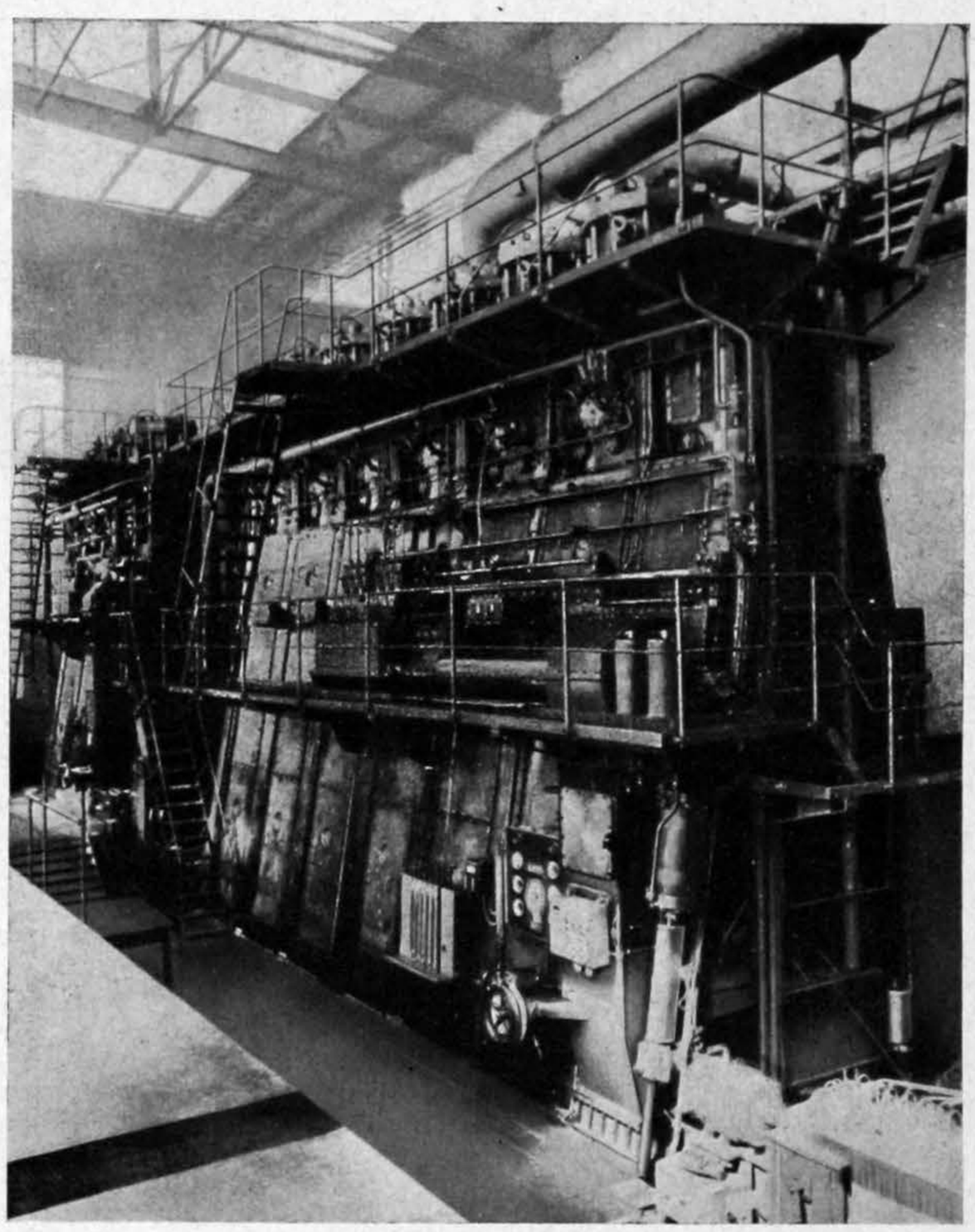
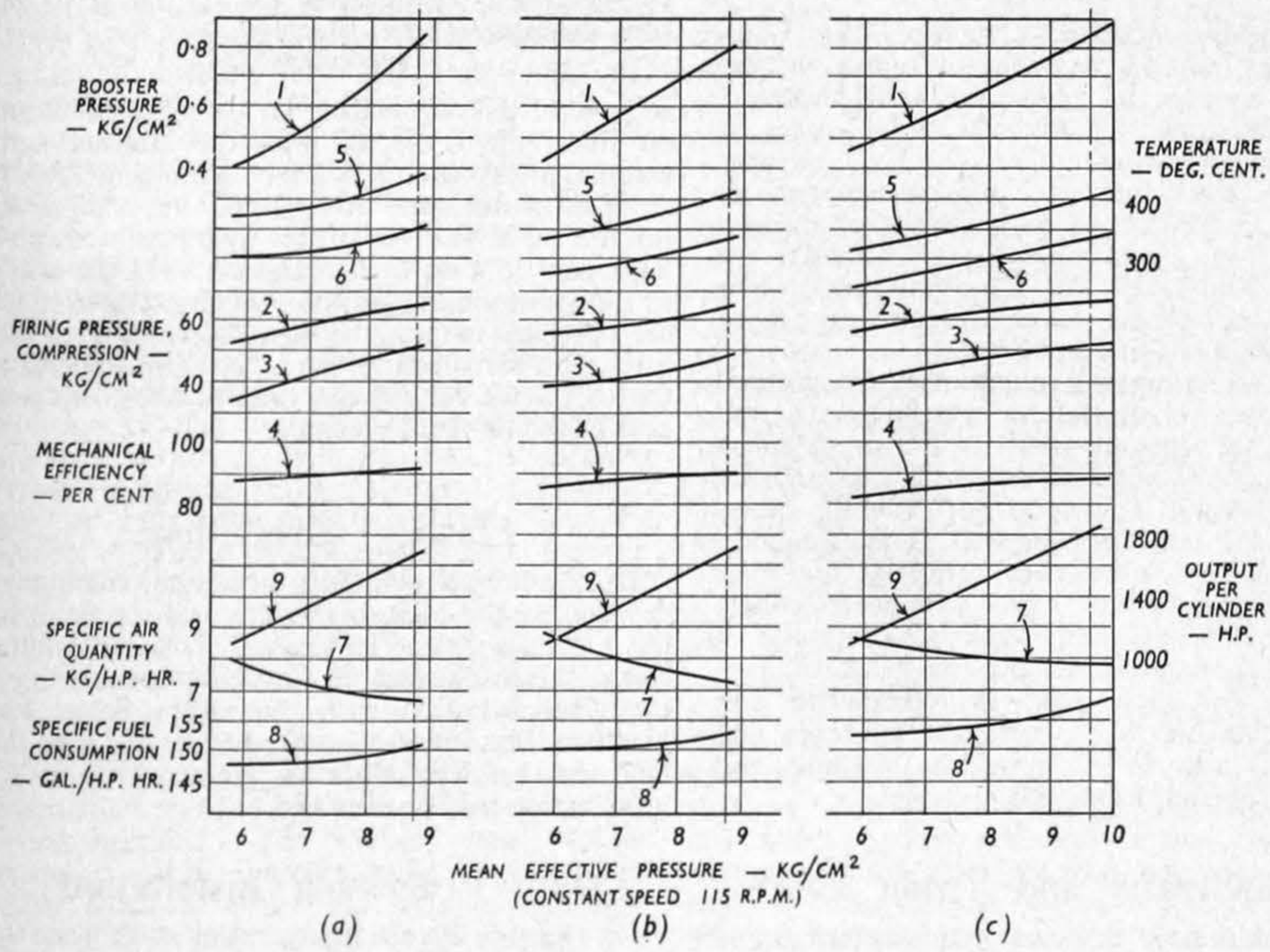
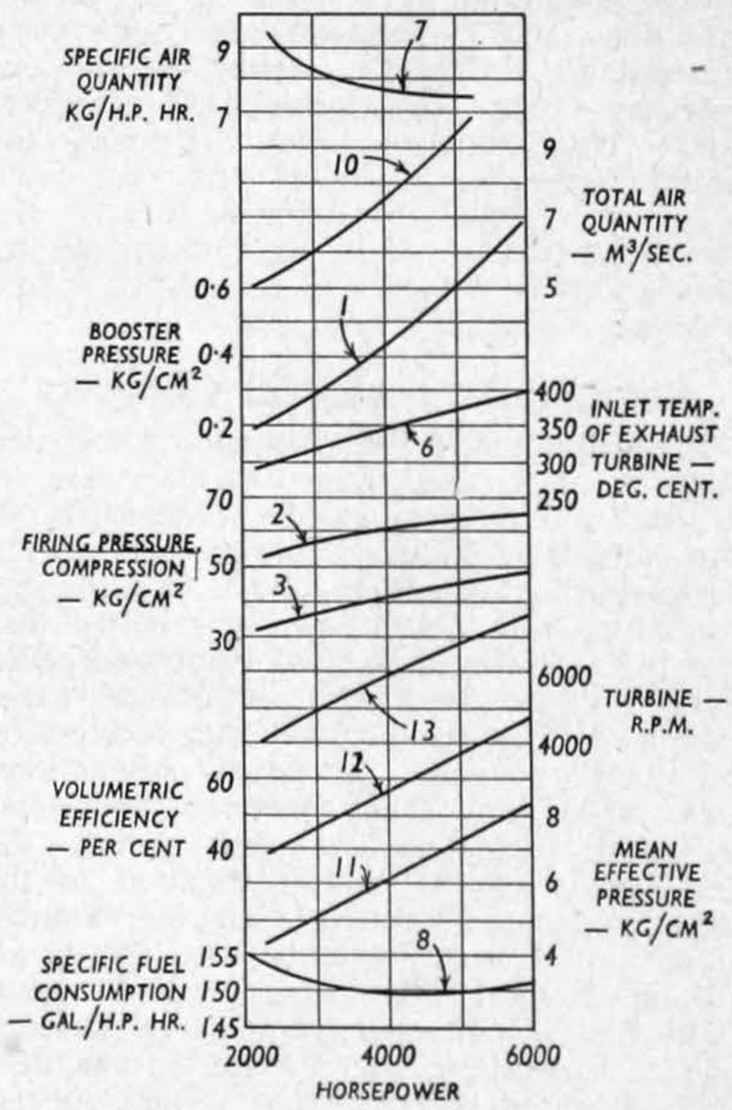


Fig. 1—Two marine diesel engines on the test bed at the works of M.A.N. They are a six-cylinder " K6Z 78/155 " engine developing 8000 metric b.h.p. (foreground) and a three-cylinder engine of the " K3Z 84/160 " design, the twelve-cylinder version of which can develop 20,000 metric b.h.p. and above





(*a*) None of the piston undersides used as scavenge pumps.
(*b*) Two piston undersides used as scavenge pumps (=30 per cent scavenge).
(*c*) Three piston undersides used as scavenge pumps (=45 per cent scavenge).

1.—Booster pressure.
2.—Firing pressure.
3.—Compression.
4.—Mechanical efficiency.
5.—Inlet temperature of exhaust turbine.
6.—Exhaust temperature of turbine.
7.—Specific air quantity.
8.—Specific fuel consumption.
9.—Output per cylinder.
10.—Total air quantity.
11.—Mean effective pressure.
12.—Volumetric efficiency.
13.—Turbine revolutions per minute.

Figs. 2 and 3—Trial results of " K6Z 78/155 " six-cylinder engine (left) and " K3Z 84/160 " three-cylinder engine (right)

flow scavenge which have so far been published.

Further tests were carried out employing the undersides of two and three pistons as scavenge pumps (Figs. 2 (*b*) and 2 (*c*)). During these trials power boosting was increased up to 84 per cent, corresponding to an effective pressure of 9·7 kg per square centimetre (Fig. 2 (*c*)). Under those conditions, the six-cylinder engine develops nearly 11,000 h.p., whereas the rated output is 8100 h.p., in other words, an overload of 35 per cent. With an effective pressure of 8 kg per square centimetre, a consumption figure of 154 grammes per metric brake horsepower per hour was achieved. A turbine inlet temperature of 375 deg. Cent. is obtained with an air quantity of 8·05 kg per metric brake horsepower per hour. The turbo-sets employed were of B.B.C. and the recent M.A.N. design, the latter being used during the demonstration on October 27.

It was recognised about two years ago that this size of engine could not develop the output required for large tankers and that neither geared nor a diesel-electric drive, using two or more engines, was able to give such good consumption figures as does a single, larger, low-speed engine. The company therefore decided on the building of an engine with a still larger cylinder volume, viz., 840mm bore and 1600mm stroke. At first, an output per cylinder of 1700 h.p. at 115 r.p.m. was provided, which corresponds to power boosting of slightly over 40 per cent. In order to obtain results initially, half a six-cylinder engine was built. This engine, which also formed part of the demonstration, gave preliminary test results very much in line with the "K6Z 78/155" (Fig. 3). The fuel consumption of the trial engine for the rated output of 5000 h.p., was 150 grammes per metric brake horsepower per hour at a firing pressure of 62 kg per square centimetre, and the exhaust temperature in front of the turbine was 375 deg. Cent. Since it is designed for a maximum firing pressure of 65 kg per square centimetre, the rate of power boosting can readily be stepped up further.

Basically, the design is similar to the "KZ 78/140," but the entire engine frame has been stiffened so as to enable a large number of cylinders to be used and at the same time avoid the danger of transverse vibrations. Accordingly, the short cast-iron columns between the cylinder block and the intermediate bottom have been replaced by a single welded beam which simultaneously forms the intermediate bottom, so that perfect sealing against the crankcase and the atmosphere is ensured.

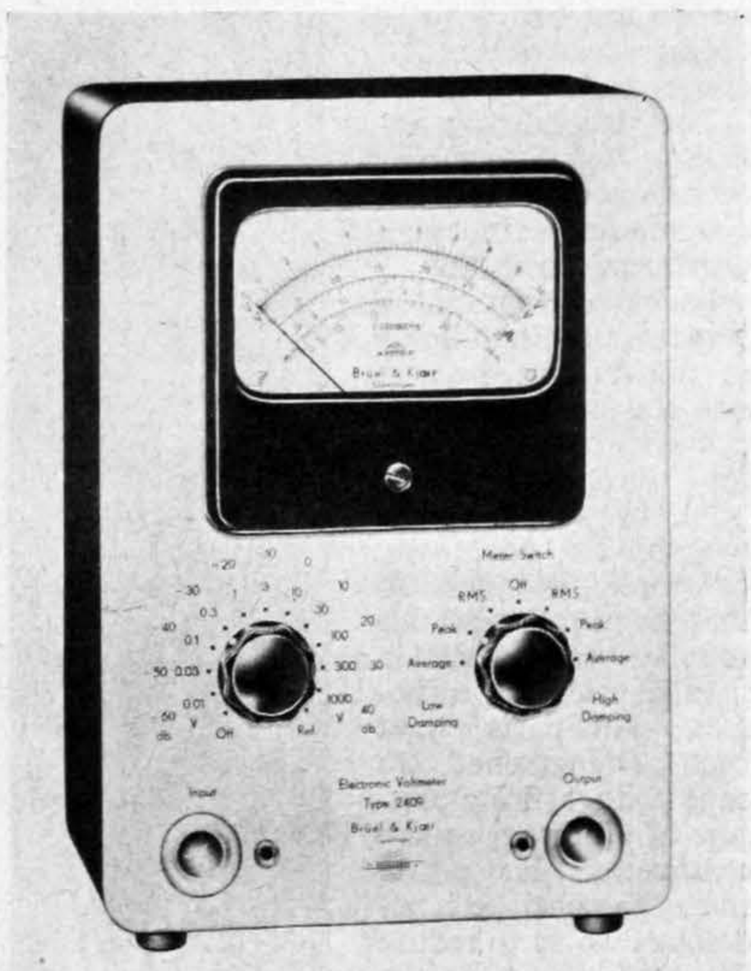
Despite its height and the piston speed of 6·15m per second at 115 r.p.m. the three-cylinder engine has been found to run without vibration, and consequently no difficulty is foreseen in building a version with twelve cylinders which would give 20,000 to 22,000 b.h.p. With a weight of about 900 tonnes, this would correspond to about 41 kg per brake horsepower. While this might be reduced, it is considered that for ships, and in particular for installations in the stern of tankers, as solid a structure as possible is desirable.

Automobile Technical Congress

The Eighth International Automobile Technical Congress of the Federation Internationale des Sociétés d'Ingénieurs et de Techniciens de l'Automobile (FISITA) is to be held at The Hague during May 9–13, 1960. At the five working sessions, about twenty papers will deal with the following aspects of automobile technology : engines (including gas turbines), transmissions, lubrication and lubricants, combustion and fuels ; chassis, gearboxes, suspensions, tyres, brakes, and safety aspects ; bodywork, equipment, aerodynamics, and styling. A simultaneous system of interpretation in the official languages of the Congress—French, English and German—will be used during all working sessions. Membership will be open, in the first instance, to members of societies affiliated to FISITA and, if space permits, also to any other interested persons. The Congress is being organised by the Koninklijk Instituut van Ingenieurs ; provisional application for participation should be sent to the General Secretariat, Burgemeester de Monchyplein 14, The Hague, Netherlands.

Audiofrequency Voltmeter

The electronic voltmeter, "Model 2409," by Brüel and Kjær, Nærum, Denmark, which we show in the accompanying illustration, is stated to be suitable for true peak, average, and r.m.s. readings over the range 1mV to 1000V, and 2 c/s to 200 kc/s. Its voltage scales are arranged to give full deflection for 10V and 31·5V, respectively ; for amplifications and attenuations a decibel scale is provided. A dbm-scale is



Audiofrequency voltmeter

provided for measurements in audiofrequency transmission and telephone lines ; the reference value being 0·775V, corresponding to 1mW in 600Ω. Two different meter damping characteristics can be selected, one as in standard VU measurements, the other giving a steady pointer deflection with low frequency signals. An output jack permits the instrument to be used as a calibrated amplifier with a low output impedance, and an amplification of up to 60dB, variable in steps of 10dB.

European-American Nuclear Committee

A European-American Nuclear Data Committee has been set up by the European Nuclear Energy Agency, in agreement with Euratom, the United States of America and Canada, to assure collaboration among O.E.E.C. member and associate countries in the measurement of nuclear properties. It is to consist of thirteen experts from the United States, Canada, the United Kingdom, the Euratom and other O.E.E.C. countries. Its operations will accord with existing bilateral agreements.

The Committee will be primarily concerned with nuclear cross-sections measurements and other basic data essential for the technical development of nuclear energy. It will critically review existing knowledge of nuclear cross-sections and constants, as well as the facilities, techniques and manpower available for their determination. Other tasks will be to collect and correlate available data, to establish a standard nomenclature and methods of presentation for such data, to recommend and sponsor, as necessary, technical meetings and symposia, and to promote the pooling and exchange of equipment and personnel.

Handicrafts and Trade Fair

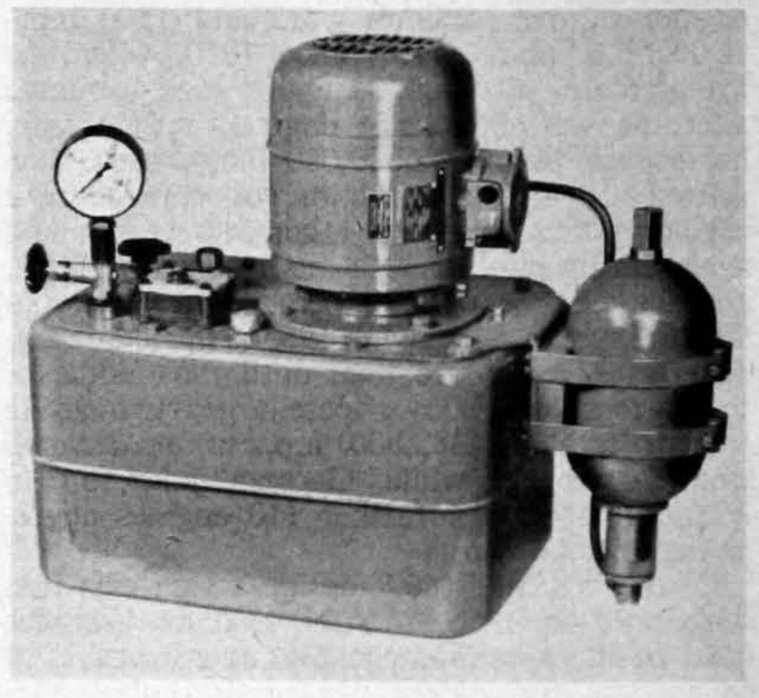
It is announced that next year's International Handicrafts and Trade Fair at Munich will be held during the period May 11–22. Of the 2400 exhibitors at the last Fair, in the spring of 1959, 45 per cent came from thirty European and overseas countries ; more than three-quarters of the exhibitors were craftsmen and 23 per cent came from the supplying industries, including machines and workshop equipment. Congresses to be held during the Fair will include those of the Mechanics' and Machinists' Trade and the German Painters' Trade, as well as the German Welding Association. These will be supplemented by special technical shows.

Second International Rocket and Satellite Congress

The complete reports and details of the working sessions held in connection with the Second International Rocket and Satellite Congress in Paris earlier this year, are to be published under the title "Les techniques des fusées et des satellites," Volume V. The subscription rate will be 10,000 francs, while non-subscribers will be able to obtain the volume for 14,000 francs. Details may be obtained from A.E.R.A., Centre d'Etudes Technique des Fusées et de l'Astronautique, 1, rue de Courty, Paris (7e).

Hydraulic Unit

The accompanying illustration shows a hydraulic unit for the operation of machine tools, hydraulic power cylinders, or oil motors. The equipment, which is made by Robert Bosch G.m.b.H., Stuttgart, is designed for 380V or 500V, three-phase current, and comprises an oil pump with 18 to 100 atmospheres delivery pressure driven by a flange-mounted motor, an



Hydraulic unit for supplying pressure oil at up to 100 atmospheres for machine tool or power applications

adjustable delivery valve, an oil filter, and an air filter, the latter allowing the internal and external pressures to equalise by admitting filtered air and, at the same time, containing a dipstick for the oil level. An air-oil hydraulic accumulator can be used in conjunction with the unit, as shown in the illustration. Such accumulators are supplied in nominal sizes of from 1 to 30 litres, and for pressures up to 200 atmospheres ; the useful oil volume amounts to about 60 per cent of the nominal volume.

Plastics Exhibition

During June 18–26, 1960, an exhibition entirely devoted to the plastics industry will be held in the Floralies Palace in Ghent. This trade fair, styled "Europlastica 60," will be organised in close collaboration with the Office Belge des Matières Plastiques, Galerie du Centre, Bloc 3, Rue des Fripiers, Brussels, from which fuller information may be obtained.

Data Processing Installation

On October 29, the inauguration took place in Stockholm of the first Ferranti "Perseus" data processing installation, stated to be the largest in Scandinavia. The computer system is operated by the Datacentralen Company, a subsidiary of two of the biggest Swedish insurance firms.

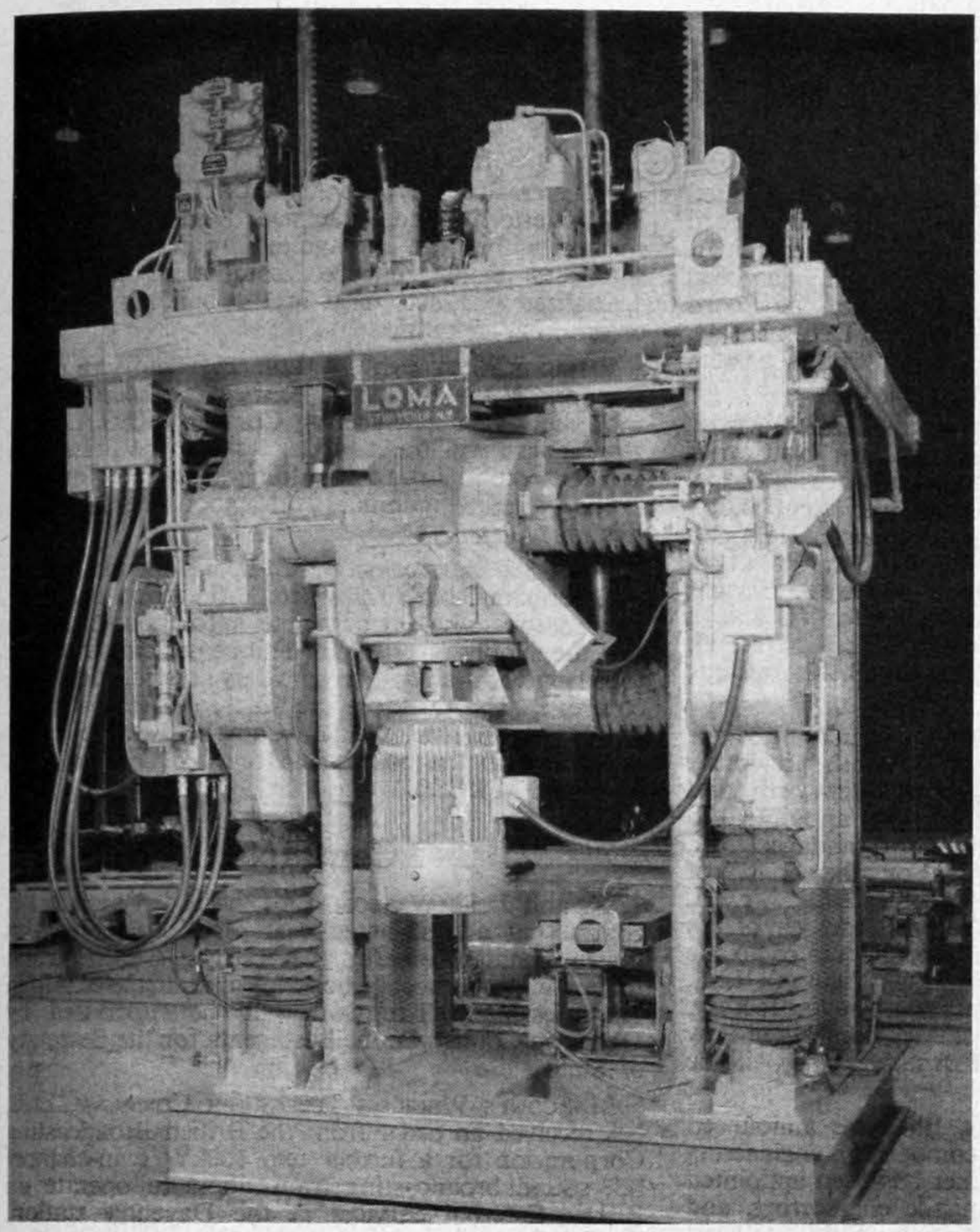


Fig. 1—Loma continuous casting machine for the production of billets and slabs

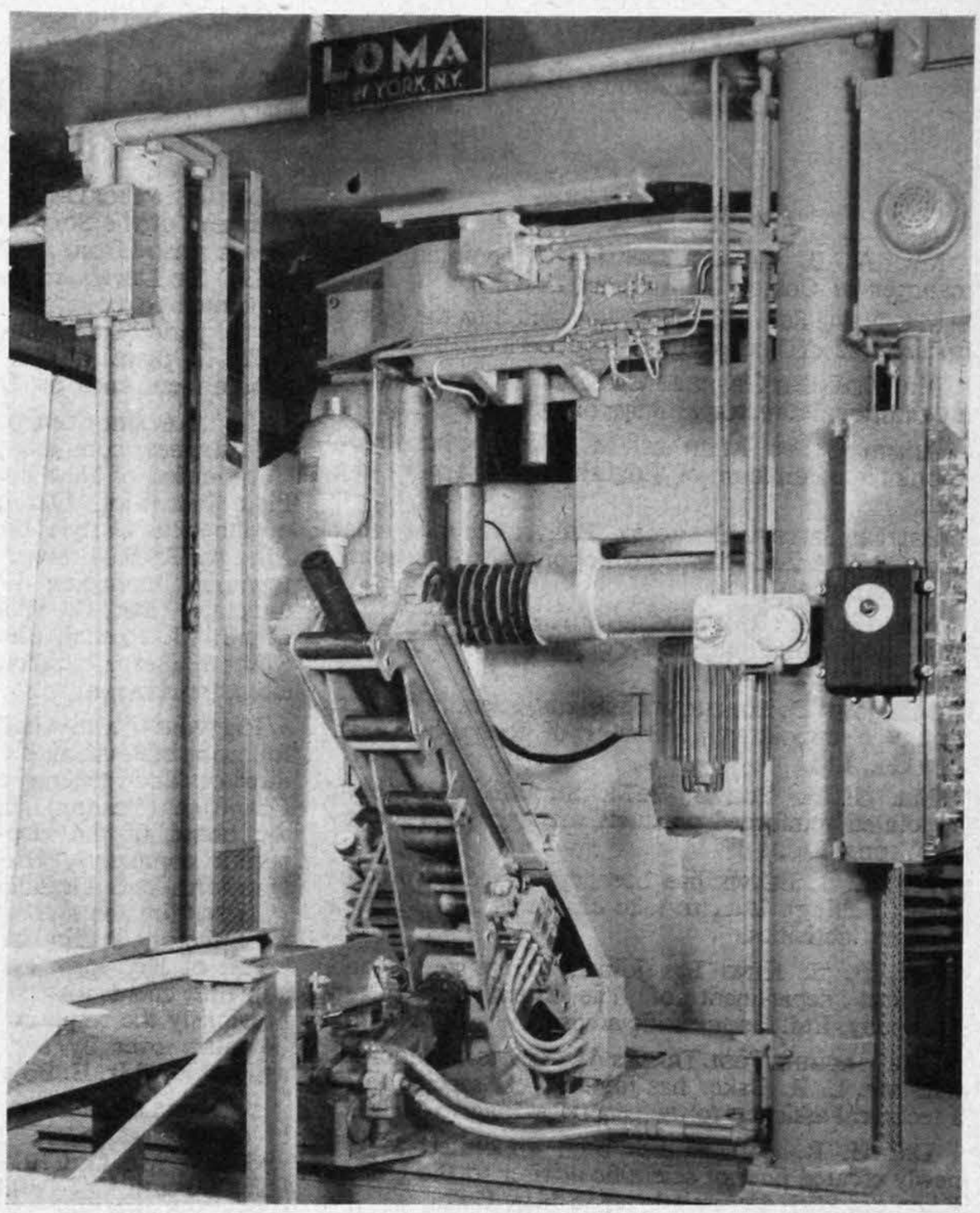


Fig. 2—Lower casting machine level, showing a cut billet being removed by the tilting discharge basket

Continuous Casting Machine for Copper Billet and Slab Production

AN important advance in copper billet and slab casting technique has been announced by the Loma Machine Manufacturing Company, of New York. The new development has resulted in a most productive and versatile fully continuous casting machine. The equipment handles copper in all its various forms—from phosphorus deoxidised and oxygen-free to fire-refined and tough-pitch materials. The basic design of the machine also lends itself to the casting of brasses, bronzes, aluminium and magnesium alloys. The shapes produced on the unit include round piercing and extrusion billets, square wire bars and rectangular slabs. The production capacity of the machine ranges from 3 tons per hour for double-strand casting of 3in diameter billets to 10 tons per hour for single-strand casting of 5½in by 33in slabs.

The Loma continuous casting machine is usually fed with liquid metal from either an arc or induction melting furnace, followed by an induction holding furnace. The molten copper, at a temperature of 2150 deg. Fah., then flows through a special refractory-lined distributor equipped with down spouts extending into the moulds. The rate of flow of the metal through the down spouts extending below the metal surface is controlled by the operator with needle valves. This " underpouring " method ensures a smooth, splash-free entry of clean metal into the mould cavity, thus eliminating internal porosity and inclusions in the cast material.

The billet, bar and slab moulds are of copper construction and are mounted at the top of the casting machine. The mould water jackets feature a special internal baffle design which greatly enhances their heat removal capacity. The cooling water initially flows through the mould jackets and then emerges from an adjustable slot at the mould bottom to impinge on the solidified metal surface in direct spray form. The spray water is collected in a water box mounted below the moulds and is recirculated. To prevent sticking of the cast copper to the mould and to ensure a smooth metal surface, the entire mould assembly is oscillated by a reciprocating gear. The vertical stroke is only a fraction of an inch and the rate of vibration can be adjusted up to several hundred cycles per minute by means of a variable speed drive.

The solidified metal strands are continuously withdrawn from the moulds by a double set of 9in diameter pinch rolls made of stainless steel. Proper clamping pressure is applied to the pinch rolls by opposed hydraulic cylinders and, in addition, spring pressure is provided to hold the stock firmly in cases of power failure. The pinch rolls are driven through reduction gearing by a 5 h.p. d.c. motor to obtain infinitely variable casting speeds up to 60in per minute. Immediately below the withdrawing rolls and mounted on a travelling carriage is the flying circular cut-off saw. The vertical travel of the saw is along two of the four main columns of the machine, while its horizontal travel is along two horizontal columns on which the travelling carriage is guided. During cut-off, the descending castings are engaged by hydraulically operated clamps situated on both sides of the saw blade. The saw employs a 36in diameter high-speed steel segmental blade driven by a 40 h.p. a.c. motor at 1200ft per minute peripheral speed. Lubrication for the saw is provided by an air-oil mist system. The cutting feed rate is adjustable up to 2in per second, while the return rate is 4in per second. The entire cycle of clamping, carriage descent, saw advance, saw return and carriage return is performed automatically. The cut billets or slabs are received in a discharge basket which is tilted automatically by a pneumatic cylinder through 90 deg. Once the basket reaches its horizontal position, the castings are ejected on to a roller conveyor by air cylinder action. Finally, an air-operated stamping device applies an identification mark to one end of each casting.

The major advantages to be obtained from the new Loma continuous casting machine are : (1) Machine mechanisation requiring only one operator improves plant productivity. (2) Steady casting conditions give a uniform, dense ingot structure from end to end. (3) Smooth metal pouring eliminates turbulence and entrapped oxides, dross and gases. (4) Rapid cooling produces a fine-grained, sound structure even in large cross-sections. (5) Predominantly longitudinal solidification prevents piping and internal stresses. (6) Long casting length and absence of cropping losses improve yield. (7) Simple, short moulds reduce the cost of and the space required by the casting shop inventory.

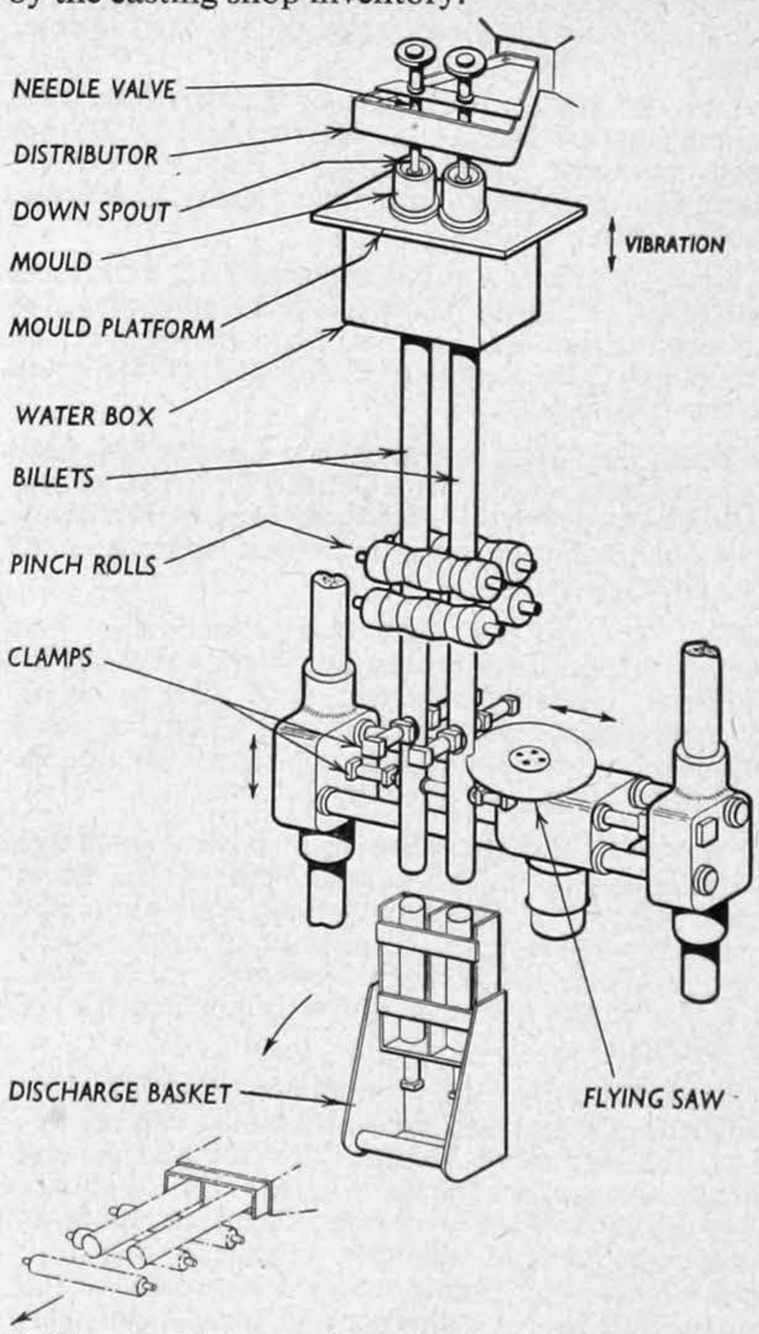


Fig. 3—Diagram of continuous casting machine arranged for two-stand production of billets

Personal and Business

Appointments

MR. A. B. CLARKE has been appointed sales manager of Cossor Instruments, Ltd.

MR. N. A. SOPER has been appointed to the board of directors of Tarmac Civil Engineering, Ltd.

MR. KENNETH GEORGE DOBSON has been appointed an additional director of Royston Industries, Ltd.

ADMIRAL SIR MICHAEL M. DENNY has been appointed a director of English Steel Corporation, Ltd.

BRITISH JEFFREY-DIAMOND, Ltd., announces that Mr. C. F. Adams has been appointed to its board of directors.

MR. H. S. RAINBOW, A.F.R.Ae.S., has been appointed chief engineer of Perkins Outboard Motors, Ltd.

MR. JOHN D. BOLCKOW, assistant general manager, has been appointed a director of Redpath Brown and Co., Ltd.

MR. J. F. PURVIS, A.M.I.Struct.E., has been appointed reinforced products manager of Thermalite Ytong, Ltd.

MR. C. J. BEAVIS has been appointed by Birlec-Efco (Melting), Ltd., to take charge of all Birlefco's smelting activities.

DR. F. E. KING has joined the refineries and technical department of The British Petroleum Company, Ltd., as scientific adviser.

THE MACHINE TOOL TRADES ASSOCIATION announces that Mr. L. R. Baker has joined the Association as a technical assistant to the general manager.

DR. H. R. AMBLER has been appointed to the newly created post of scientific adviser to the United Kingdom High Commissioner in New Delhi.

A.E.I. LAMP AND LIGHTING COMPANY, Ltd., has appointed Mr. J. J. Bonaker as assistant manager export with his office at Melton Road, Leicester.

MR. F. BURGESS has been elected chairman of the British Valve Manufacturers Association for the year 1959-60. Mr. J. W. Plowman has been elected vice-chairman.

THE EASTERN REGION OF BRITISH RAILWAYS has announced the appointment of Mr. J. Bonham-Carter as assistant general manager, Eastern Region, in succession to Mr. A. J. White, who has retired.

EDGAR ALLEN AND CO., Ltd., has announced the appointment of Mr. F. S. Marsden as transport and traffic manager in succession to Mr. C. Shaw who has retired. Mr. H. D. Boyd, director, has retired.

THE PRESSED STEEL COMPANY, Ltd., announces that Mr. Cecil F. Tracy has joined its organisation as a divisional director of the Prestcold division with the title of production director of the new Swansea plant.

LONDON MIDLAND REGION OF BRITISH RAILWAYS announces that Mr. D. A. Harris, A.M.I.C.E., has been appointed district engineer, Bangor. Mr. M. Harbottle has been appointed district engineer, Derby South.

THE GENERAL ELECTRIC COMPANY, Ltd., announces that Mr. C. F. Boyes has been appointed manager of the central London area branch, and Mr. F. H. Farthing has been appointed manager of the south eastern area branch.

PROFESSOR CHARLES FREDERICK CARTER has been appointed a member of the Council for Scientific and Industrial Research. He takes the place of Professsor E. A. G. Robinson, who retires on completion of his period of service.

THE MINISTRY OF TRANSPORT announces that The Rt. Hon. Ernest Marples, M.P., Minister of Transport, has appointed Mr. J. Garlick to be his principal private secretary. Lord Chesham, joint parliamentary secretary, has appointed Mr. L. A. Prior to be his private secretary.

CAPTAIN S. HARRISON-SMITH, at present in charge of the activities in the atomic field of the Swan Hunter Group of Companies, has been appointed engineering assistant to the director in charge of its Neptune Works at Walker, Newcastle upon Tyne. He will continue in charge of the atomic activities of the Group.

UNION CARBIDE, Ltd., announces the following changes in the responsibilities of senior executives : Mr. L. E. Whitmore becomes director and general manager, Polyethylene division ; Mr. J. F. Widman, previously director of marketing, chemicals, becomes director and general manager, chemicals division ; Mr. R. Wilson has been appointed a director of the company and becomes director and general manager, alloys division.

SIR JOHN PICKLES, M.I.E.E., has been reappointed chairman of the South of Scotland Electricity Board for the period from January 1, 1960, to December 31, 1963. Sir David Anderson, M.I.Mech.E., has been appointed to be a part-time member of the Board for the period from January 1, 1960, to December 31, 1962, in place of Sir John Imrie whose present appointment ends on December 31, 1959.

CARLYLE AIR-CONDITIONING AND REFRIGERATION, Ltd., the new company formed this year by Carrier Corporation of New York in association with Stone-Platt Industries, Ltd., announces the composition of the new Carlyle board of directors. This is : Mr. A. J. S. Brown, chairman ; Mr. Ralph S. Reynolds, managing director ; Mr. H. W. Harper, director ; Mr. O. W. Bynum, director (U.S.A.) ; Mr. J. M. Rachal, director (U.S.A.) ; Mr. A. H. Chilton, alternate director ; and Mr. S. K. Prestige, alternate director.

HEPWORTH AND GRANDAGE, Ltd., announces the following staff changes : Mr. T. L. Booth, previously director and general manager of Hepworth and Grandage (Yeadon), Ltd., has been appointed to the board of the Hepworth and Grandage, Ltd., parent company. He remains on the board of Hepworth and Grandage (Yeadon), Ltd. Mr. H. Forrest, director and works general manager of the main factory at Bradford has been appointed to the board of Hepworth and Grandage (Yeadon), Ltd., and the general managership of the Yeadon factory, previously the responsibility of Mr. Booth, will now be taken over by Mr. A. Rowntree, who will be assisted by Mr. E. Boyes.

DE HAVILLAND PROPELLERS, Ltd., has announced a reorganisation in the company's engineering division. Mr. G. C. I. Gardiner has been appointed chief executive of ballistic missile engineering, and whilst relinquishing his position as chief engineer, will remain technical director. Mr. T. W. Air has been appointed chief engineer of ballistic missiles and becomes responsible for the technical aspects of this work ; Mr. G. H. F. Brown has been appointed chief engineer (propellers, aircraft and industrial equipment) in charge of engineering activities other than weapons ; and Dr. G. H. Hough has been appointed chief engineer (air-to-air guided weapons) with full technical and administrative responsibility for the company's design and development programmes for air-to-air missiles. Mr. C. C. Williams has been appointed general manager of the company's ballistic missile organisation in its various locations.

Business Announcements

ELECTRO-HYDRAULICS, Ltd., states that it has taken over Scott Electric Vehicles, Ltd., Kidderminster.

THE PLESSEY GROUP OF COMPANIES announces that Mr. J. R. Thomas has retired after twenty-seven years' service.

C. C. WAKEFIELD AND CO., Ltd., states that the head office of the Wakefield Group of Companies has moved to Castrol House, Marylebone Road, London, N.W.1 (telephone Hunter 4455).

CRAWFORD COLLETS, Ltd., Witney, announces that it has appointed Alfred Herbert, Ltd., Carliol Square, Newcastle, 1, as its accredited agent for north-east England with effect from December 1.

RENOLD CHAINS, Ltd., has removed its northern district branch office from 50-52, Scotswood Road, Newcastle upon Tyne, to larger premises at Queensway North, Team Valley, Gateshead-on-Tyne, 11.

MR. A. S. D. BARRATT, technical director of Edwards High Vacuum, Ltd., is resigning from the board of directors at the end of the year to become an independent consultant. He has been appointed technical consultant to the company.

MR. LEONARD CLARKE, M.I.Mech.E., founder and, for twenty-five years, managing director of L. Clarke and Co., Ltd., has retired as chairman of the company at his own request and will no longer act as consultant. He retains a seat on the board of directors.

ENFIELD ROLLING MILLS, Ltd., and STANDARD TELEPHONES AND CABLES, Ltd., announce that they have concluded negotiations for the merger of the power cable businesses carried on by Enfield Cables, Ltd., and by Standard Telephones and Cables, Ltd. It is proposed that a new company will be formed which will be owned equally by Enfield Cables, Ltd., and Standard Telephones and Cables, Ltd. The new company's operations will be restricted to power cables and will start on January 1, 1960. The proposals require the sanction of the holders of the 4 per cent. first debenture stock, 1961-76, of Enfield Cables, Ltd.

PREMIER BITUMEN AND ASPHALTE COMPANY (1959), Ltd., Western Road, Bracknell, Berkshire, has been formed within the Expandite Group, to manufacture and market bitumen compounds and other specialised products used in the building and civil engineering industries.

J. BROCKHOUSE AND CO., Ltd., 25, Hanover Square, London, W.1, states that agreement has been reached with the Lester Engineering Company, U.S.A., that Brockhouse will build, under licence, the Lester 4/6 and 6/9 oz. injection moulding machines for sale in the United Kingdom and throughout the Commonwealth.

GRESHAM AUTOMATION, Ltd., Gresham House, Twickenham Road, Hanworth, Middlesex, has been formed to advise on complete automation schemes and the supply of Gresham unit sequencing systems, together with all other ancillary instruments and controls. The directors are Mr. John P. Coleman, M.I.E.E., and Mr. R. M. Campbell. Also, as a consultant to the board, is Dr. D. B. Foster, M.I. Mech.E., M.I.E.E.

Contracts

W. and J. R. WATSON, Ltd., has been awarded a contract at an estimated cost of £600,000, for an improvement scheme on the Glasgow-Carlisle trunk road (A.74) between Lockerbie and Ecclefechan in Dumfriesshire. The work will be supervised by Dumfries County Council as agents for the Secretary of State.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., has received an order from the British Broadcasting Corporation for a further two 100kW twin-channel h.f. sound broadcasting transmitters to operate on B.B.C. External Services at the Daventry station. The new equipments are a departure from conventional practice in that the penultimate and final r.f. amplifier and modulator valve stages are vapour-cooled, the heat generated by the valves being transferred to water jackets and the steam taken by convection to an air-cooled condenser. Condensate is returned by gravity feed to the water jackets. The vapour-cooled valves are manufactured by the English Electric Valve Company, Ltd. Each of the new transmitters is provided with two r.f. amplifier cabinets so that while one is carrying the programme service, the stand-by amplifier can be set up to an alternative frequency. A frequency change-over can then be made virtually instantaneously by switching a common modulator to feed the standby amplifier.

Miscellanea

THE ASSOCIATION OF ENGINEERING DISTRIBUTORS.—The annual luncheon of the Association of Engineering Distributors was held on Tuesday, November 3, at the Park Lane Hotel, Piccadilly, London, W.1. The annual general meeting of the Association was held in the morning, preceding the luncheon, and was followed by a talk on "Method Study in Distribution," given by Mr. C. E. M. Clarke. The guest of honour at the luncheon was Mr. Morton D. Oliphant, president of the National Union of Manufacturers.

NATIONAL LIBRARY FOR SCIENCE AND TECHNOLOGY.—A consultative committee has been appointed to advise the Department of Scientific and Industrial Research on the services of the National Lending Library for Science and Technology. Literature is now being collected for the library by the D.S.I.R. Lending Library Unit at 20, Chester Terrace, Regent's Park, London, N.W.1. The library will be located near Boston Spa, Yorkshire, and its transfer will take place in the first half of 1961. Its collection of scientific literature, which will become the largest in the United Kingdom, will be available to any organisations through loan and photo-copying services. The chairman of the consultative committee is Sir Lindor Brown, F.R.S., Biological Secretary of the Royal Society.

CABLE LAYING.—A film entitled "Cable Laying Journey" has been produced for W. T. Henley's Telegraph Works Company, Ltd., by John Byrd Productions, and was shown in London last week. The film deals with the manufacture, supply, jointing and supervision of installation of some 88 miles of 33kV three-core oil-filled cable and pilot/supervisory cables for the Kent coast electrification scheme of the Southern Region of British Railways. Sequences showing the installation of the cable include those at Selling tunnel (where the cable was taken over the hill instead of through the tunnel), alongside the track near Whitstable, where the cable is installed in ducts under the track, and at the foot of the cliffs between Dover and Folkestone. The film runs for thirty minutes and is available on loan in 16mm size.

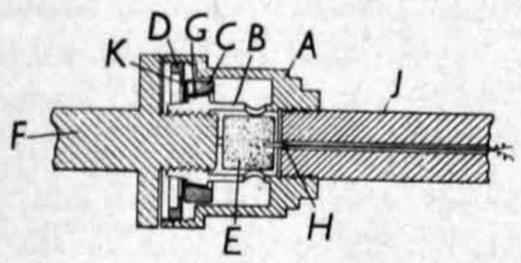
British Patent Specifications

When an abridgment is not illustrated the specification is without drawings, unless otherwise stated. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

AIRCRAFT EQUIPMENT

821,445. July 3, 1957.—Explosively Operated Quickly Releasable Holding Devices, National Research Development Corporation, 1, Tilney Street, London, W.1. (*Inventor: Leslie George Abberton.*)

This invention relates to explosively operated quickly releasable holding devices such as may be used to attach to an aircraft a fuel tank which is to be jettisoned when empty. An object is to provide a simple attachment which produces very few or no flying fragments when operated. In the drawing



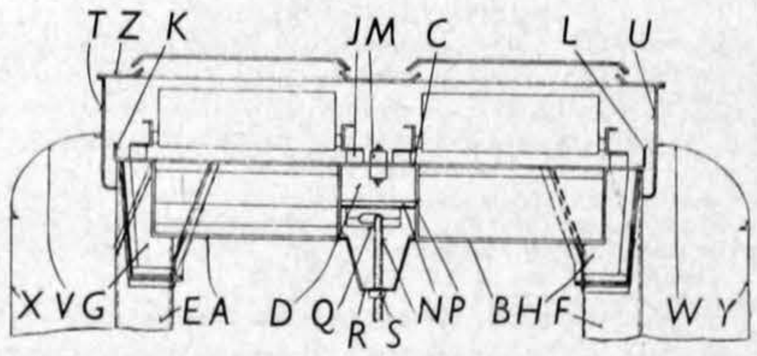
No. 821,445

the invention is described by way of example only. It shows a longitudinal section of a nut attachment connecting two shafts, the section plane being taken between a pair of collet jaws. The body *A* is formed with an internal split collet *B* and the attachment includes a tapered retaining ring *C*, a locking piece in the form of a ring *D* and an explosive charge *E* housed within the collet. The collet is slotted longitudinally to form four jaws, the slots terminating in radial holes. The jaws of the collet are threaded for attachment to a shaft *F* which has a flange extending to the outer circumference of the nut body. The external surfaces of the collet jaws have a tapered annular flange *G*. The retaining ring *C* is tapered on its inner surface to fit over the flange and its position may be adjusted to hold the collet jaws so that they firmly grip the shaft. The ring is driven into and may be locked in position by the locking ring *D* which is screwed into internal threads on the nut body until its internal flange bears on the face of the tapered ring. The explosive charge housed within the collet is fired by means of an igniter *H*. The end of the nut is screwed on to a second shaft *J* or equivalent component from which the shaft *F* is required to be released. The shaft *J* is shown with a central hole through which are passed the leads from the electric igniter. On firing the charge the propellant gases pass through the holes in the collet walls and force the tapered ring forward, deforming the flange *K* of the locking ring. The flange is arranged to be weak enough to be bent right back by the force of the explosion so that the ring *C* is driven forward clear of the flange *G* until it strikes the shaft flange. The explosive charge acts upon the collet jaws and the shaft *F* and the jaws being freed from the restraint of the ring are forced open to release the shaft which is driven clear by the propellant gases. The ring *C* is prevented from flying free of the nut by the shaft flange until the shaft is driven apart from the nut after which the pressure inside the nut is released. The angle on the tapered ring and the flange *G* very largely determines the magnitude of the force required to displace the ring and the characteristics of the device can be altered considerably by varying this angle.—*October* 7, 1959.

ELECTRIC TRACTION

820,871. March 7, 1956.—Cooling Electric Locomotive Starting Rheostats, Vilém Trebín, Plzen, Czechoslovakia, Jiri Hes, Plzen, Czechoslovakia, and Závody V.I. Lenina, Národní Podnik, Plzen, Czechoslovakia.

It is the object of the present invention to provide an arrangement which ensures a more even cooling of locomotive starting rheostats by the cooling air supplied from blowers. To this end the frame which supports the rheostats is formed by two troughs which are open at the top and extend in parallel a distance apart from one another. The space between the troughs is covered so as to form a central trough with its opening pointing downwards, and the rheostats are mounted above the two outer troughs, whilst their supply cables are arranged within the central trough. The outer troughs are connected to conduits for the supply of cooling air. The cross-sectional drawing shows the parallel troughs *A*, *B*, which extend longitudinally and are open at the top. The side walls of the troughs which face one another are connected at their upper edge by a transverse wall *C* so that another trough *D* with its opening pointing downwards is formed. Troughs *A*, *B* are divided by walls into two portions, each supplied with cooling air through a separate tube. Deflecting plates are arranged in each trough which extend to increasing depths, in order to deflect equal portions of the incoming air stream towards the individual rheostat casings. The frame is supported in the locomotive on uprights *E*, *F*, of tubular form through intermediate tubular supports *G*, *H* of the frame, the last mentioned supports having openings communicating with the cavities of the tubular



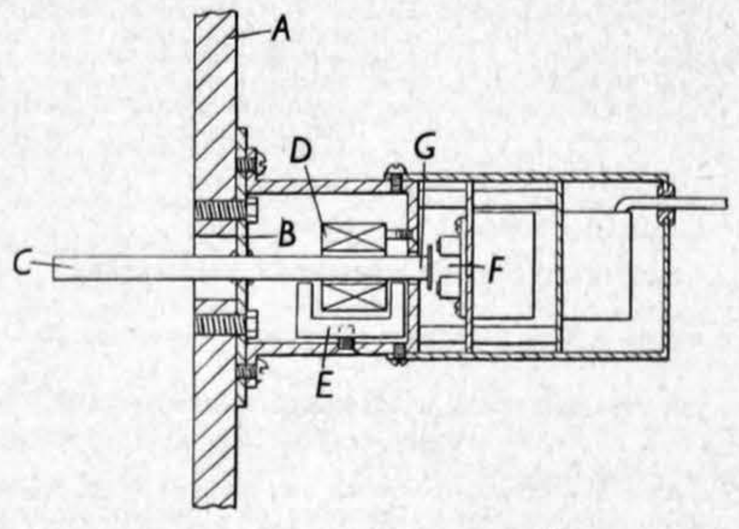
No. 820,871

uprights. The purpose of this arrangement is to provide supply channels for auxiliary cooling air streams if it is desired to cool the rheostats while the locomotive is stationary. The rheostat casings rest through insulators *J* on lateral flanges *K*, *L*, at the outer sides of the troughs and on the transverse wall *C* which connects the two troughs. The transverse wall also carries insulators *M* through which the terminals of the rheostats are connected to the conductors leading to the rheostat switches. These conductors are combined to form a cable *N* which is fastened to cross members *P* in the central trough by wooden clamping means *Q*. Thus the central trough forms a cable channel, and is closed at the bottom by a removable cover *R* in which openings *S* are provided through which the cable can pass. Due to the fact that the cable trough is situated between the troughs *A* and *B* which are effectively cooled, the cables are protected from overheating. The upper ends of the carrier uprights are interconnected by longitudinal walls *T*, *U*, which walls surround the rheostats and are connected to the lateral parts *V*, *W*, of the roof of the locomotive. This arrangement allows complete separation of the starting rheostats from the motor room space, and mechanical connection of both side walls *X*, *Y*, of the locomotive casing. Cover *Z* of the rheostats forms the roof of the locomotive and openings in the roof allow the cooling air to escape.—*September* 30, 1959.

ELECTRONICS

821,148. September 6, 1957.—Level Detector, Bailey Meters and Controls, Ltd., Purley Way, Croydon Surrey. (*Inventors: John Dennis Attwell and Bernard Augustine Worswick.*)

The present invention includes a vibrating member, such as a rod, which detects the presence or absence of material at a certain level by changes in its amplitude of vibration. The drawing is a sectional elevation of a unit arranged at a wall *A* of a tank for liquid for detecting the presence or absence of liquid.



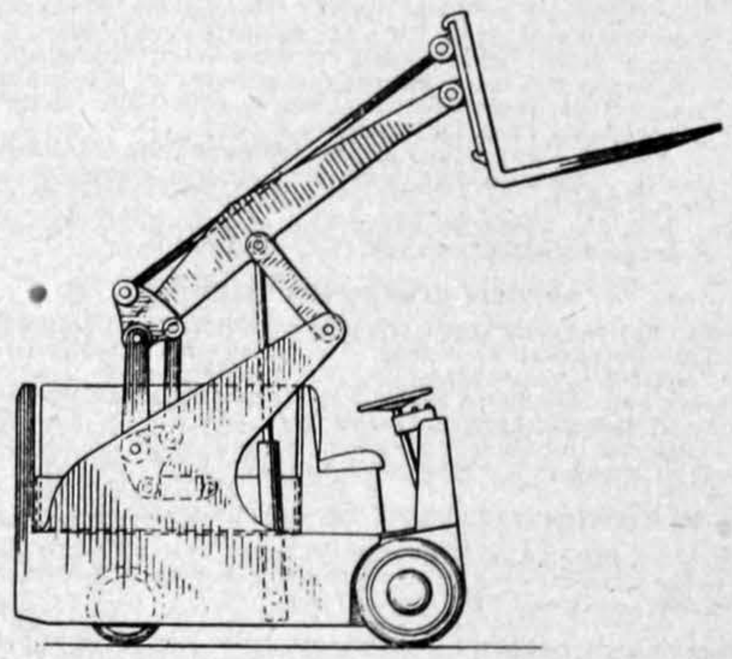
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The plate *B* supports a rod, *C*, of ferro-magnetic material, at its mid-point, the rod projecting within the tank with a part outside the tank. A solenoid *D* surrounds a length of the rod and is adapted to supply to the rod the power necessary to sustain it in longitudinal vibrations at its lowest natural frequency. Also mounted within the casing is a U-shaped permanent polarising magnet *E* to provide a magnetising force sufficient to ensure that the magnetic field in the length of the rod influenced by the solenoid does not change in sense. Electromagnetic device *F* is influenced by the vibrations of the end of the rod, and with solenoid *D* is connected in the electronic system. When the rod vibrates longitudinally the end *G* alternately approaches and recedes from the electromagnetic device *F*, and the latter generates an alternating electromotive force of the rod vibration frequency which, applied to a thermionic system, ensures an alternating component in the current through the solenoid *D* of the same frequency. In the operation of the arrangement, the electronic amplifying system tends to sustain the rod in longitudinal vibrations at its lowest natural frequency, at which the mid-point of the rod is a node and maximum movements of the rod take place at its two ends. When the liquid level in the tank is below that of the rod, the rod vibrates at its maximum amplitude and the maximum signals traverse the electronic amplifying system. When, however, the liquid is at a level high enough to contact the end of the rod within the bunker, its vibration is destroyed or at least very greatly reduced in amplitude, and the signals traversing the electronic amplifying system are brought to zero or to a low value. The external control system initiates or performs whatever action is arranged for it under such circumstances. The specification includes a circuit diagram and explanation of the electronic system and shows a modified construction for materials other than liquid which might adhere to the rod; also a float-operated system in which the rod is normally uncontacted by the liquid.—*September* 30, 1959.

LIFTING TRUCKS

821,383. July 29, 1957.—Power-Operated Lifting Truck, Yale and Towne Manufacturing Company, 405, Lexington Avenue, New York 17, New York, United States of America.

The general design of the power-operated lifting truck described in detail in this specification can be seen in the drawing. Its load-carrying member is



No. 821,383

supported through a lever and links which enable loads to be raised vertically in the same way as by conventional fork lift trucks. The linkage system also enables the forks to be tilted to an angle which is retained throughout the lifting operation.—*October* 7, 1959.

METALLURGY

821,716. November 23, 1956.—Continuously Annealing Steel Strip, United States Steel Corporation, 525, William Penn Place, Pittsburgh, 30, Pennsylvania, United States of America.

According to the invention a method of continuously annealing low-carbon, cold-rolled ferrous strip consists of continuously passing the strip through an enclosure having heating, cooling and holding zones, equalising the temperature of the strip in the heating zone in the range of 1250 deg. to 1300 deg. Fah. to recrystallise the cold-rolled structure; cooling the temperature in less than two minutes to below 1000 deg. Fah. in the cooling zone and then holding the strip for at least thirty seconds in the temperature range of 800 deg. to 1000 deg. Fah. in the holding zone. It is stated that annealing at subcritical temperatures is possible since ferrite grains which have been distorted and highly stressed as a result of cold rolling, have the ability to recrystallise and re-orient themselves into a normal structure at temperatures as low as 1000 deg. Fah. However, the pearlite grains which have also been stressed and distorted by cold rolling remain unaffected at subcritical temperatures. Prior practices in subcritical annealing have relied on long time at annealing temperature coupled with slow cooling to govern the degree of hardness realised from the annealing operation. This practice is based on the premise that steel must be held at subcritical annealing temperatures for long periods to permit recrystallisation of the ferrite and agglomeration of the carbides. The annealing practice of this invention is a radical departure from the recognised practice in subcritical annealing as is shown in curves reproduced in the specification.—*October* 14, 1959.

Catalogues and Brochures

W. C. HOLMES AND CO., Ltd., P.O. Box No. B.7, Turnbridge, Huddersfield.—Publication No. 64, describing "Holmes" inert gas generators.

STURTEVANT ENGINEERING COMPANY, Ltd., Southern House, Cannon Street, London, E.C.4.—Publication No. 7204, describing type O.H. high-voltage electrostatic separator.

MACHINE SHOP EQUIPMENT, Ltd., Spenser Street, London, S.W.1.—Illustrated catalogue giving technical details of "RB" cartridge tooling for internal and external machining.

ALLAN LEVIN, Ltd., 21, Mackenzie Street, Slough, Buckinghamshire.—Brochure describing the Swedish "Nor-Vac" hydraulic floor crane, which is now being imported into this country.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., Chelmsford, Essex.—Illustrated booklet (Ref. SP75), giving details of the 1kW wideband h.f. radio transmitter "HS113" with wideband amplifier covering the h.f. frequency band from 2 to 24 Mc/s, so that variable tuning elements are dispensed with and different frequencies are selected by simple switching. The drive units may be separated from the amplifiers and installed under direct control in the station operating consoles.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ANTIQUARIAN HOROLOGICAL SOCIETY

To-day, Nov. 20.—Science Museum, South Kensington, London, S.W.7, "The A.H.S. Tour of Germany, July, 1959," F. A. B. Ward, 7 p.m.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Mon., Nov. 23.—NORTH WEST LONDON BRANCH: Compass Hotel, Watford, Film, "Electrical Shop Window of 1959," 8.15 p.m.

Thurs., Nov. 26.—BRIGHTON, HOVE AND DISTRICT BRANCH: New Imperial Hotel, First Avenue, Hove, Film, "Electrical Shop Window of 1959," 7.30 p.m. ★ SOUTHAMPTON BRANCH: Polygon Hotel, Southampton, "Problems of Ventilation," J. B. Spokes, 8 p.m. ★ SOUTH LONDON BRANCH: Greyhound Hotel, High Street, Croydon, Surrey, "Railway Electric Locomotives," D. B. McKenzie, 8 p.m.

Fri., Nov. 27.—STOKE AND CREWE BRANCH: Grand Hotel, Hanley, "Protective Equipment for Industrial Plant," W. L. Stern, 7.30 p.m.

Sat., Nov. 28.—ESSEX BRANCH: Visit to Park Royal Brewery of Arthur Guinness Son and Co., Ltd., 10.30 a.m.

BRITISH COMPUTER SOCIETY

Tues., Nov. 24.—LIVERPOOL BRANCH: Mathematical Institute, The University, Liverpool, "Choosing and Installing a Computer—A Case Study," A. J. Platt, 6.30 p.m.

Thurs., Nov. 26.—SOUTH WALES AND MONMOUTHSHIRE BRANCH: Small Shandon Lecture Theatre, University College, Cardiff, "Practical Problems Encountered Arising from Installation of a Computer," D. J. Hasell, 6.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Fri., Nov. 27.—SOUTH MIDLANDS SECTION: North Gloucestershire Technical College, Cheltenham, "A Vidicon Television Camera Channel," B. J. Pover, 7 p.m.

CENTRAL LONDON PRODUCTIVITY ASSOCIATION

To-day, Nov. 20.—21, Tothill Street, London, S.W.1, "Education for Productivity," Stafford Beer, 2 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Tues., Nov. 24.—NORTH WESTERN REGION: Engineers' Club, Manchester, Brains Trust on "Incentive Schemes for Boiler Operators," 2.30 p.m.

Wed., Nov. 25.—SCOTTISH REGION: Royal Hotel, 5, Union Street, Dundee, Discussion on "The Utilisation of Small Coals," opened by R. Cleland, 10.30 a.m.; Discussion on "Coal to Oil Conversion," opened by L. H. W. Savage, 2 p.m.

Thurs., Nov. 26.—WESTERN REGION: Seabank Hotel, Porthcawl, Glam, "The Development of Coal Production and Preparation," A. W. Davis; Films, "The Fast Plough" "Coal Preparation," and "New Developments in Coal Preparation," 11 a.m.; Films, "Combustion," "The Cyclone Furnace," and "Smog," 2.15 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Nov. 23.—LEEDS CENTRE: The British Lighting Council, 24, Aire Street, Leeds, 1, "Polarised Light and its Applications," D. L. Smare, 6.15 p.m. ★ LEICESTER CENTRE: Demonstration Theatre, East Midlands Electricity Board, Charles Street, Leicester, "Modern Lighting in Production," L. E. Gibbs, 7 p.m.

Mon., Nov. 30.—BIRMINGHAM CENTRE: Regent House, St. Philip's Place, Colmore Row, Birmingham, "The Association of Light and Colour," A. D. Charters, 6 p.m.

INSTITUTE OF FUEL

Wed., Nov. 25.—MELCHETT LECTURE: Institution of Civil Engineers, Great George Street, London, S.W.1, "Surface: A Common Problem for Research and Engineering in Fuel Technology," P. O. Rosin, 5.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Nov. 23.—WEST OF ENGLAND SECTION: Smith's Assembly Rooms, Bath, "The Controllable Pitch Propeller," H. Twitchen, 7.30 p.m.

Wed., Nov. 25.—MERSEYSIDE AND NORTH WESTERN SECTION: Technical College, Birkenhead, "Modern Marine Watertube Boilers," A. P. Monk, 7.15 p.m.

Thurs., Nov. 26.—NORTH EAST COAST SECTION: Technical College, Sunderland, "Auxiliaries," P. Scorer, 4 p.m. ★ WEST MIDLANDS SECTION: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, "The Manufacture of Thick Walled Seamless Pressure Tubes," R. R. Gilchrist, 7 p.m. ★ SOUTHERN JOINT BRANCH: College of Technology, Portsmouth, Joint lecture with the Institution of Naval Architects, "Marine Lubricants and the Use of Additives," R. W. Bale, 7.30 p.m. ★ KINGSTON UPON HULL AND EAST MIDLANDS SECTION: Royal Station Hotel, Kingston upon Hull, "The Manufacture of Marine Propellers," J. Langham, 7.30 p.m. ★ JOINT MEETING WITH THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS: The Memorial Building, 76, Mark Lane, London, E.C.3, "Human Problems in Marine Engineering," C. C. Pounder, 3 p.m.; "Co-Ordinated Alignment of Line Shaft, Propulsion Gear and Turbines," J. J. Zrodowski and H. C. Andersen, 5.30 p.m.

Fri., Nov. 27.—NORTHERN IRELAND PANEL: Central Hall, College of Technology, Belfast, "Reactor Design, Particularly of Types Suitable for Marine Propulsion," E. Long, 7.30 p.m.

INSTITUTE OF NAVIGATION

To-day, Nov. 20.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Radiometry, Radio-Astronomy and Infra-Red Techniques," C. M. Cade, 5.15 p.m.

INSTITUTE OF SHEET METAL ENGINEERING

Wed., Nov. 25.—WOLVERHAMPTON SECTION: Wolverhampton and Staffordshire College of Technology, Wulfruna Street, Wolverhampton, "Joining of Material by Plastics," L. W. Taylor, 6.45 p.m. ★ NORTH-WEST BRANCH: Engineers' Club, 17, Albert Square, Manchester, "Application of Cold Rolled Sections," E. Griffin, 7 p.m.

INSTITUTE OF WELDING

Wed., Nov. 25.—MEDWAY SECTION: F. Braby and Co., Ltd., London Works, Thames Road, Crayford, Kent, Film, "Off-Shore Rig," introduced by W. Roy, 7.30 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Mon. Nov. 30.—WEST MIDLANDS CENTRE: Room No. 118, Gosta Green Technical College, Birmingham, "The Latest Developments in Metallurgy with Possible Agricultural Engineering Uses," J. Williams, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Nov. 24.—Royal Institution, Albemarle Street, London, W.1, Symposium on "Nuclear Energy," to be held in conjunction with the British Nuclear Energy Conference, 2.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Nov. 24.—Great George Street, Westminster, London, S.W.1, "The Mechanisation of Railway Civil Engineering Maintenance Works," A. Dean, P. Chalmers and A. C. Layhe, 5.30 p.m.

Thurs., Nov. 26.—Great George Street, Westminster, London, S.W.1, Informal Debate, "Is the Practical Training of Civil Engineers Adequate?" Principal speakers, G. A. Wilson, A. Dean and C. Brand, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Nov. 20.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "The Ordinary National Certificate—A New Look," opened by T. Siklos, 6 p.m.

Mon., Nov. 23.—MERSEY AND NORTH WALES CENTRE: Town Hall, Chester, "Research on the Performance of High-Voltage Insulators in Polluted Atmospheres," J. S. Forrest, P. J. Lambeth and D. F. Oakeshott, 6.30 p.m. ★ NORTH-EASTERN CENTRE: Neville Hall, Westgate Road, Newcastle upon Tyne, "The Application of Low-Pressure Resins to some High-Voltage Switchgear Designs," T. R. Manley, K. Rothwell and W. Gray, 6.15 p.m. ★ NORTH WESTERN CENTRE: Engineers' Club, 17, Albert Square, Manchester, Discussion on "Modern Applications of Field Platting," opened by E. R. Hartill, 6.15 p.m. ★ SOUTH MIDLAND ELECTRONICS AND COMMUNICATIONS GROUP: James Watt Institute, Birmingham, "Learning Machines," P. Huggins, 6 p.m. ★ WESTERN UTILISATION GROUP: South Wales Institute of Engineers, Cardiff, "Discrimination between H.R.C. Fuses," E. Jacks, 6 p.m. ★ READING DISTRICT BRANCH: George Hotel, King Street, Reading, "An Introduction to Electronic Computers," R. C. M. Barnes, 7.15 p.m.

Tues., Nov. 24.—EAST MIDLAND CENTRE: College of Further Education, Loughborough, "Development of High-Voltage Air-Break Circuit-Breakers with Insulated-Steel-Plate Arc Chutes," F. S. Fay, J. A. Thomas, D. Legg, and J. S. Morton, 6.30 p.m. ★ NORTH-EASTERN CENTRE: Technical College, Carlisle, "The Provision of Adequate Electrical Installations in Buildings,"—"Multi-Storey Flats and Maisonettes," C. A. Belcher, 7 p.m. ★ NORTH MIDLAND CENTRE: Main Hall, Institute of Technology, Bradford, "A System for the Automatic Recognition of Patterns," R. L. Grimsdale, F. W. Sumner, C. J. Tunis and T. Kilburn, 6.30 p.m. ★ NORTH-WESTERN SUPPLY GROUP: Engineers' Club, Albert Square, Manchester, "Generator/Motor Problems in Pumped Storage Installations," J. H. Walker, 6.15 p.m.

Wed., Nov. 25.—ELECTRONICS AND COMMUNICATIONS SECTION: Savoy Place, London, W.C.2, "Radio Aspects of the International Geophysical Year," R. L. Smith-Rose, 5.30 p.m. ★ NORTH SCOTLAND, SOUTH-WEST AND SOUTH-EAST SCOTLAND SUB-CENTRES: St. Andrews Hall, Glasgow, Faraday Lecture, "Electrical Machines," M. G. Say, 7.30 p.m. ★ RUGBY SUB-CENTRE: College of Technology and Arts, Rugby, "Subscriber Trunk Dialling," D. A. Barron, 6.30 p.m.

Thurs., Nov. 26.—ORDINARY MEETING: Savoy Place, London, W.C.2, "The Application of Low-Pressure Resins to Some High-Voltage Switchgear Designs," T. R. Manley, K. Rothwell and W. Gray, 5.30 p.m. ★ EAST MIDLAND CENTRE: George Hotel, Kettering, "An Electrical Engineering Project in India," H. E. Knight, 7.30 p.m. ★ SOUTH MIDLAND CENTRE: College of Technology, Gosta Green, Birmingham, Education Discussion Circle Meeting, "The Organisation of Courses for Electrical Technicians," opened by M. W. Humphrey Davies, 6.15 p.m. ★ WESTERN SUPPLY GROUP: Conference Room, S.W.E.B. Showrooms, The Kingsway, Swansea, "Construction Problems," R. Lefevre, 6 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, Nov. 20.—NORTH EAST BRANCH: King's College, Newcastle upon Tyne, "Modern Trends in Winter Road Maintenance," W. I. J. Price, 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Sat., Nov. 21.—LONDON GRADUATES' SECTION: Visit to B.E.A. Engineering Base, London Airport, 10 a.m.

Mon., Nov. 23.—EDUCATION GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Modern Aspects of the Teaching of Vibration Theory," 6 p.m.

Tues., Nov. 24.—SOUTH WALES BRANCH: South Wales Institute of Engineers, Cardiff, Repetition of the Thomas Lowe Gray Lecture, "Refrigeration for Marine Cargo Purposes," H. R. Howells, 6 p.m. ★ WESTERN BRANCH: Engineering Laboratories, The University, Bristol, "Modern Aids in the Design of Railway Bogies," A. W. Manser, 6.30 p.m. ★ BIRMINGHAM A.D. CENTRE: James Watt Institute, Birmingham, "Some Problems We Meet," L. H. Dawtrey, 6.30 p.m. ★ WESTERN A.D. CENTRE: Royal Hotel, Bristol, "Problems Encountered in the Lubrication of Small Two-Stroke Engines," A. Towle, 6.45 p.m. LONDON GRADUATES' SECTION: 1, Birdcage Walk, Westminster, London, S.W.1, "Ball and Roller Bearing Manufacture," J. Anderson, 6.30 p.m.

Wed., Nov. 25.—THOMAS HAWKSLEY LECTURE: 1, Birdcage Walk, Westminster, London, S.W.1, "The Effect of Nuclear Radiation on Engineering Materials," A. H. Cottrell, 6 p.m. ★ EASTERN GRADUATES' SECTION: College of Technology, Luton, "Prediction of Motor Vehicle Performance," T. J. Brown, 7.30 p.m.

Thurs., Nov. 26.—APPLIED MECHANICS GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "The Application of Creep Results to Engineering Design," 6 p.m. ★ INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP: Engineers' Club, Albert Square, Manchester, "Management Accounting for the Small and Medium Size Company," A. J. Platt, 6.45 p.m. ★ SOUTHERN BRANCH: Royal Pavilion Hotel, Castle Square, Brighton, Discussions on "The Work of Research Engineers," E. N. Soar, and "The Sales Organisation of C.V.A. Jigs, Moulds and Tools, Ltd.," H. M. Lebrecht, 7.15 p.m. ★ EAST MIDLANDS GRADUATES' SECTION: College of Further Education, Grantham, "Rubber Models as an Aid to Design," A. C. D'Souza, 7.15 p.m. ★ SOUTHERN GRADUATES' SECTION: Pendragon Hotel, Clarence Parade, Southsea, "Introducing Innovations," L. A. Ferney, 7 p.m.

INSTITUTION OF PLANT ENGINEERS

Tues., Nov. 24.—SOUTH WALES BRANCH: South Wales Engineers' Institute, Park Place, Cardiff, "The Engineering Applications of Electro-Deposited Metals," J. W. Oswald, 7.30 p.m.

Thurs., Nov. 26.—SHEFFIELD AND DISTRICT BRANCH: Grand Hotel, Sheffield, "Some Modern Steel for the Engineer," E. Johnson, 7.30 p.m.

Fri., Nov. 27.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Instrumentation in Industry with Particular Reference to Control of Temperature, Pressure Flow, Weight, &c.," L. F. Cohen, 7.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Nov. 20.—NORTH MIDLANDS REGION: Louis Room, St. James's Restaurant, St. James's Street, Derby, "Russian Approach to the Production of Machine Tools," N. Stubbs, 7 p.m.

Mon., Nov. 23.—SHEFFIELD GRADUATE SECTION: Stanley Works (G.B.), Ltd., Rutland Road, Sheffield, "Introduction of a New Product," 6.30 p.m. ★ NORTH WESTERN REGION: Reynolds Hall, Manchester College of Science and Technology, Sackville Street, Manchester, "Diploma in Technology," C. W. Whitworth, 7.15 p.m.

Wed., Nov. 25.—EAST AND WEST RIDINGS REGION: Works visit to Davy United Engineering Company, Ltd., Darnall Works, Sheffield, 9, 7 p.m. ★ MIDLAND REGION: Walker Technical College, Oakengates, Shrewsbury, "The Fabrication of Nuclear Power Plants," S. H. Griffiths, 7.30 p.m. MIDLANDS REGION: Star Hotel, Worcester, "High Cost of Low Overheads," C. H. Starr, 7.30 p.m. ★ SOUTH WESTERN REGION: Large Lecture Theatre, Engineering Faculty of Bristol University, Bristol, "Training of a Production Engineer for the Aircraft Industry," J. Loxham, 7 p.m.

Thurs., Nov. 26.—COVENTRY GRADUATE SECTION: Craven Arms, High Street, Coventry, "Some Applications for Production Inspection," J. R. Adams, 7.30 p.m. ★ NORTH MIDLANDS REGION: Ruston Club, Lincoln, "Modern Techniques in Presswork," J. A. Grainger, 7.30 p.m. ★ ROCHESTER GRADUATE SECTION: Sun Hotel, Chatham, Kent, "Properties and Application of High Alumina Ceramics in Industry," F. E. V. Spencer, 7.30 p.m.

Fri., Nov. 27.—WALES REGION: South Wales Institute of Engineers, Park Place, Cardiff, "Photography in Engineering," P. H. Herbert, 7 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Tues., Nov. 23.—MANCHESTER SECTION: Engineers' Club, Manchester, "Developments in Flame and Ozone Resistant Compounds," L. Bustos, G. Cornil, W. A. Tandy and J. Walker, 6.45 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Nov. 20.—LANCASHIRE AND CHESHIRE BRANCH: College of Science and Technology, Manchester, "Plate Girder Design," K. C. Rockey, 6.30 p.m.

Thurs., Nov. 26.—11, Upper Belgrave Street, London, S.W.1, "A Commentary on the New British Standard 449 (1959). The Use of Structural Steel in Building," J. Mason, 6 p.m.

Fri., Nov. 27.—MIDLAND COUNTIES BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, "A Commentary on the New British Standard 449 (1959). The Use of Structural Steel in Building," J. Mason, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

Fri., Nov. 27.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Annual General Meeting, 7 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Nov. 27.—Lecture Theatre, Mining Institute, Neville Hall, Newcastle upon Tyne, "Some Aspects of Guided Missiles," C. Rowley, 6.15 p.m.

PLASTICS INSTITUTE

To-day, Nov. 20.—Royal Institute of British Architects, 66, Portland Place, London, W.1, Conference on "The Influence of Plastics in Building," 10 a.m.

REINFORCED CONCRETE ASSOCIATION

Thurs., Nov. 26.—WEST OF ENGLAND BRANCH: New School of Engineering, The University, Bristol, "Factory Production of Precast Concrete," F. W. Gifford, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Nov. 24.—The Library, 4, Hamilton Place, London, W.1, "Heat and Mass Transfer in Aeronautical Engineering," D. B. Spalding, 7 p.m.

Thurs., Nov. 26.—THIRD LANCHESTER MEMORIAL LECTURE: Church House, Westminster, London, S.W.1, "Some Developments in Boundary Layer Research in the Last Thirty Years," H. Schlichting, 6 p.m.

Fri., Nov. 27.—MAN-POWERED AIRCRAFT GROUP: Library, 4, Hamilton Place, London, W.1, "Man As an Aero Engine," D. R. Wilkie, 7 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN

To-day, Nov. 20.—21, Albemarle Street, London, W.1, "Atoms and Molecules," Sir Lawrence Bragg, 9 p.m.

ROYAL SOCIETY OF ARTS

Mon., Nov. 23.—CANTOR LECTURE: John Adam Street, Adelphi, London, W.C.2, "Commercial and Higher Professional Education," A. J. McIntosh, 6 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Wed. to Fri., Nov. 25 *to* 27.—Federation of British Industries, Tothill Street, London, S.W.1, Symposium on "Corrosion Problems of the Petroleum Industry," 9.30 a.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., Nov. 24.—Manson House, 26, Portland Place, London, W.1, "Application of Instrumentation to Glass Melting Furnaces," N. I. Walker, 6.30 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

To-day, Nov. 20.—Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Metallurgical Aspects of Flat Rolled Products," A. J. K. Honeyman, 6.45 p.m.

Advanced Engineering Courses

Problems of Radioactivity at Water and Sewage Works. THE MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY, Manchester, 1. Two-day course, Thursday and Friday, January 14, and 15, 1960. Fee £5 5s.