

# THE ENGINEER

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## A COMMON EUROPEAN MARKET

Ever since the war a strengthening tide has been running towards the linking of Western European nations into an economic entity. Large steps have indeed already been taken towards that end. The Organisation for European Economic Co-operation has brought about a great liberalisation of trade and the European Payments Union provides a means of balancing out the monetary effects of fluctuations in trade within the area. Closer economic union has actually been achieved within the Benelux group of Belgium, Luxemburg and the Netherlands and, within the iron, coal and steel trades, between that group, Western Germany and France. Other examples of co-operation include Euratom, the international research organisation for the peaceful uses of nuclear energy; such international researches as that being conducted by the flame research unit at IJmuiden; and the proposed cross-channel cable link between the British and French electric power systems. So far has the idea of economic unity now been carried that six European countries have over the last year been studying the possibility of joining together in a customs union and an actual treaty is now in an advanced stage of preparation. Those

countries are France, Germany, Italy, Belgium, Luxemburg, and the Netherlands. Other countries are actively considering whether it would be advantageous to join that union or to link themselves in some way with it. The advantages envisaged would follow from the creation of a single common market, without trade barriers, covering 200 to 250 million people. The existence of such a market, it is expected, would create the incentive for the development of large-scale production by highly productive methods and the economic resources to make the necessary capital available, with a consequent all-round material enrichment. The question is obviously posed to the United Kingdom whether it should join such a customs union or become associated in some way with it. That is a question our Government is now carefully studying.

There are obvious difficulties. At present the European market, though important to our importing and exporting industries, is not of prime importance. Only about 25 per cent of this country's trade is done with Europe, whereas 50 per cent is directed to and from the Commonwealth. In 1955 out of total imports from the world of £3886 millions, £1791

millions came from the Commonwealth and only £907 millions from Europe; and similarly out of total exports to the world of £3023 millions, £1432 millions went to the Commonwealth and only £785 millions to Europe. For engineering firms in general the importance of the Commonwealth market is even greater than those figures suggest; substantially more than half their exports go to the Commonwealth, and less than one-quarter to Europe. Clearly neither the U.K. nor the Commonwealth, which enjoy favoured treatment in each other's markets, could contemplate a complete break up of this beneficial system; nor could the U.K. realistically consider any project for joining a European free trade area if the Commonwealth as a whole objected. The actual plan which the Government has under consideration would associate the U.K. with the European customs union in such a way that trade barriers would be removed for all classes of goods except food, drink and tobacco. This arrangement would preserve the preference for about 90 per cent of the goods we receive from the Commonwealth. Preferential treatment would presumably continue to be offered by the Commonwealth to U.K. exports. The preliminary reactions of the Commonwealth to that plan seem to have been favourable. For the nations involved foresee that a rich and prosperous Europe would be able to increase its imports

from the Commonwealth, that an enriched U.K. and Europe should be the more able to invest capital towards its further development and that—a point of special interest to Canada—the present shortage of dollars in Europe which so restricts trade, might be ended.

Should the project now being examined by the Government prove practicable, ought this country, to adopt the plan? As an imaginative conception creating within Western Europe a trading area prospectively as economically powerful as the U.S.A. or Russia the idea is undoubtedly attractive. But harder-headed thinking indicates that a common market of about 250 million people cannot be created without a good deal of industrial readjustment resulting at the least in much discomfort for many people. The U.K. market, for all but food, drink and tobacco, would progressively over a term of years be thrown open for European industries to compete directly and upon level terms with our own. Would the fact that similarly our industries could compete on level terms on the Continent of Europe compensate? Our impression is that within the engineering industries as a whole this country has nothing seriously to fear from that competition, though certainly a few individual firms might be unable to meet it. About other industries of which our knowledge is far less complete we cannot express an opinion. Yet the question must be asked, can this country afford not to adopt the plan? For it should be realised that if the European union comes into being without British participation the consequences for this country are likely to be profound and disquieting. In world markets, even if not at home, British industries already have to compete against European products. If the advocates of the scheme are right and the creation of a great common market in Europe stimulates the development of high production methods, European products might well become cheaper than British. Is it likely under such circumstances that we could continue to hold Commonwealth markets against that competition? Again, would the Commonwealth continue to cling to a United Kingdom unable to provide capital for its development nearly as effectively as a united Europe? Eventually, no doubt, after a period of very uncomfortable adjustment, Britain's economy could be brought into balance; and, indeed, prosperity might be enjoyed, just as small nations like Switzerland and Sweden are prosperous to-day. But Britain would then inevitably become a very second-class power. We applaud, therefore, the Government's intention, declared by Mr. Macmillan, to examine the project not merely as an idle exercise but with the definite intention of finding, if possible, a practicable means by which the United

Kingdom can be associated with Western Europe in the creation of a common market, without breaking the Commonwealth link which is of such high value to this country. To fear European competition is reasonable enough. But the fear should act as a stimulus to exploit the possibilities inherent in an assured common "home" market of 250 million people; it should not lead to demands by this industry or that for special protection, for that would limit their markets to 50,000,000 people and exclude their

## The Engineer

100 Years Ago

(OCTOBER 10, 1856)

"METROPOLITAN SEWAGE"

"We see no difficulty whatever in disposing of the sewage of the metropolis, vast as it is, by distributing it in a fluid state, as manure, to such places as shall upon examination be found most to require it. We believe we are not far wrong in stating that there exist as many as 60,000 acres of unproductive common land within an easy distance of London, which is now of little or no value; but which, after a few years, might be rendered productive, and worth, perhaps, £5 per acre, if treated with regular doses of genuine London 'slush.' Many persons, we know, look with great horror on the black stream which may be daily seen issuing from the sewers into the Thames; but we have learned to tolerate it for a time, even there, believing that if it did not appear in the offensive form in which it does appear, that we should forget the very existence of so valuable a compound. Faraday turned up his nose at it; but we also turn up our eyes, and with something of a prophetic vision, see in it the source of smiling corn fields, and acres of everything that is good in the vegetable world, and tons of all that is delicate in the animal kingdom. This consideration brings us at once to account in the most satisfactory and conclusive way for the predilection of the Aldermen of the City of London, not only for the 'pea-soup' of which the Thames is said to be composed, but also for the raw material out of which it is made. Although not in any way connected with this worthy body of practical men who stand unmoved the jokes and pokes of their less fortunate fellow-citizens, yet we plead guilty to looking with complacency as they do on the Thames water and drain products, in the full assurance that there is something in them which, sooner or later, will be presented to us in a more attractive form."

participation in stimulating competition for the larger market. It is indeed probable that the European customs union would refuse this country participation in the common market if that participation were hedged around with exceptions.

### CONSERVING THE EXPENDABLE

Professor Jones displayed an enviable erudition in his review of the world's mineral resources, given at the Institution of Civil Engineers last week (see Seven Day Journal). He was both encyclopædic and entertaining, grouping together all the main facts about the various minerals, with such interesting diversions as pictures of a tin dredger in Malaya and a

"not very big" hole in the ground in Greenland which is the world's only source of cryolite. But as an exposition of the conservation of minerals—it was the first of a series on the "conservation of natural resources"—the lecture was not exactly convincing! That, of course, was not the fault of Professor Jones. It would be asking too much of any mortal man to explain how to halt the Gadarene progress of industrial civilisation. Reserves of ores and fossil fuels are all now being dissipated at an alarming rate, and the only signs of change are not towards conservation but towards an increasing rate of usage. The professor pointed out that if the whole world were brought up to Western European standards of life, mineral consumption would increase tenfold.

Granted that there is no prospect of immediate exhaustion, as measured by our individual spans of life, yet on a geological time-scale it is evident that our present spendthrift age will pass in a twinkling of an eye. Still, it seems to be characteristic of man's progress to do the easy thing first, and only search for alternatives when that is no longer possible. Energy from the atomic nucleus shows prospect of replacing the fossil fuels for many purposes; and it is possible, too, that new synthetic materials may be developed to replace materials reduced from natural ores. Certainly as minerals become scarcer economics will encourage the development of substitutes. Aluminium, for instance, is a very abundant element in the earth's crust, and Professor Jones noted that experiments in the United States on the extraction of aluminium from high-grade clays (i.e. clays with 15 per cent of aluminium) were well on the way to success. There are inexhaustible supplies of magnesium in the seas; and after all (who knows?) the moon, which will surely be under exploration within a hundred years, may turn out to be a solid lump of iron ore and the crust of Mars may overflow with fuel oil! If astronomers are to be believed there are inexhaustible supplies of methane in the atmosphere of Jupiter; and might not cloud-enshrouded Venus turn out a humid hot house, a very paradise for green plants? And are those suggestions really quite as satirical as they sound? For, seriously, can any examination of reserves of minerals which pretends to look far into the future possibly be trusted which does not take prospective exploration of the solar system into account? Of course such exploration may prove impossible. Then one thing is sure. It can safely be said that there is at least one metal found on earth which presents no problem of conservation. Gold is simply stored in vaults, and is not consumed in the same way as other metals. Perhaps in the distant future it will be the most abundant metal left on earth!

# A Seven Day Journal

## Mineral Resources

THE first of a series of six lectures on "The Conservation of Natural Resources," which are to be given during the remaining part of this year at the Institution of Civil Engineers, was delivered by Professor W. K. Jones on Thursday, October 4th. The series will supplement Sir Harold Hartley's recent Graham Clark lecture, and will, eventually, be published with that lecture in a single volume. Professor Jones lectured on "Mineral Resources" and reviewed the occurrence and utilisation of various minerals, chiefly metallic ores, which are of economic value in industry. The sporadic occurrence of important ores was stressed by the lecturer. For instance, tin was found chiefly in six localities, and most countries had consequently to import it; when present surface deposits were worked out, Professor Jones considered, the chief sources of tin would be from mines in Bolivia and Cornwall. Other metallic ores were even more restricted in their occurrence—nickel, manganese and columbium ores were amongst the examples quoted—pointing to the dependence of the nations upon each other for adequate supplies, a dependence which would increase, Professor Jones affirmed, as greater use was made of them. He emphasised the vast increases which had taken place in recent years, both in the quantity of ores consumed and in the number of minerals of economic significance. Forty per cent of the total quantity of copper which had been mined had been extracted in the last twelve years, he said, and more lead and zinc had been extracted in the last twenty-five years than in all the time before then. Thousands of tons of lead were blown into the atmosphere annually from high octane petrols and lost for ever, he went on, and emphasised that there was no second crop of ore deposits. Professor Jones suggested four methods of "conservation," namely, the development of alternative materials such as plastics; advances in the technology of mining and the recovery of metals from their ores; further geological prospecting; and "conservation" in actual use, an instance quoted being the use of concrete instead of structural steel.

## Institute of Marine Engineers' Presidential Address

SIR DONALD F. ANDERSON, this year's president of the Institute of Marine Engineers, gave his presidential address on Tuesday of this week. His subject was "Marine Engineering as a Part of the Shipping Industry," and he thought that the marine engineer's function was primarily a commercial one, in association with naval architects, shipbuilders, shipbrokers and ship managers. Although technical developments were being pressed forward in many directions, he affirmed that the basic ideas with regard to ships remained substantially the same. The main reason for slow progress was that the shipping industry had to make ships trade at a profit, in contrast with air transport, which was sustained by the taxpayer and operated on the principle that profits were relatively of secondary importance. Sir Donald went on to comment that the Ministry of Supply did not sponsor marine engine development at the taxpayers' expense, nor did it offer to make good any loss sustained by the industry should such an engine prove unsuccessful. The marine engineer could not indulge in daring designs, but was

forced to limit his experiments to those channels which would result in a more competitive ship as measured by the commercial yardstick. In short, said Sir Donald, increased speed, nuclear power, gas turbines and other modern developments could only be used if they gave commercial advancement. The president made a plea for greater simplicity and doubted the wisdom of gaining a small increase in efficiency, at added capital cost, and by so doing introducing greater complexity. Ships' engineers, he maintained, were competent, but not specialist, officers, who had to operate many and diverse installations, mainly without outside help; thus marine machinery must be reliable under widely varying conditions. Therefore, the most advanced shore practice could not be used at sea until any proneness to failure had been eradicated and it had become reliable in the hands of a non-specialist. However, he averred, marine engineers must keep their knowledge up to date so as to be able to decide when developments could be adopted, although the assessment of the suitability of machinery must be influenced by the qualifications of those who have to operate it.

## Historical Review of British Hydro-Electricity

THE Institution of Structural Engineers installed its new president, Mr. J. Guthrie Brown, at a meeting held on October 4th. Mr. Guthrie Brown's presidential address was entitled "Sixty Years of Hydro-Electric Development in Great Britain," and he reviewed all the various hydro-electric power schemes which have been constructed up to the present time, mentioning points of special interest in their design and construction. The first use of water power to generate electricity was at Cragside, Northumberland, he noted, in 1882, when a water turbine generated 8 h.p. from a 30ft head, and a belt-driven dynamo delivered power at 90V over a distance of 1 mile. The first major scheme had been at Foyers, in Inverness-shire, for the production of aluminium, and after sixty years was still in operation. The seven generating sets, Mr. Guthrie Brown said, were still in use and were probably the oldest of their kind in the world. They were vertical-shaft sets operated by Girard turbines, running at 150 r.p.m., and generating 5000 h.p. altogether (two more were added in 1904), with an overall efficiency of 70 per cent. Other topics described by the speaker in his address included the crude conditions of work on the Kinlochleven scheme, when the old-time "navvy" was employed on his last full-scale venture, and the dam disasters in North Wales in 1925, which led to the introduction of the Reservoirs (Safety Provisions) Act of 1930. The cheapest scheme ever constructed in Great Britain, he noted, was the Galloway scheme, which cost £29 per kilowatt installed, and was built in the period 1931-1936; present-day costs were from £100 to £150 per kilowatt of installed plant. Mr. Guthrie Brown went on to outline the events leading to the formation of the North of Scotland Hydro-Electric Board, and the work of the Board since its inception in 1944. His address included tables of data for all the hydro-electric stations in the country; the latest assessment of potential water power resources for Great Britain was 10,000 million units, or a continuous output of 1140MW, he noted. Successive estimates had been larger, and it might be that these

figures were too small, but the development of less economic schemes would probably be ruled out indefinitely as the nuclear age advanced.

## Institution of Production Engineers

MORE than 500 members and guests were present at the annual dinner of the Institution of Production Engineers, which was held in London on Friday last, October 5th. In his speech welcoming the guests, Mr. E. W. Hancock, the president, spoke of the work of the institution and the opportunity it gave young engineers to exchange knowledge and to benefit from the knowledge of older members of the profession. In this work of training and encouraging young engineers the professional institutions served a particularly important function of considerable value both to industry and the nation. Referring to the recent Machine Tool Exhibition, Mr. Hancock said that it provided an excellent demonstration of the great ability of the British machine tool industry and the high degree of craftsmanship which existed in this country. Nevertheless, he pointed out that the majority of the very costly and high-quality machines in British factories were working far below their productive capacity owing to short working hours. There were 168 hours available for production each week, and it should be an aim of both production engineers and trade unions to find means of using all of these hours to the full by double-day-shift working. In the course of his speech Mr. Hancock mentioned the relatively small intake of youth for technical training in this country each year, as compared with competitive overseas countries, and this matter was again referred to by Mr. Iain Macleod, the Minister of Labour and National Service, in his response to the toast. The Minister pointed out that a great opportunity faced industry during the next few years, as the number of youths leaving school would be bigger than ever before. Full advantage should be taken by industry of this fact to encourage the greatest possible number of boys to undergo training as craftsmen and technologists. The Ministry of Labour and National Service and the Ministry of Education were both ready and willing to help employers to interest youth, and it was up to industry to provide the encouragement and the best training facilities possible so that this great potential would be used to its fullest advantage.

## Rejection of Development Schemes at Victoria Station

THE London County Council has announced that it has decided not to grant permission at present for five proposals for development in the neighbourhood of Victoria Station. The schemes submitted to the L.C.C. involved a multi-storey garage, two large office buildings over the station and its approaches, a scheme for offices, an hotel and flats, and an air terminal, including a helicopter landing ground over the approaches. The Council points out that in principle it is not opposed to redevelopment of the area, and in fact welcomes, in principle, some of the proposals. However, it considers that none of the schemes considered makes any contribution to the solution of road traffic congestion, and any development should be on comprehensive lines directed towards easing congestion. The Council is informing the two Ministries concerned, and is inquiring about governmental intentions regarding a road, rail or mono-rail link with London Airport.

# Calder Hall Power Station

No. II—(Continued from page 468, October 5th)

Calder Hall "A" power station will be formally opened by Her Majesty the Queen on October 17th, three and a half years after the design team started work on the scheme. It is the first nuclear power station to generate electricity on an industrial scale. The main plant consists of two gas-cooled graphite-moderated natural uranium reactors, the heat from which is taken by the coolant, carbon dioxide under pressure, to heat exchangers where steam is generated for the four 23MW turbo-alternators. The reactor is designed for the production of plutonium as well as the generation of electricity. An identical station, known as Calder Hall "B," is under construction on an adjoining site and is due to be completed in 1958.

WORK on the steam cycle for Calder Hall originated in 1948, when, at the invitation of Risley, Babcock and Wilcox, Ltd., in collaboration with Parolle Electrical Plant Company, Ltd., undertook a design study of steam-raising plant for a gas-cooled graphite-moderated reactor power station. About three years later this work was directed more specifically towards the nuclear power station, which was to become known as Calder Hall. At this stage Babcock and Wilcox, Ltd., worked in collaboration with

of using a gas turbine cycle was rejected because the available temperature drop was low and the steam cycle was chosen because of the prospects of fairly good efficiency under the operating conditions imposed by the reactor.

Consideration was given to a closed-cycle coolant system in which CO<sub>2</sub> abstracted heat from the reactor and was circulated to heat exchangers, where steam was generated. With CO<sub>2</sub> pressurised to 8 atm. abs. and a coolant temperature of not more than 650 deg. Fah. the thermal efficiency, after allowing for the power taken by the gas circulators and other auxiliaries, reached an optimum value of just under 22 per cent with a reactor inlet gas temperature of about 375 deg. Fah. as indicated in Fig. 6. A lower inlet temperature

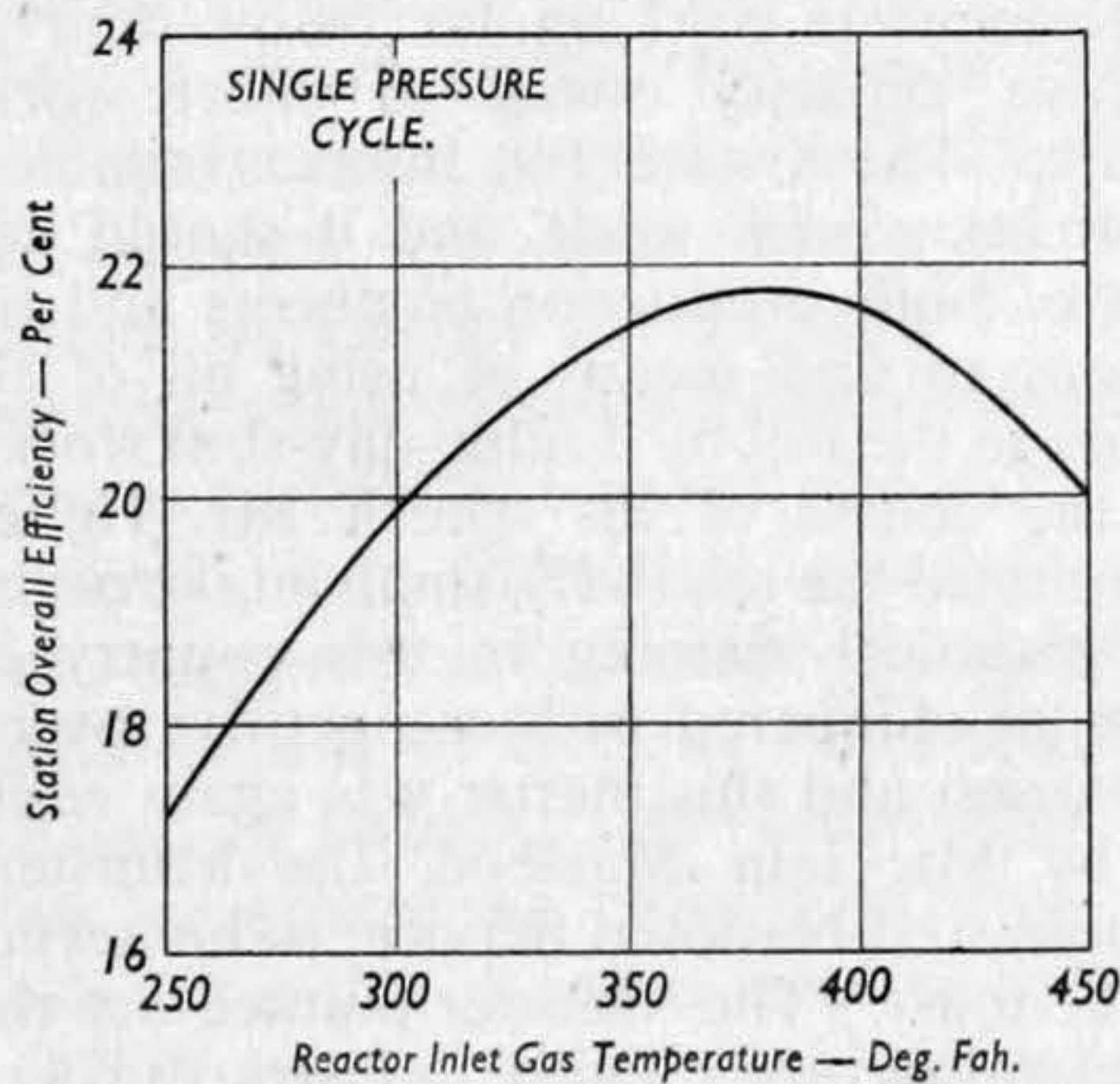


Fig. 6—Station efficiency of gas-cooled graphite-moderated reactor

C. A. Parsons and Co., Ltd., the firm which was to supply the turbo-alternators for the station. The following year orders for the steam-raising plant were placed with Babcock and Wilcox, Ltd.

Some aspects of the design and construction of the steam generating plant are considered here.

## STEAM GENERATING PLANT

When the study of the gas-cooled graphite-moderated reactor as a means of power production was initiated, about eight years ago, it was appreciated that the available temperature drop would be low, in the early stages of development, at least. Under these conditions the problem was that of obtaining optimum power output and station efficiency with reasonable capital cost. The possibility

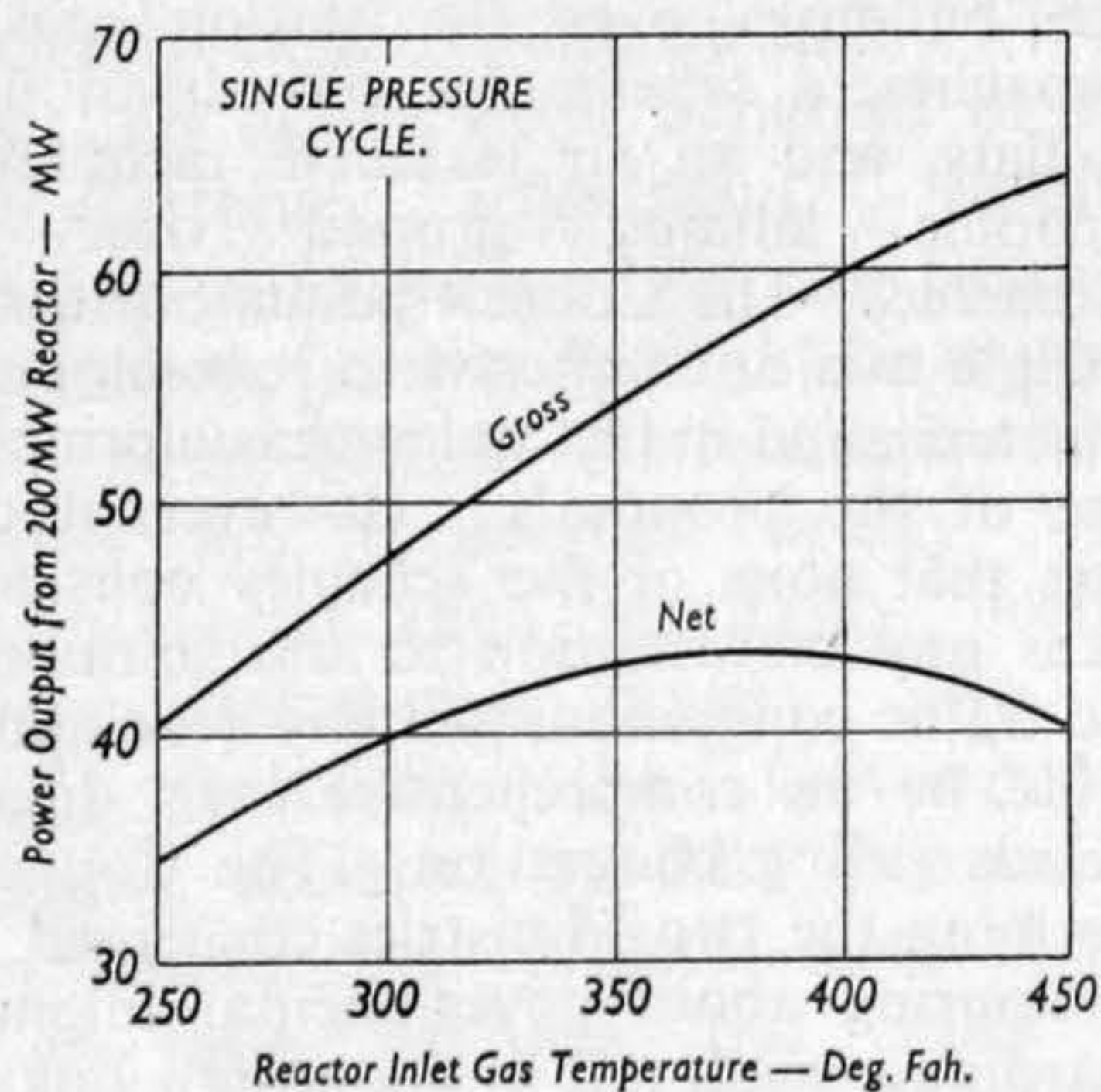


Fig. 7—Gross and net output of gas-cooled reactor

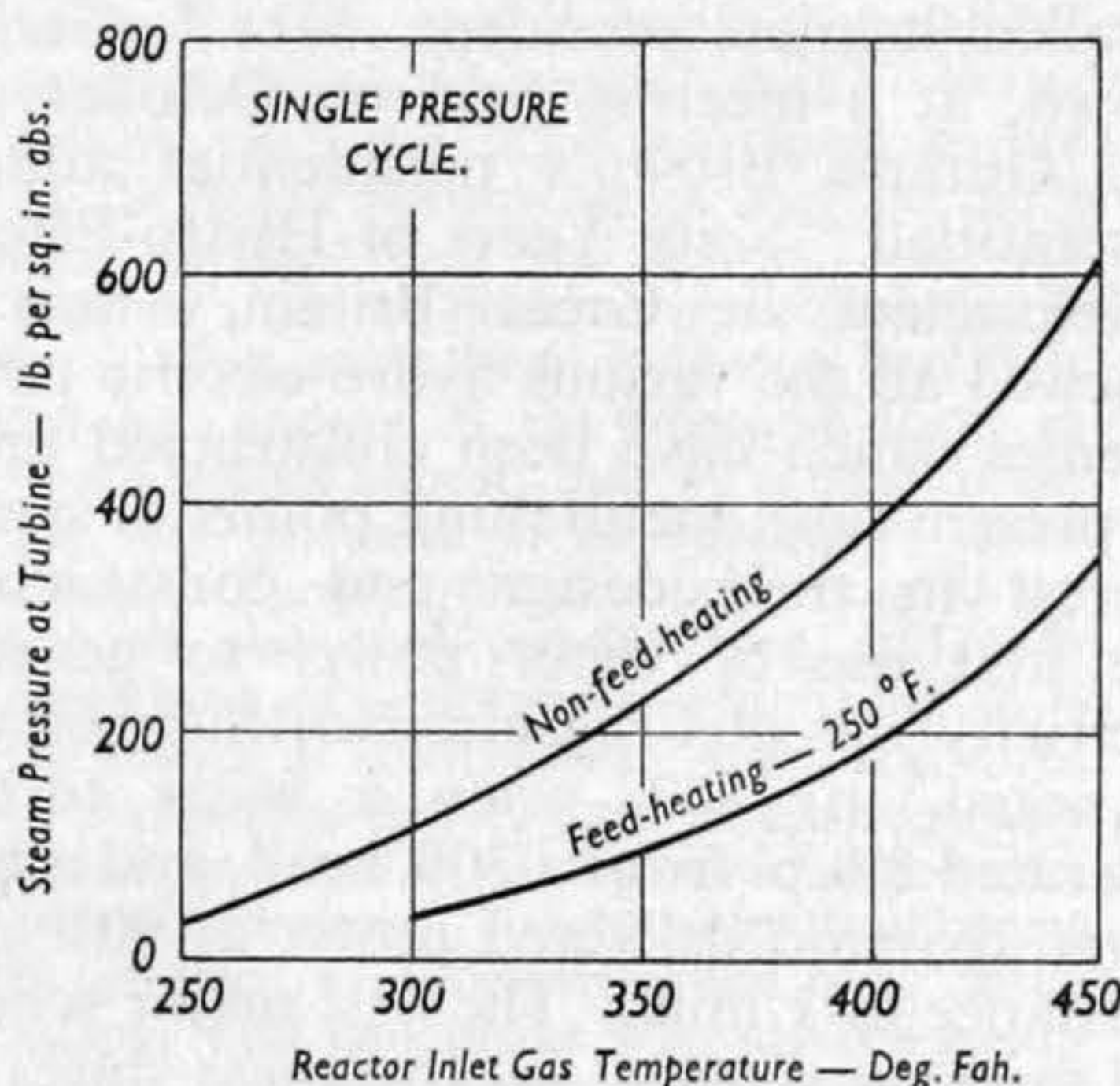


Fig. 8—Steam pressure of gas-cooled reactor

would appear to be desirable because for a given outlet temperature the coolant flow and circulator power would be reduced. On the other hand, the attainable steam pressure would depend almost entirely on the recooled gas temperature and the acceptance of a lower gas temperature would involve lower steam pressures and reduced electrical output.

Thermodynamically the optimum conditions are realised at the point when the increasing electrical output resulting from higher steam pressure is counterbalanced by the increasing circulator power required at the higher recooled gas temperatures. The results are shown graphically in Fig. 7, from which it is seen that the maximum electrical output (net) is about 43MW at a reactor inlet gas temperature of between 350 deg. and 400 deg. Fah.

Feed heating was one of the possible methods of improving the thermal efficiency that was studied. But investigation showed that feed heating offered no gains. For any given gas temperatures at reactor inlet and outlet, higher steam pressures could be obtained without feed heating than with it. This higher steam pressure would nullify the gain directly attributable to feed heating, which would involve reduced steam pressure. Taking steam pressure as the criterion the

advantages of omitting feed heating are apparent from Fig. 8.

Another approach towards improved efficiency was to examine the dual pressure steam cycle. The resulting comparison with the single pressure cycle is set out in Fig. 9.

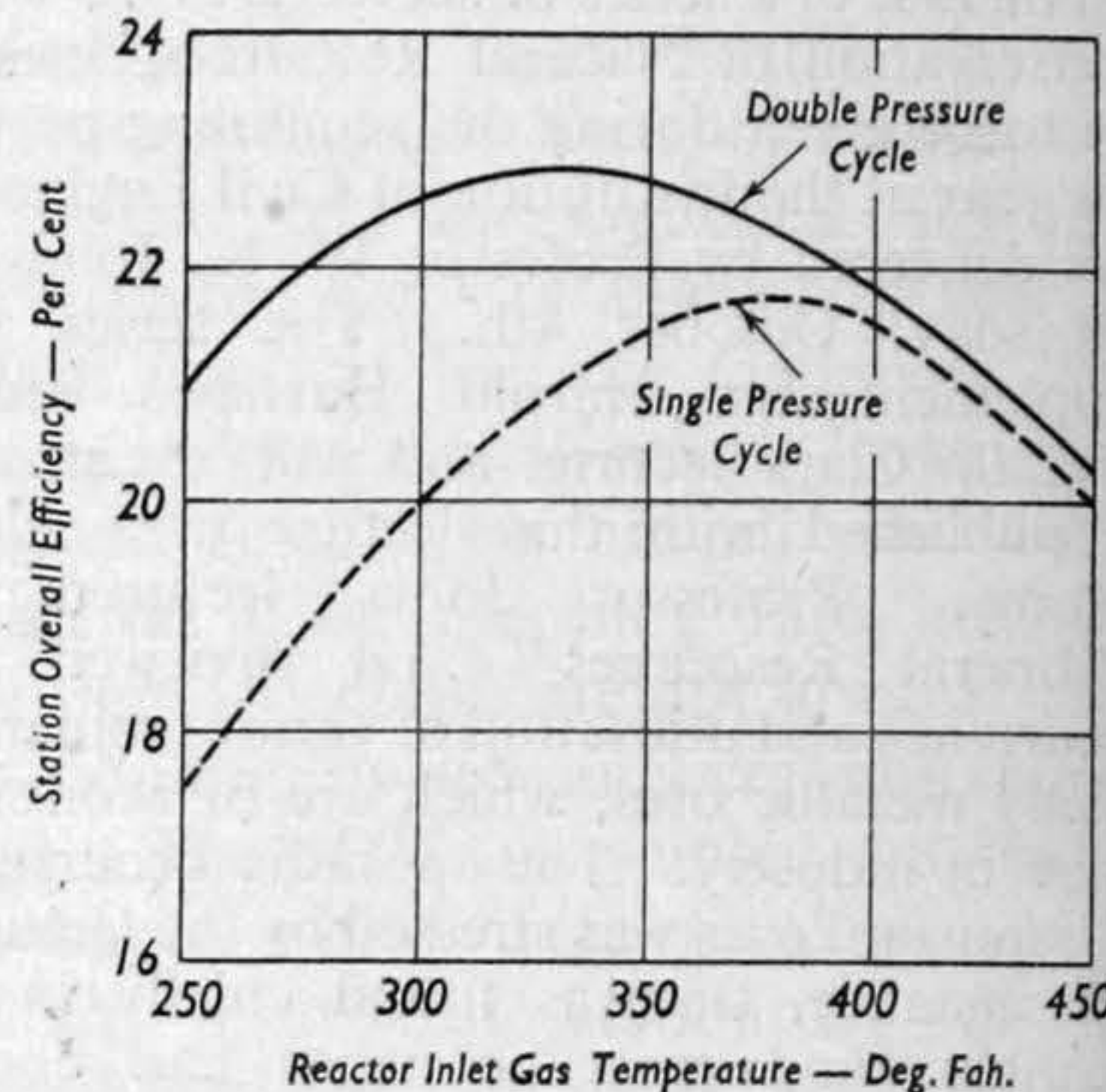


Fig. 9—Station efficiency of gas-cooled reactor, with dual pressure and single pressure cycles

From these curves it is clear that the dual pressure not only has a higher maximum efficiency than that of the single pressure cycle, but that this maximum occurs at a much lower reactor inlet gas temperature so that gas circulation is simplified. At the lower end of the temperature scale the advantage of the dual pressure cycle over the single pressure cycle is further emphasised. At 250 deg. Fah. inlet temperature, for example, the efficiencies of the two cycles are about 21 per cent and 17 per cent respectively.

The importance of this last advantage springs from the fact that the reactor is designed to produce both plutonium and electrical power. With a given capital outlay on uranium and graphite a higher temperature drop across the reactor would mean that the thermal rating of the reactor could be increased. But, assuming that the outlet gas temperature was limited by the permissible fuel element temperature, the only way of obtaining an increased temperature drop across the reactor would be by lowering the inlet gas temperature. With a lower inlet temperature the dual pressure cycle shows to particular advantage as is clear from Fig. 9.

The principle of the dual pressure cycle as applied at Calder Hall is shown diagrammatically in Fig. 10. In each of the four heat exchangers associated with each reactor there are two steam-raising circuits, each with its own boiler drum, feed pump and economiser, evaporator and superheater sections. About 65 per cent of the total steam is generated at the higher pressure and

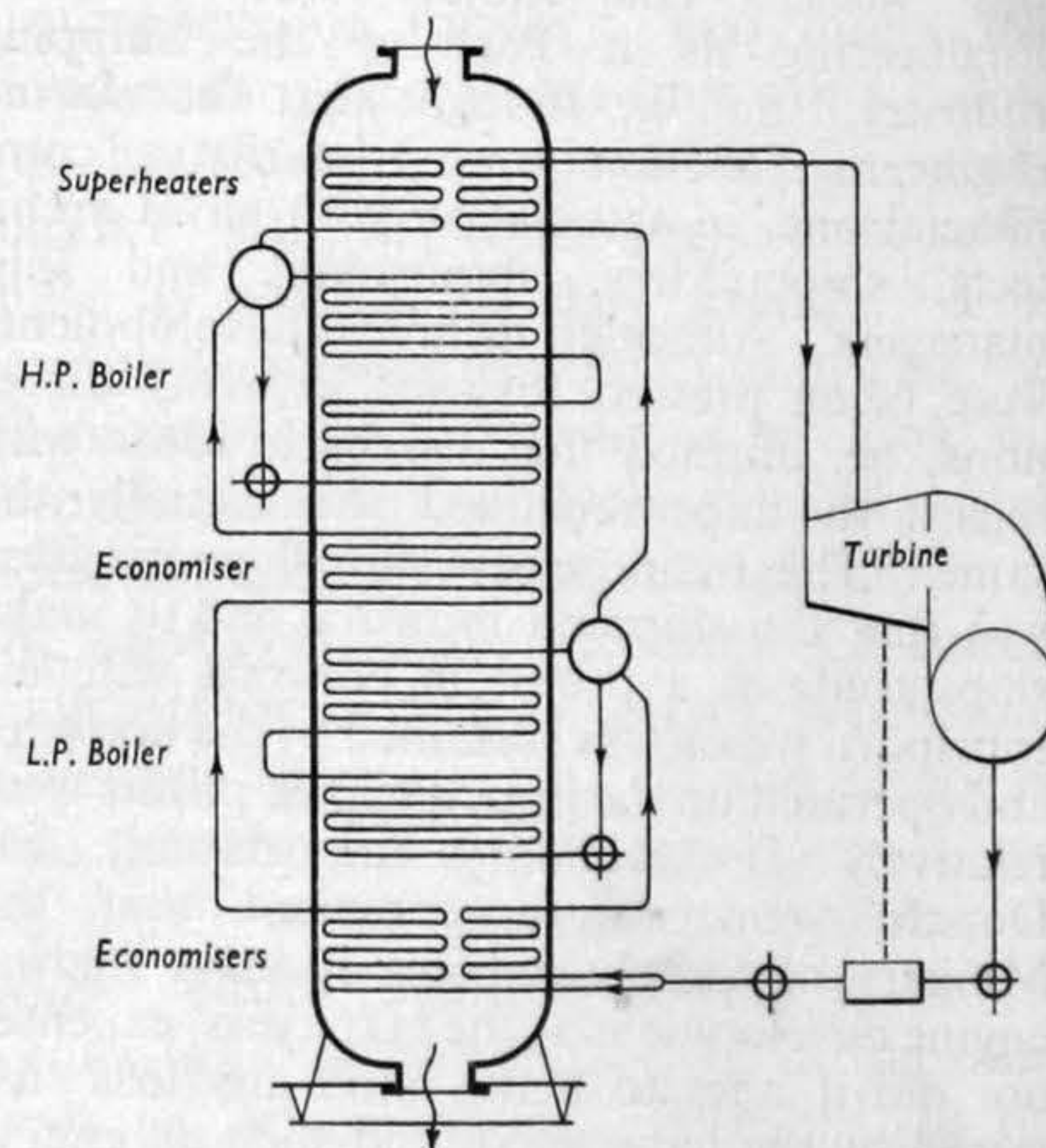


Fig. 10—Double pressure steam cycle diagram for Calder Hall heat exchangers



Fig. 11—Finned tube element for a heat exchange section undergoing hydraulic test in the workshop

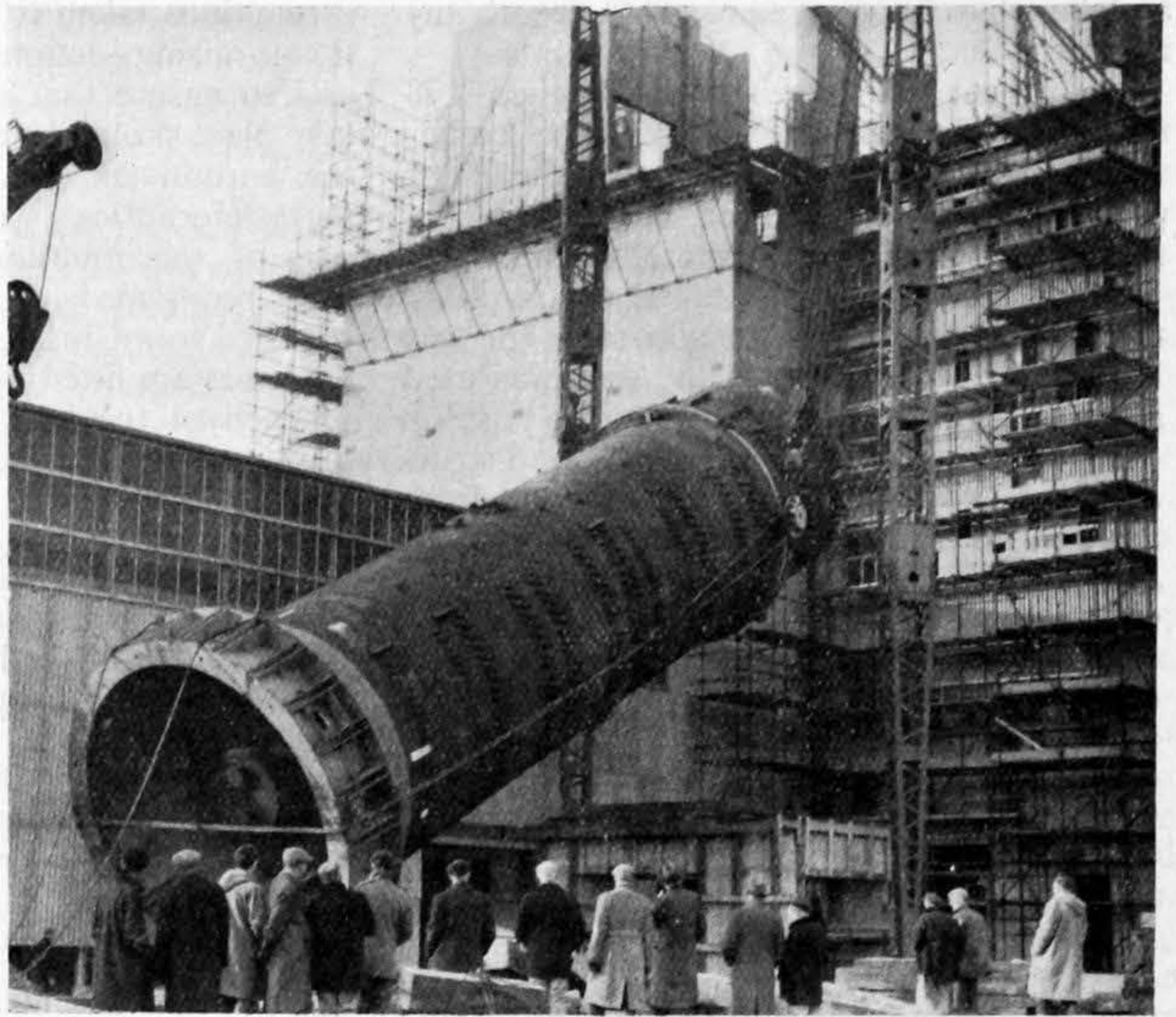


Fig. 12—Two 102ft gin poles were used to lift the heat exchanger shell into position on its plinth

35 per cent at the lower; the h.p. steam is fed to the governor valve of the steam turbine and the l.p. steam to an appropriate stage in the expansion as will be described more fully.

Two interesting aspects of the design of the heat exchangers are: first, the very large coolant flow rate (of the order of eight to ten times that of the gas flow in a conventional boiler generating 630,000 lb of steam per hour); and, secondly, the small temperature differences between the coolant and the water or steam, compared with those encountered in conventional boilers. The main design requirement was to circulate very large quantities of coolant with effective heat transfer, despite the small temperature differences, and with a low pressure drop to economise in circulator power. Since the maximum draught was required in the reactor itself it was doubly important to reduce the pressure drop in the heat exchangers and considerable use was made of the expedient of extended heat transfer surfaces.

Apart from the superheaters, all the tubular heating surfaces in the Calder Hall heat exchangers are studded, giving a fourfold extension of surface, compared with the plain tube. Some details of the heat transfer surfaces are tabulated herewith. The studs

sleeve in the pressure shell. Any leakage of steam or water that might occur from these connections would, therefore, be to atmosphere and could not contaminate the coolant. When connections had to be inside the shell (such as the junctions between tubes making up the multi-loop elements) they were made in the maker's workshops under strictly controlled conditions, including stringent inspection and leak tests, using high-pressure hydrogen and high vacuum procedures. In Fig. 11 we show a finned tube element undergoing hydraulic testing in the maker's works.

Each heat exchanger is enclosed in a vertical cylindrical pressure shell, 18ft diameter and 70ft high, made of 1 5/8 in steel plate. The steel used was Colvilles' "Coltuf 28," which has a minimum tensile strength of 28 tons per square inch, a minimum yield stress of 17 tons per square inch and a

minimum impact value of 45ft-lb at -10 deg. Cent.

Transport limitations on the roads between the manufacturer's works and the Calder Hall site determined the diameter of the shell and the size of sections that could be works welded. The shell was, therefore, transported to site in the form of six fusion-welded ring sections, two domed fusion-welded ends of semi-ellipsoidal shape, and the two halves of the supporting skirt which can be seen in Fig. 12. Each section was complete with nozzles and branches and was stress-relieved in the maker's works before despatch. To complete the shell the ring sections and the domed ends were welded circumferentially and stress-relieved on site. This site welding was done in a special shop equipped with rail tracks, whereby two pressure vessel shells could be handled simultaneously on bogies equipped with motor-driven castors, so that the sections could be rotated to allow of down-hand welding of the circumferential seams.

Because of the size of the work, a box-type furnace would have been uneconomic for the job of stress-relieving. A high-frequency induction heating equipment, developed by the Electric Furnace Company, Ltd., was, therefore, used on site, both for local preheating and for post-weld stress-relieving. The equipment consisted essentially of a vertical-spindle, totally-enclosed, water-cooled motor generator set designed to supply an output of 200kW to flexible inductor cables which were wound round the area to be welded (Fig. 13) and were lagged to reduce loss of the heat induced in the metal. When the area to be welded had been brought up to the required temperature of about 630 deg. Cent., after about three hours the welding was begun. The temperature was then held for one and a half hours before being allowed to fall at a controlled rate of 200 deg. Cent. per hour, by predetermined regulation of the input power. Two sets of cables were used for the operation, so that, while one weld was being treated, the next one could be prepared by placing the cable and lagging in position, both outside and inside the shell.

While it was lying on its side each completed shell was hydraulically pressure tested. Then, before being lifted into position, it was subjected to scrupulous cleaning process and

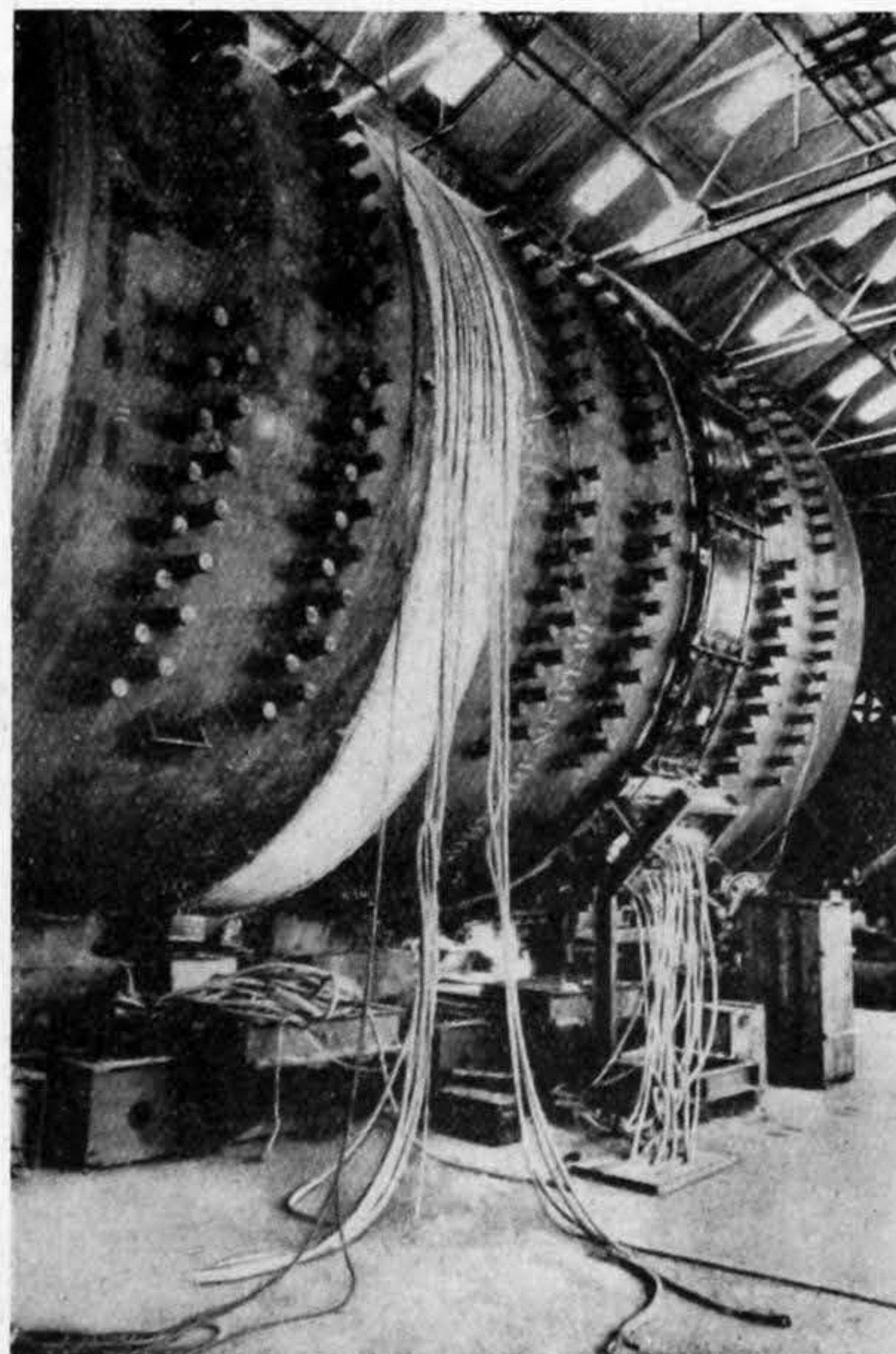


Fig. 13—Cables were wound round the heat exchanger shell so that induction heating could be used for preheating the circumferential welds and for the subsequent process of stress relieving

are of aerofoil section and they were welded to the tubes in automatic machines; upwards of 90,000,000 studs were required for the eight heat exchangers. The tubular heating surfaces consist of horizontal multi-loop banks.

An important consideration in the design of the heat exchangers was that the chances of leakage of steam or water into the coolant should be minimised. Accordingly, it was arranged that all connections between tubes and headers should be kept outside the shell of the heat exchanger. The ends of each tube element were taken separately through a

*Surface Area Per Heat Exchanger Exposed to Live Gas*

|  |  | Square feet |
|--|--|-------------|
| High pressure superheater...                   | 64 plain tube elements in parallel ...   | 4,700       |
| High pressure evaporator ...                   | 64 studded tube elements in parallel ... | 31,500      |
| High pressure, high temperature economiser ... | 42 studded tube elements in parallel ... | 15,750      |
| Low pressure superheater ...                   | 32 plain tube elements in parallel ...   | 785         |
| Low pressure evaporator ...                    | 64 studded tube elements in parallel ... | 31,500      |
| Low pressure and high pressure economiser ...  | 42 studded tube elements in parallel ... | 15,750      |

sealed with a charge of silica gel to absorb any moisture.

Each heat exchanger shell weighed 178 tons and was fitted with a split steel collar, weighing about 15 tons, to assist in the lifting process, which was effected with the help of two 102ft gin poles as illustrated in Fig. 12.

When the shell was installed on its plinth the work of tubing was started; the gas inlet branch at the top of the shell was used as a means of access for lowering into position the multiloop elements, the baffles, and structural steelwork. Tubing was built up from the bottom of the shell, first the economiser, followed by the heating surfaces, with the superheater section at the top.

For the whole tubing operation a meticulous standard of cleanliness was stipulated, to prevent subsequent contamination of the

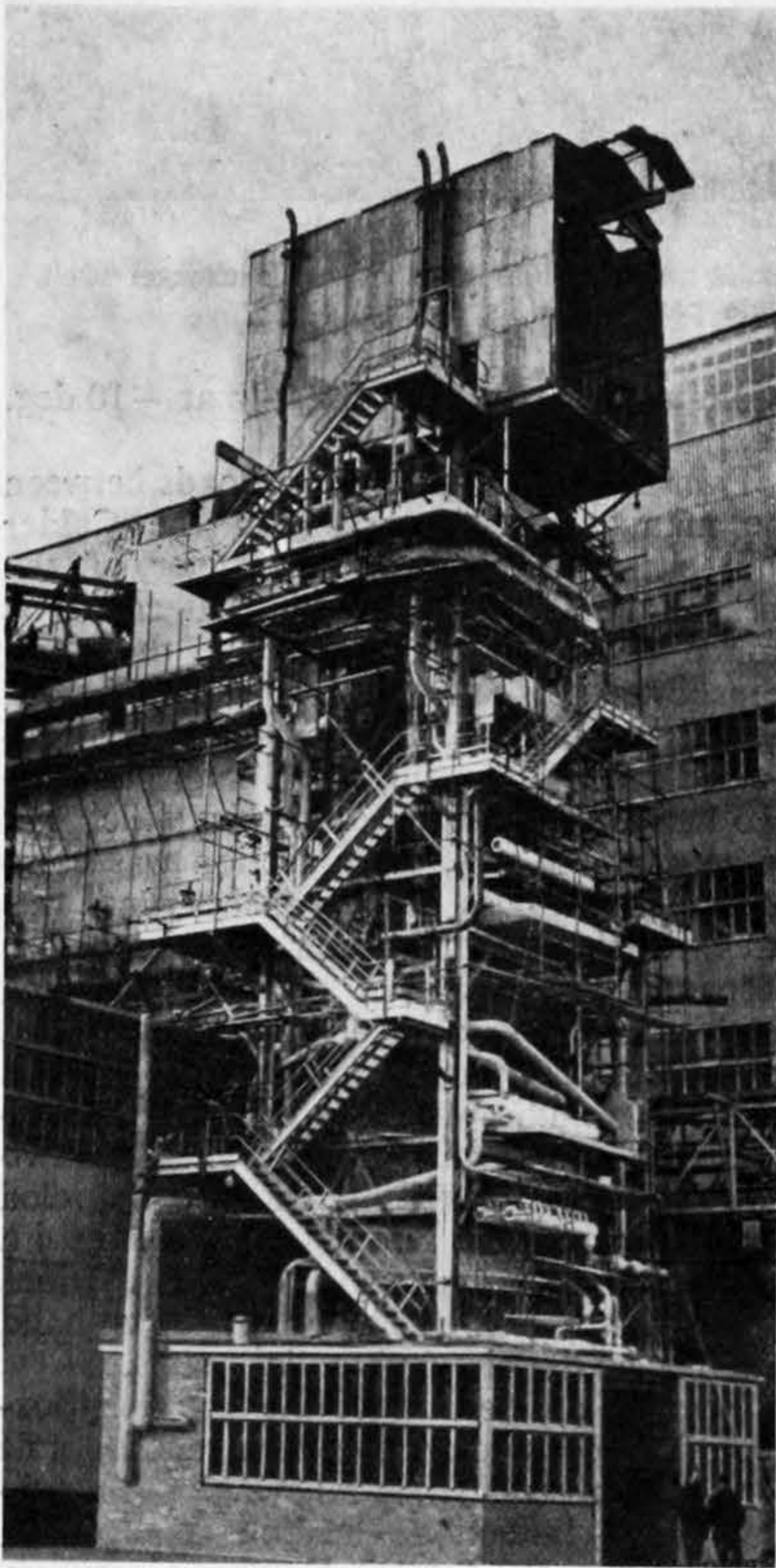


Fig. 14—Final stages in the construction of one of the eight steam generating towers at Calder Hall "A" power station

coolant. All parts were, therefore, shot blasted to clean metal before being installed.

After being shot blasted each heat-exchanger element was stored in a steel transit case and taken to a temporary "clean room" at the top of the tower, for installation. Here each piece was lowered through an air-lock chamber into the tower. Throughout this stage of the installation special clothing was worn by the erecting staff. To avoid condensation and to preserve the surface cleanliness of all parts, a controlled atmosphere was maintained by air-conditioning equipment.

Outside the shell the steam and water drums and the pipework and pumps for the high-pressure and low-pressure steam circuits were erected and the heat exchanger was then subjected to another hydraulic pressure test. A view of one of the steam generating towers nearing completion is given in Fig. 14. Reference has already been made to the

precautions taken to avoid leakage from the steam-raising sections of the heat exchanger and to ensure that any leakage which does take place should be to atmosphere and not to the carbon dioxide. If, however, despite these precautions, a leak should occur in one of the multiloop elements, the fault can be remedied without access being required to the inside of the shell. Humidity detectors are fitted in the gas outlet branches of each of the heat exchangers; after the faulty tower has been detected it can be taken out of service, allowing the reactor to operate with the remaining three heat exchangers. When the defective tower has been emptied gas sampling probes can be used to identify the leaky element which can then be cut and capped outside the pressure shell. Finally, the tower can be returned to service with the faulty element by-passed, since the gas temperatures are not high enough to cause overheating.

#### GAS CIRCULATORS

One of the main considerations that determined the design of the gas circulators was that the temperature of the gas leaving the reactor should be constant. To meet this requirement at partial loads and during start-up of the reactor it was necessary to provide for large variations in circulator speed and for prolonged running at reduced speeds. On a conservative basis a speed range of 10 : 1 was specified.

The system that was adopted to suit these conditions consists of a d.c. motor with Ward-Leonard control driving a slow-speed centrifugal blower (Fig. 15). To keep gas leakage to a minimum consistent with reliable operation and to simplify the problems of shaft sealing, the impeller is of the overhung design. The speeds of the seal surfaces require a wet seal\* and provision is made to prevent the leakage of oil into the system, either directly or by diffusion. The seal is a modified version of one produced for hydrogen-cooled alternators. To ensure that the seal can be inspected or removed while the system is under gas, but with the

\* "Mechanical Engineering Features of Calder Hall Nuclear Power Station." World Power Conference, Vienna, 1956.

circulator at rest, a "standstill" seal is incorporated between the impeller and the labyrinth gland. It can be brought into operation to allow the blower to be rotated at very low speeds; a pony motor of about 10/100 h.p. is, therefore, mounted on the set and geared to the impeller shaft. To avoid the risk of the pony motor being driven by the main d.c. motor, a Sinclair "SS" clutch is included in the gear train.

Each circulator has a rating of about 2000 h.p. In normal operation the mass flow of carbon dioxide through the reactor is 1964 lb per second and the conditions at the circulator outlet are 100 lb per square inch and 284 deg. Fah. About 2 per cent of the mass flow through each circulator is taken from the downstream side and is filtered and fed back into the system on the upstream side of the circulator, with the object of preventing graphite dust and iron oxide from accumulating in the system.

The speeds of the four circulators serving each reactor can be remotely controlled by a single operation in the main control room, and there are arrangements to ensure that all circulators run at the same speed. These provisions, and the fact that the four heat exchangers are connected to a common header, make for equalisation of mass flow between the four units.

The required flexibility without risk of leakage in the ducting between the reactors, heat exchangers and circulators is given by tied metal bellows. Single hanger bellows are used where uniplanar deflections are involved, and, where flexibility is needed in more than one plane, a special gimbal ring construction is used. The complete bellows unit consists of two heavy flanges connected by plain rings to the bellows section itself and outlet casings housing the hinge pins spigoted to the bellows flange. To carry the weight of the large ducts, valves and bellows, constant-support hangers are fitted. Some of them were manufactured in Great Britain for the first time. In general, each length of duct valve and bellows unit is individually supported.

The main contractor for the gas circulators and the ducts between them and the reactors

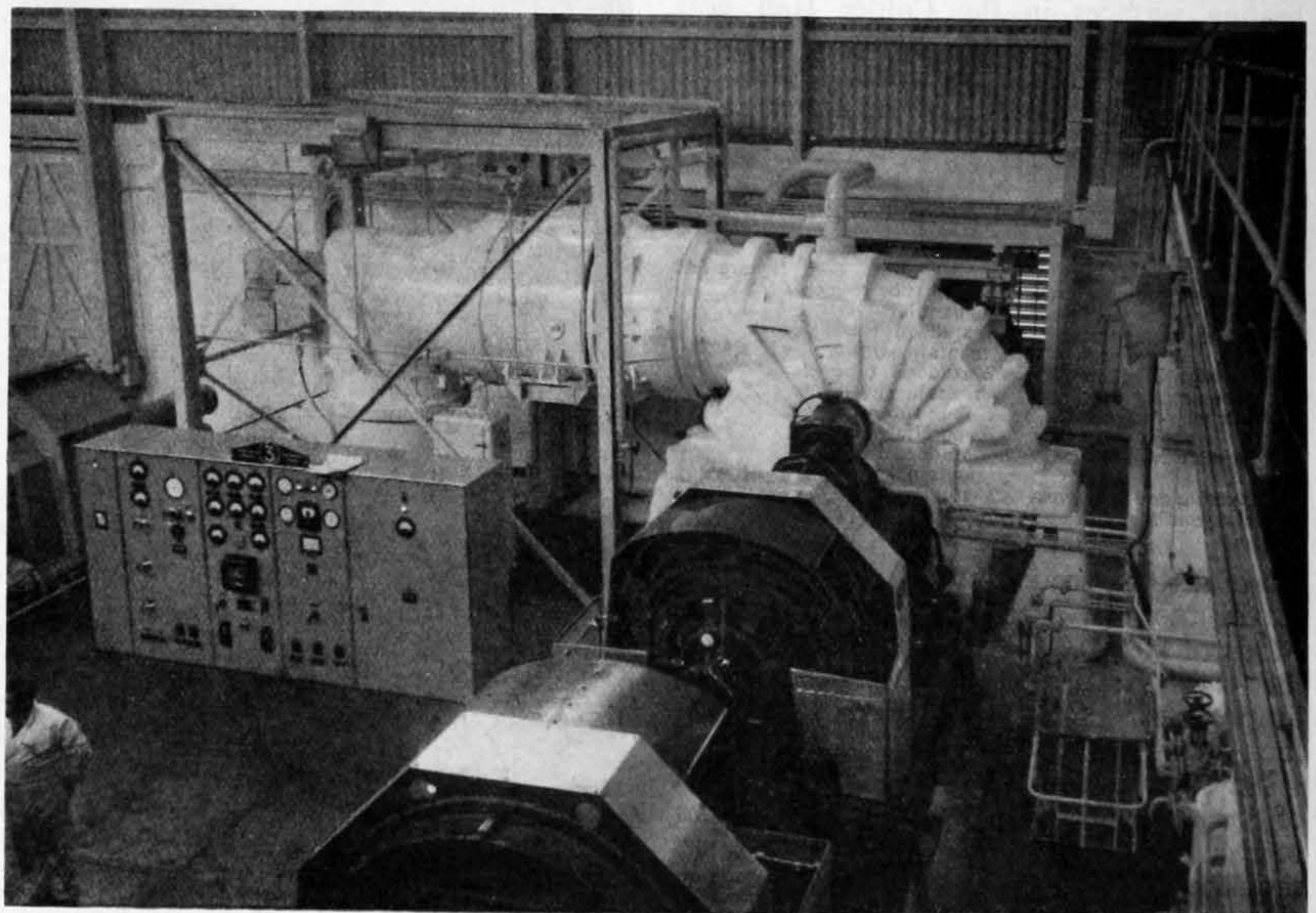


Fig. 15—One of the four motor-driven gas circulators for pumping the carbon dioxide coolant through each reactor and the associated heat exchangers. The gas conditions are 100 lb per square inch and 284 deg. Fah. at the circulator outlet

and heat exchangers was C. A. Parsons and Co., Ltd.

CARBON DIOXIDE SUPPLIES

The total requirements of carbon dioxide at Calder Hall call for considerable reserves on site and they are met by bulk delivery and bulk storage of liquid carbon dioxide by the Carbon Dioxide Company, a division of The Distillers Company, Ltd.

The installation at Calder Hall supplied and erected by this company is stated to be the largest single installation at present in operation in the British Isles. It consists of four specially insulated steel tanks, in which a total of 22 tons of liquid carbon dioxide may be stored. Each tank is fitted with an automatic pressure-controlled refrigerator, which cools the liquid to about 0 deg. Fah. and maintains the pressure at 300 lb per square inch.

The storage tanks are filled by bulk deliveries in the company's standard road tankers, which carry 4 tons of liquid at sub-zero temperatures under pressure. The vehicles are discharged at Calder Hall by

means of an electrically driven transfer pump on the vehicle powered by a generator coupled to the tractor engine. Filling or emptying a tanker takes approximately one hour and is carried out without interrupting normal working of the plant.

For use in the reactor circuit, the liquid carbon dioxide is vaporised in four specially designed evaporators, which were developed and built by the company's research and development department in conjunction with the U.K. Atomic Energy Authority. The evaporators consist of two parallel banks of steam-jacketed tubes, the number and size of which were calculated to meet the maximum demand of the system. Each unit can vaporise more than 2 tons of carbon dioxide an hour. The units are coupled to a manifold, giving a total output of over 8 tons an hour when the main circuit is being filled or purged. The same system supplies the smaller quantity of carbon dioxide gas required for normal operation. More than 20 tons of carbon dioxide are needed for a complete filling of the reactor and the coolant circuits.

(To be continued)

Quoich, the site is a good one, the rock-fill being granulite, obtainable partly from a quarry nearby and partly from the tunnel spoil.

A rockfill dam is also to be built on the Board's Breadalbane scheme. More examples may follow, as the saving of cement is encouraged by the Board where possible. Bulk cement deliveries still cannot be made to sites in the Northern Highlands.

DESIGN AND CONSTRUCTION OF QUOICH DAM

The accompanying drawing, Fig. 3, shows the dam in cross section, from which it will be seen that watertightness is obtained from a reinforced concrete membrane on the upstream face of the dam. This method was adopted in preference to a central core of impermeable material, we are informed, so that the maximum structural use could be made of the filling material. Design is based on a stability analysis of the side slopes, allowing for the added weight of compacting plant at work on the edge of the dam. The specification for the dam is somewhat more demanding in some respects than the practice adopted in other countries, doubtless because of its novelty here. Material less than 3/4 in in size has not been used in its construction; such fine material is a possible cause of settlement in a rockfill dam, as it can be washed out by rain. The rock is placed in 2ft layers, the layers themselves sloping downwards at 1 in 24 towards the upstream face. Each layer is compacted mechanically, and the rock is sluiced, when placed, with jets of water to ensure good compaction.

The quarry, from which three-quarters of the material for the dam was obtained, was opened a few hundred yards upstream from the dam site. Here, rock was quarried by conventional methods, and then taken to the preparation plant. Rock from the tunnelling was also brought to this plant, in which the rock is passed over rotating cylinders, and, at the same time, washed with water. The cylinders are 3/4 in apart, so the fine material falls between them, and the coarser rock is retained. The cylinders are inclined, so the "acceptable" sizes roll down them into a hopper. Chains suspended above the cylinders ensure that the rock is agitated sufficiently for most of the fine material to escape. Rock is taken from the hopper in steel-bodied tipping trucks for emplacement in the dam. Lagoons for settling out the sludge from the water used in the plant were constructed and were cleared out at intervals by dragline. Nearby, a concrete batching and mixing plant was installed, including crushers for obtaining coarse and fine aggregates from the washed rock, and aggregate storage bins. In the later stages of the work, impounding was started and so this concrete plant was replaced by one near the crest of the dam, higher up.

# North of Scotland Hydro-Electric Schemes

## No. VIII: THE GARRY AND MORISTON SCHEMES—PART II\*

(Continued from page 470, October 5th)

The adjoining catchments of the Garry and Moriston rivers in Inverness-shire have for many years been recognised as favourable sources for the development of hydro-electric power. The North of Scotland Hydro-Electric Board's developments here will yield about 383 million kWh annually, from an installed capacity of 106MW. An account of the Quoich reservoir of the Garry scheme is given in this week's instalment.

ROCK-FILL dams have been included, as alternatives to gravity or buttress dams, in several of the tenders put out for the Board's schemes. Quoich dam was, however, the first case where the rockfill dam was adopted, and so it is the first major dam of its kind to be built in this country. It is well known that the rockfill dam has been extensively used in other countries, particularly in Sweden and the United States. An interesting point is, however, that an early example of a rockfill dam, the Trieg dam of the Lochaber hydro-electric scheme, was built in Scotland nearly thirty years ago.† This dam has a thin core wall of reinforced concrete, as distinct from the upstream membrane of Quoich dam. In the discussion on the Affric hydro-electric scheme, in the *Journal I.C.E.* of September, 1953, Sir William Halcrow pointed out that the design of the Trieg dam had interested certain foreign consultants who had visited the Lochaber scheme more than any other feature, and it might have been, he affirmed, that the seed had been sown in the minds of the Swedish engineers who had developed the design further in their own country.

Since that time, the rockfill dam has made considerable progress in other countries, but its use is more restricted on Scottish sites than would be expected. The prevalent

rocks are schists, which are generally laminar in structure, and sometimes deteriorate due to weathering. Thus many sites can be ruled out for this class of dam. Fishery interests are also unfavourable to the rockfill dam, for the sluicing away of "fines" during construction may make a river temporarily unsuitable for fish. To prevent this, precautions have to be taken to settle out the sluicings, thus adding somewhat to the expense. Nevertheless, the broad conclusion has been drawn that, if suitable tunnel spoil is available, the rockfill dam is cheaper than alternative concrete structures up to a certain height, but if quarrying costs have to be borne, concrete dams are likely to prove more economical. Adding to these considerations the factor of lack of experience of contractors with this class of construction, the reasons why it has been employed before only once in Great Britain are clear. At

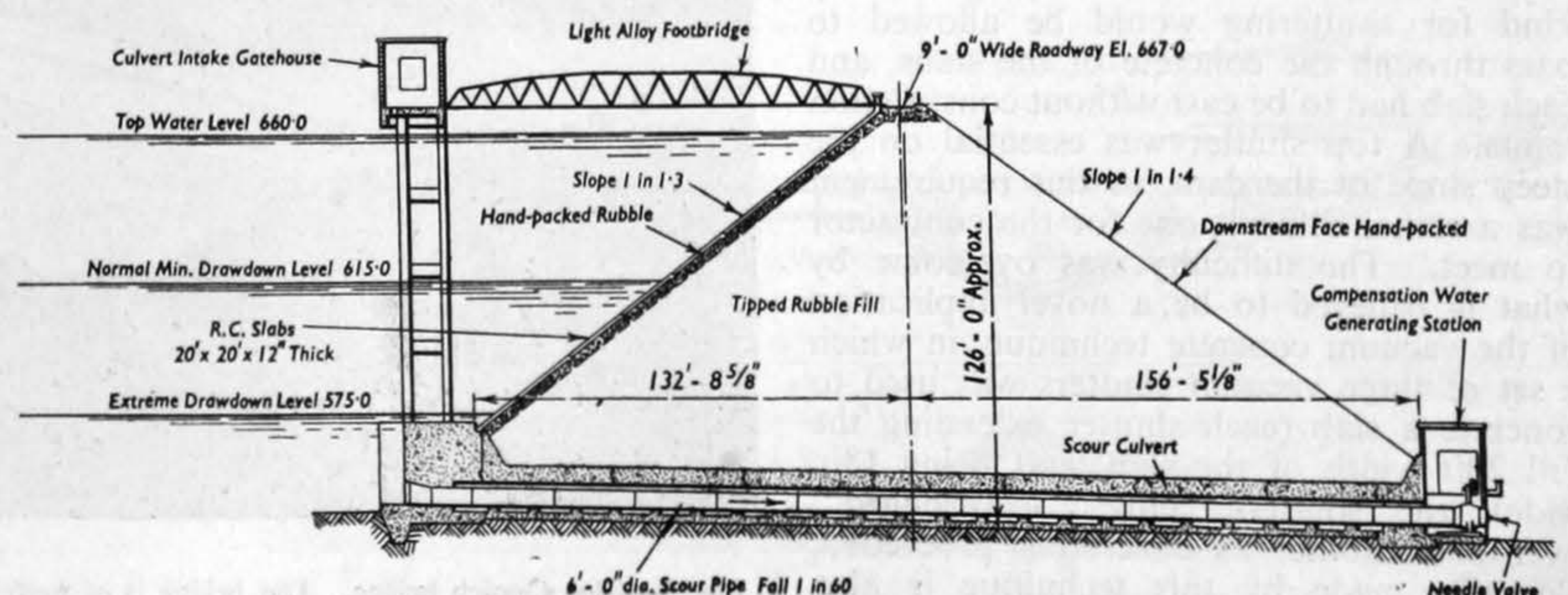


Fig. 3—Cross section of Quoich dam on centre line of scour culvert

\* No. I: "An Introductory Survey," appeared July 14, 1950; No. II: "The Loch Sloy Project," July 21-August 4, 1950; No. III: "The Fannich Project," June 8-15, 1951; No. IV: "The Mullardoch-Fasnakyle-Affric Project," April 11-25, 1952; No. V: "Some Schemes for Local Supply," October 16-23, 1953; No. VI: "The Tummel Garry Scheme," September 2-23, 1955; No. VII: "The Shira Scheme," April 20-27, 1956.  
† "The Second Stage of the Lochaber Water Power Scheme," by Professor A. H. Naylor, *Journal I.C.E.*, Volume V, page 3, February, 1937.

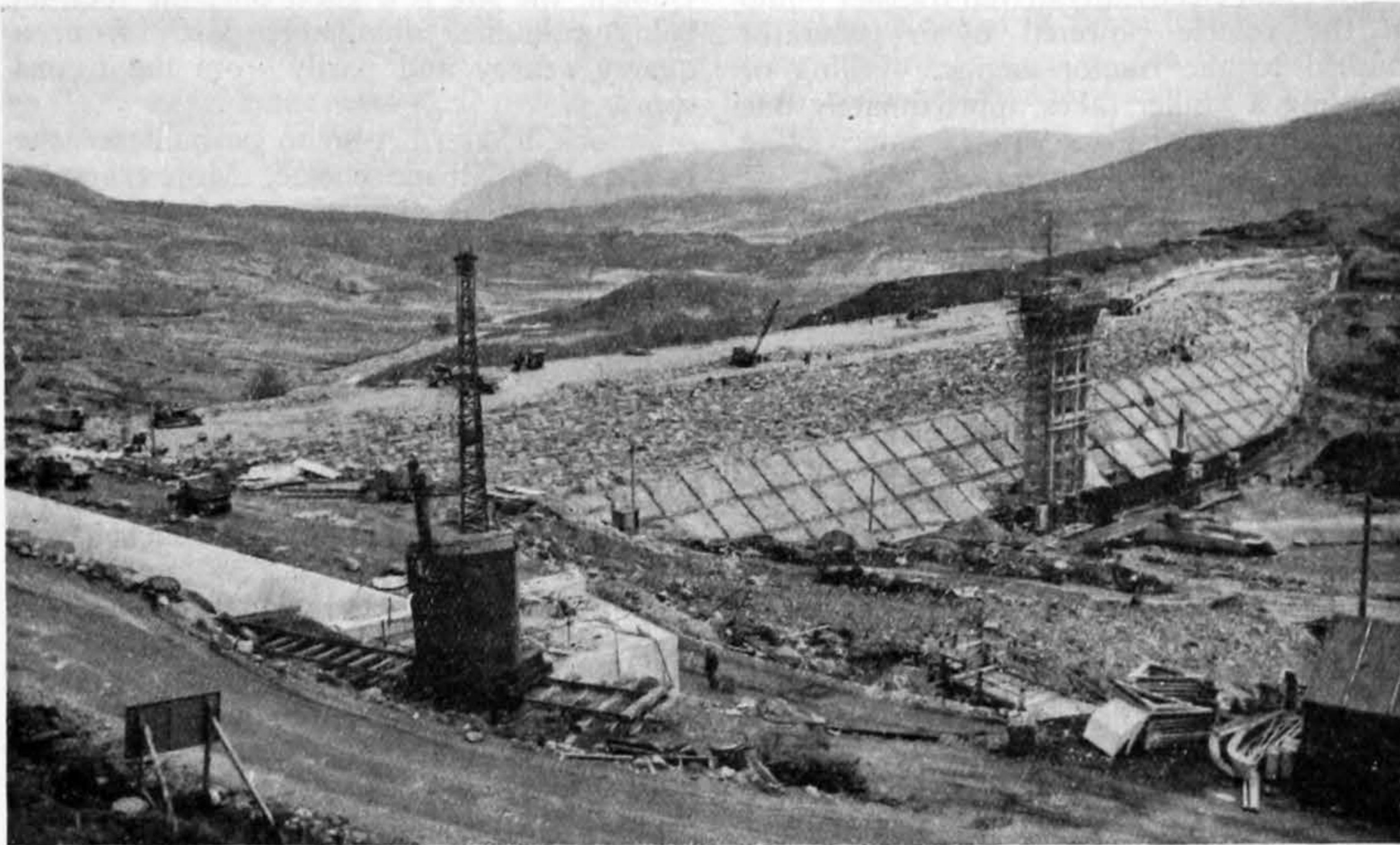


Fig. 4—Quoich dam is here shown at an advanced stage of construction. Part of the upstream face has been prepared for the reinforced concrete beams and slabs comprising the sealing membrane, and the first slabs have been cast

In constructing the dam, a vibrating roller was used to compact the 2ft layers of rock, with the aid of water jets as already mentioned. When the work was in full swing, the plant in use for this work included a 10-ton roller, a 3.5-ton vibrating roller, and nine trucks of 9 cubic yards capacity. Rock was placed at a rate of up to 9500 cubic yards per week, and the dam has taken two and a half years to build altogether. A good idea of the site during the later stages of construction is given by Fig. 4.

The side slopes of the dam are rather steep, and so as to avoid difficulty in compacting the edges of each 2ft layer, the method generally adopted was to build a "dry wall," 2ft high at each side, and then fill in the rock layer. Later on, after an interval of three months, further rubble was hand placed on the upstream face to form a layer varying in thickness from 3ft to 15ft as a base for the concrete slabs forming the impermeable membrane. Stones for this work were selected at the quarry. The downstream face of the dam has been left with pitched stones exposed, which gives the structure a neat appearance, as it is approached from lower down the valley.

The specifications for placing the concrete membrane were also severe. Best quality concrete (4 : 1 mix, 3400 lb per square inch strength at twenty-eight days) was called for, to be placed in slabs 20ft by 20ft in size, and 15in thick, near the base of the dam, and 12in thick higher up. The joints between the slabs are sealed with copper strips filled with bitumen, which are intended to be flexible enough to take up any movements due to settlement of the dam. It was also stipulated that no bolts or fixings of any kind for shuttering would be allowed to pass through the concrete of the slabs, and each slab had to be cast without construction joints. A top shutter was essential on the steep slope of the dam, so this requirement was a rather difficult one for the contractor to meet. The difficulty was overcome by what is believed to be a novel application of the vacuum concrete technique, in which a set of three vacuum shutters was used to concrete a slab (each shutter extending the full 20ft width of the slab, and being 18in wide), the shutters being "leapfrogged" over one another as concreting proceeded. Concrete made by this technique is also claimed to be rather superior in quality,

which was, of course, an additional advantage. On completion, the concrete surface is painted with a bituminous paint.

The concrete membrane formed by the slabs is continued down, at the heel of the dam, into the cut-off trench, which was excavated in the bedrock. Grouting up to a pressure of 60 lb per square inch was carried out here, as is normally the case with other kinds of dam.

One of the problems of constructing a rock-fill dam is that of accommodating settlement and of reducing it to a minimum after construction is complete. At Quoich, it has been estimated that the completed dam will settle about 2in to 3in only at its deepest part. The measuring devices incorporated in the dam to measure settlement and deflection under load are as follows. There are three nests of concentric tubes, arranged so that the base of each tube in the nest is anchored to a steel frame embedded in the dam—the outer tube to the uppermost frame, and so on; thus any settlement at the level of each frame can be observed. Two "Swedish wells" for measuring deflection and settlement, in conjunction with a plumbing

theodolite, are also incorporated. They consist of open-jointed pipes, with reference cross-wires fixed at intervals, from which measurements of displacement can be made with the theodolite, and of settlement by measuring to the crest. And there are a

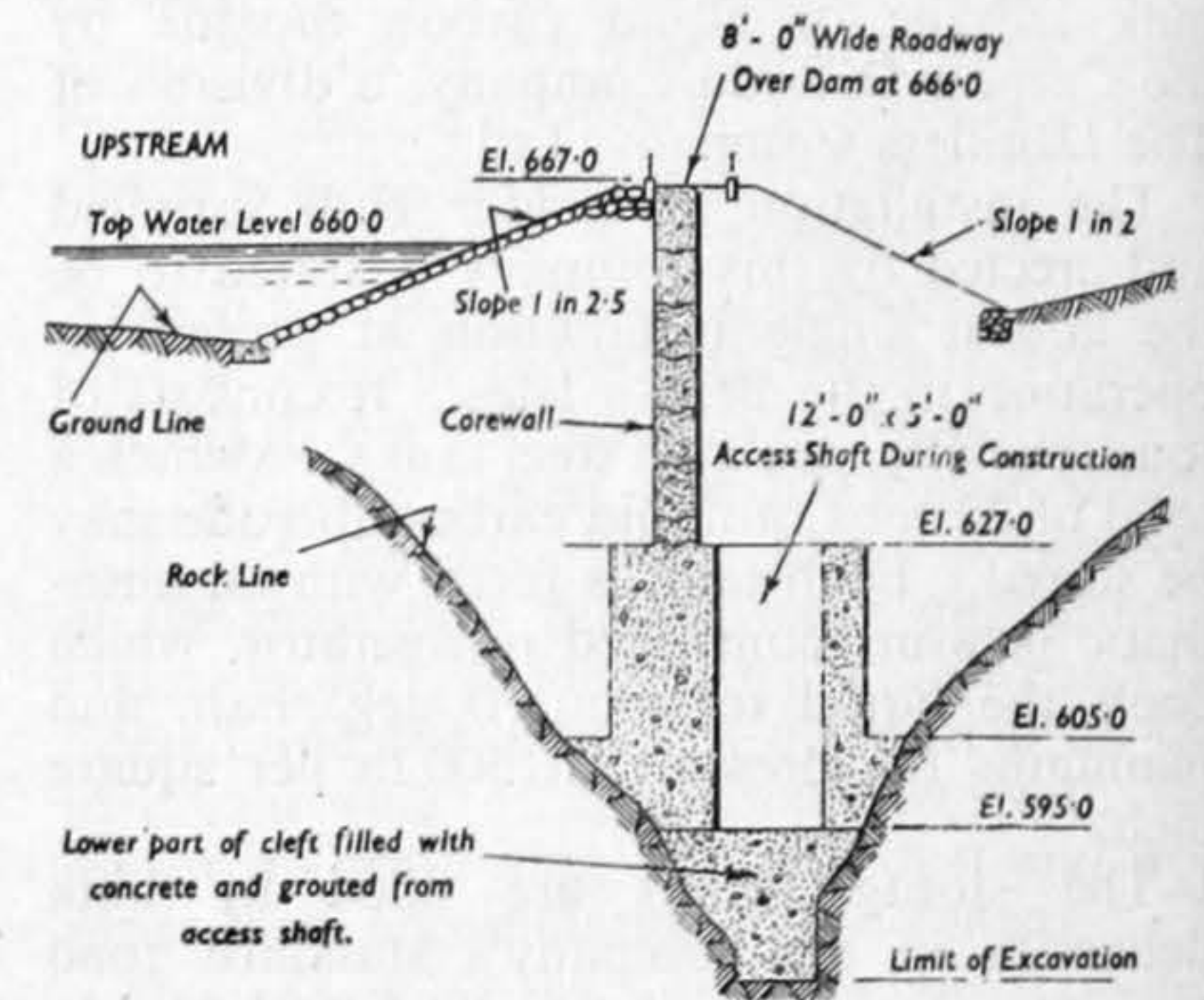


Fig. 6—Detail of special excavation work at Cruadhach north dam

number of "reference" points on the upstream face, which can be accurately positioned from survey points nearby, when the reservoir is drawn down. There are also drainage pipes in the base of the dam, leading to a central pipe where leakage can be measured.

#### HYDRAULIC CONTROL WORKS AT QUOICH DAM

The hydraulic works at Quoich dam are relatively simple. Near the centre there are two scour culverts, each 6ft in diameter, passing through the base of the dam. They are controlled on the upstream side from a tower comprising a reinforced concrete frame, which is connected with the roadway on the crest of the dam by an aluminium footbridge of 133ft span. One of the culverts leads to a 72in/60in needle valve, which provides its normal control on the downstream side, but it can also be closed from the tower by a free-rolling emergency gate. The second culvert is intended for emptying the reservoir when its level is very low, and it is closed, from the tower, by a manually-operated single-faced sluice. On the downstream side it is closed by a blank flange.

The first culvert, which operates, if neces-

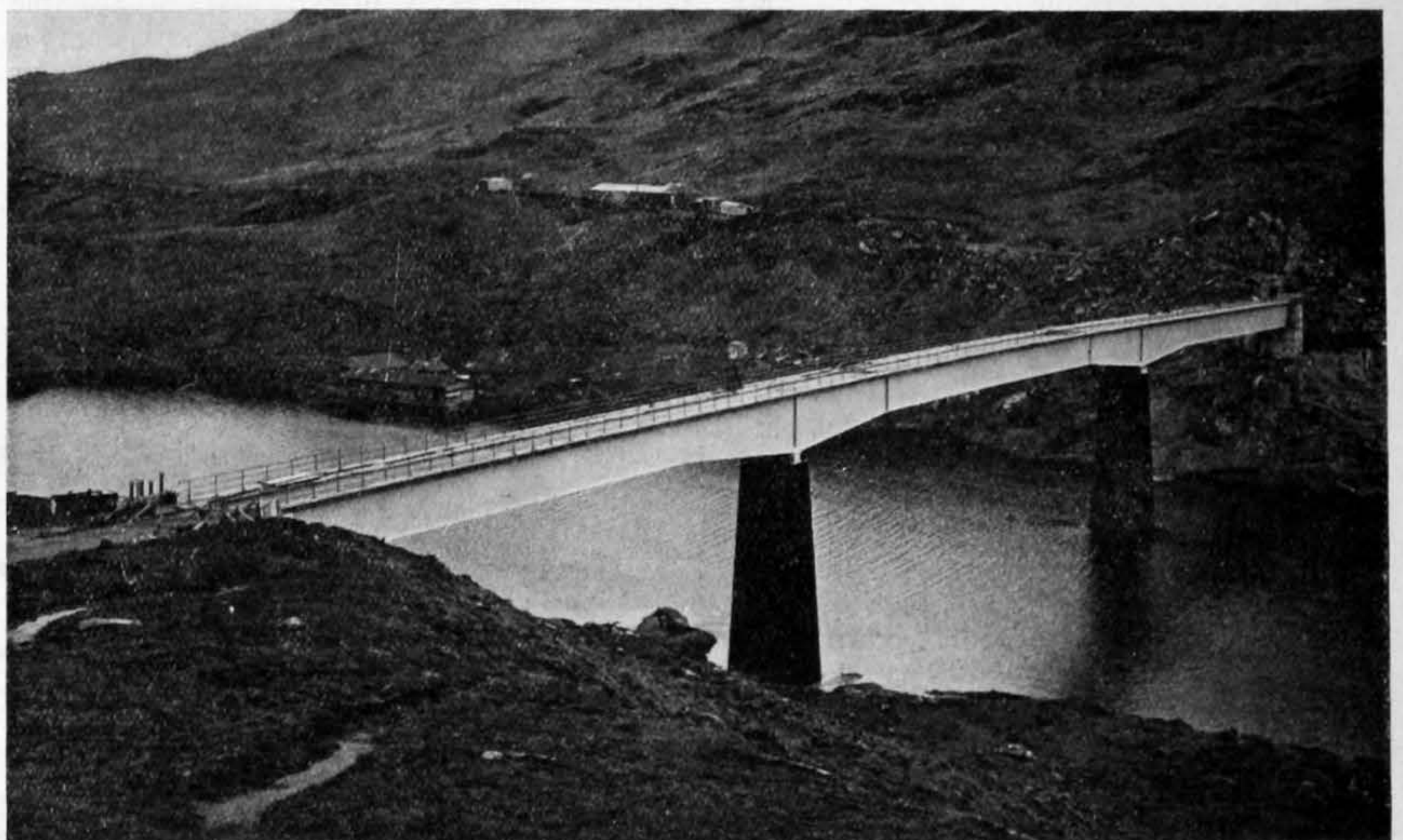


Fig. 5—Glen Quoich bridge. The bridge is of welded construction, with roadway slabs—each the full width of the bridge—of precast concrete

sary, at all reservoir levels through the needle valve, also has a branch pipe just on the downstream side of the dam, connected with a 350kW turbo-alternator set. Compensation water will normally be passed through this set before it is discharged into the river.

The spillweir is at the left abutment of the dam. It leads into a channel, which turns down the steeply sloping hillside and discharges the floods back into the natural course of the river. It was the intention to line the channel with concrete throughout its length and to form a ski-jump at the end. This layout was studied with a hydraulic model to ensure that the discharge would fall in the centre of the stream and not erode the river banks unduly. However, as the discharge channel was excavated the rock was found to be sounder than had been anticipated and the concrete lining was omitted from a point a short distance downstream of the dam. The roughness of the rock will dissipate part of the energy of the flow and no special arrangements have been made against scour at the lower end except to turn the channel to enter the river tangentially.

The intake works of the main power tunnel abut on the end of the spillweir channel. The intake consists of a deep cutting excavated in the rock with concrete retaining walls in some places (so that the intake is kept clear of peat and debris) leading to screens, with raking gear, as usually installed at a tunnel entrance. Behind the screens are a guard and a control gate, operating in a shaft excavated in the rock.

#### OTHER WORKS AT QUOICH RESERVOIR

The top water level at Quoich reservoir is higher than the level of the watershed between the Rivers Garry and Carnach, so two dams have been built to seal its upstream end. They are known as Cruadhach north and south dams, and are both concrete gravity structures, with lengths and heights of 450ft and 280ft and 53ft and 70ft respectively. The parapet level of these dams is 667ft A.O.D.—that is 7ft above the spillweir crest at Quoich dam. They are simple gravity dams, without spillways or control sluices of any kind.

The construction of these two dams, which are fairly sizeable structures as the figures above show, necessitated work in the most remote area of the scheme; a special camp was built to serve them, and an access road built for 2½ miles from the existing road running beside Loch Quoich. The site has the highest rainfall of any of the major constructional sites; a record rainfall of 10.2in in 22½ hours was recorded at the south dam in December, 1954.

An interesting problem arose at the site of the north dam, where an old stream bed, filled with moraine, was exposed at one end of the excavation for the dam. (This discovery, incidentally, showed that at one time part of the catchment did drain to the west.) After excavation by normal methods had been carried as deep as possible, sound rock had not been exposed over a certain area. This area was then "blanketed" over with concrete, and a concrete wall subsequently built up over it, leaving a shaft in the centre. The concrete wall thus constructed formed the base of the central core of a moraine and rockfill dam, which was constructed over this section. Finally, excavation was started again at the base of the shaft, and the excavated "cleft" in the rock was concreted and grouted. The diagram, Fig. 6, illustrates the dam constructed here and the special excavation work.

An aqueduct was also constructed to divert the flow from an adjoining catchment

1.1 square miles in extent, into the Quoich reservoir. This aqueduct—the Coire Shubh Beag aqueduct—is 6500ft in length, and comprises concrete pipes 30in to 42in in diameter.

Extensive road diversion works were also needed to reconstruct, above the top water level, the road which runs beside Loch Quoich and continues to Kinloch Hourn, an isolated hamlet on the west coast at the head of Loch Hourn. An extensive arm will be formed on the north side of the reservoir, where the River Quoich flows into it. A bridge has been built here, as a more economical alternative than a lengthy diversion round the perimeter.

The bridge is shown in Fig. 5; it is 560ft in length, with a central span of 220ft. It is of interest because high-tensile steel has

been used in its construction, and all the joints are welded. There is a 9ft carriageway formed from precast concrete elements, each of the full width and covering a length of 9ft 3in of the bridge. This method of construction reduced site work to a minimum, which was a considerable advantage in this case.

The civil engineering contractor who constructed the various impounding works at Quoich reservoir was Richard Costain, Ltd. The steel bridge was designed and erected by Sir William Arrol and Co., Ltd. All of these works were, of course, under the control of the civil engineering consultants, Sir William Halcrow and Partners. The associated road diversion works were carried out by A. Robertson Ltd., for County Council of Inverness.

(To be continued)

## Rocket Motors

By S. ALLEN

*On Thursday, October 11th, an account of the development of the Armstrong-Siddeley "Screamer" aircraft rocket motor was given to the Royal Aeronautical Society at the R.A.F. Technical College, Henlow. We reproduce below parts of the paper dealing with the combustion chamber.*

#### COMBUSTION CHAMBER

THE combustion problem is mainly concerned with arranging for rapid and intimate mixing of the fuel and oxidant. When this has been achieved the time required for reaction is very short indeed, of the order of  $10^{-7}$  second. Premixing of the fuel and oxidant before entry to the chamber is certainly not practicable when liquid oxygen and kerosene are used, first because of the danger of explosions and, secondly, because there is no temperature at which both are liquid. It seems certain that the reaction between fuel and oxidant proceeds in the gaseous phase and therefore evaporation must take place before reaction can start. Thus the initial state to be achieved is the formation of a cloud of small droplets with the fuel and oxidant droplets intermingled. By this means rapid evaporation occurs and, having occurred, results in intimate mixing of the fuel and oxidant in the gaseous phase.

A considerable amount of work has been done on the production of atomised fuel for gas turbines by means of swirl type sprayers. Unfortunately, this type of sprayer is not suitable for rocket use, mainly because efficient spray production is confined to fairly low flow numbers, the flow number being defined as flow in gallons per hour/pressure difference in pounds per square inch. The range of flow numbers normally used in gas turbine practice covers the range 0.5

to 10, and where the larger numbers are used for full throttle sea level conditions a sprayer having a smaller flow number is provided for part-throttle altitude conditions.

Now the fuel flow at maximum thrust for the "Screamer" was about 4000 gallons per hour. With an injection pressure drop of 100 lb per square inch this gives a flow number of 400. To reduce the flow number to a reasonable figure it would have been necessary to use at least forty sprayers for the fuel. If the oxidant were also sprayed the number of sprayers would be increased to at least 100. It was not possible to provide space for this number of sprayers.

The best compromise to provide breaking up of the fuel and oxidant and mingling of the droplets, appeared to be to provide a number of plain jets, drilled so that the fuel jet impinged on the oxygen jet. This gave a neat injector plate, which formed the closed end of the combustion chamber, but gave rise to some tedious drilling operations.

The injector design not only affects the combustion efficiency and thus the specific impulse, but also has a marked effect on the cooling of the combustion chamber. What actually happens inside the combustion chamber can only be conjectured, for a full-scale rocket does not lend itself to the insertion of windows or probes of any kind, first, because of the difficulty of cooling them, and, secondly, because of the effect of their presence on the cooling and combustion.

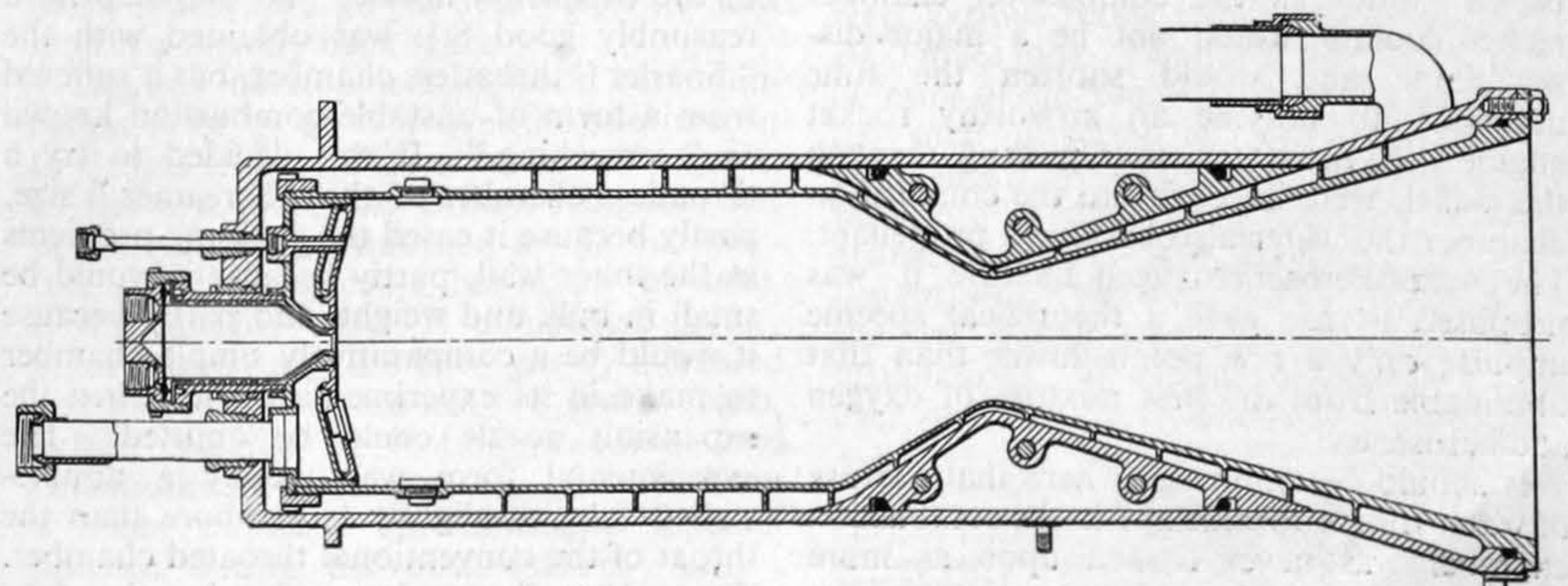


Fig. 1—4000lb methanol oxygen chamber

However, it is often possible to make a guess at what is happening from the condition of the chamber wall and injector face. Because of this the development of the injector and the combustion chamber must proceed together in the later stages, although it is possible to obtain valuable information about the injector by running it in a chamber which is heavily cooled by some external means—usually a copious supply of water.

The original thought was to base the design of the combustion chamber on the 4000 lb oxygen methanol chamber shown on Fig. 1. Because of the large range of thrust to be covered the injection pressure at full thrust had to be fairly high. Because of the high combustion temperature of the oxygen/kerosene mixture and the poor cooling qualities of kerosene, it was necessary to maintain a high coolant velocity with a correspondingly high pressure drop through the jacket, so that there was a fairly high buckling pressure. Calculations on the inner shell also indicated that under the conditions obtaining the thickness of the mild steel wall at the throat should not exceed  $\frac{1}{8}$  in. In order to have adequate resistance to buckling it was necessary to make use of the helical passage walls as stress carrying members and they were machined integral with the inner shell of the combustion chamber. Early experiments were limited to thrust up to 2000 lb, as neither the pumps nor the power available were suitable for higher thrust. Electrically driven "Snarler" pumps were used. Continual trouble was experienced with erosion at the throat of the combustion chamber nozzle during these tests, and it was obvious that some form of film cooling would be necessary. The "scrolled" type of inner shell was expensive and time-consuming to produce, and did not lend itself well to staged film cooling. Thought was given therefore to an alternative design which would be comparatively cheap to make and, at the same time, would lend itself to rapid modification.

The first attempt was to construct what became known as the "hoop" combustion chamber. In this the inner portion was formed of a series of aluminium alloy rings drilled axially and dowelled together, the whole assembly being clamped endwise in an outer steel casing. This chamber is illustrated in Fig. 2. By this method the chamber could be manufactured by turning and drilling operations and the cost of replacing damaged portions, or portions requiring modification, was small. The use of aluminium alloy also eased the cooling problem, although this was counterbalanced by the lower cooling velocity consequent upon using axial flow cooling and drilled passages.

It was realised at this time that one of the major development problems was the use of kerosene as a coolant. As it had already been decided to carry water for the turbine gas generator it was considered that the use of water as the combustion chamber jacket coolant would not be a major disadvantage and would shorten the time necessary to provide an airworthy rocket engine. If the water, after passing through the jacket, were injected into the combustion chamber the water also became a propellant. The water/kerosene/oxygen mixture it was proposed to use gave a theoretical specific impulse only a few points lower than that obtainable from the best mixture of oxygen and kerosene.

It should be emphasised here that the use of water for the turbine and in the combustion chamber was never looked upon as more than an interim step to shorten development

time. It was considered that it was essential to get the "Screamer" flying reliably at the earliest possible date, and to incorporate improvements such as the non-use of water later.

Calculations indicated that it should be possible to cool the "Screamer" with water forming 13 per cent of the total propellants. Development work started with much more than this, the amount of water being gradually reduced as information was gained.

About eight hours' running was done on the "hoop" chamber at thrusts up to 6000 lb. At this thrust level erosion and burning of the throat occurred. In attempts to overcome this the main weakness of the "hoop" chamber was encountered. During running the hoops took a slight permanent set in compression and on the next run would be slightly loose; the cooling water escaped in considerable quantity between the hoops, thus completely upsetting the distribution of film cooling. It was found to be difficult to make allowance for expansion in this type of chamber. At this time promising results were being obtained with another type of combustion chamber and it was decided to abandon the hoop construction.

The second type of combustion chamber was really inherited from "Snarler" days, when an experiment was made with a throatless chamber. The original "Snarler" throatless chamber was run on liquid oxygen

later an uncooled and then a cooled nozzle being added. The uncooled nozzle, of course, had a limited life even when made of Nimonic.

The first stages of development showed that the design of a solid injector having numerous impinging jets drilled in it was a long and tedious machining job, unless special tooling was provided. Apart from the delay involved in producing such tooling, it was obvious that many changes in injector pattern would be made before the design was "frozen." Some other means was sought therefore of producing the injector. The main difficulty with the original design was that it was quite possible to scrap an injector nearing completion by the breakage of a drill in a hole. Although there are ways of removing broken drills, their removal invariably results in a ragged hole. A design using inserted rings, copper brazed in position, was finally chosen. These rings were fairly easy to produce and the cost of scrapping one was small.

The early running on the throatless chamber was done with an amount of cooling water considerably in excess of the brochure figure. Having run the chamber up to the equivalent of 8000 lb thrust with excess water flow, the development work was then directed to reducing the water flow to the brochure figure of 13 per cent. At the same time, a series of tests was made using different combinations of injection holes. Briefly, the

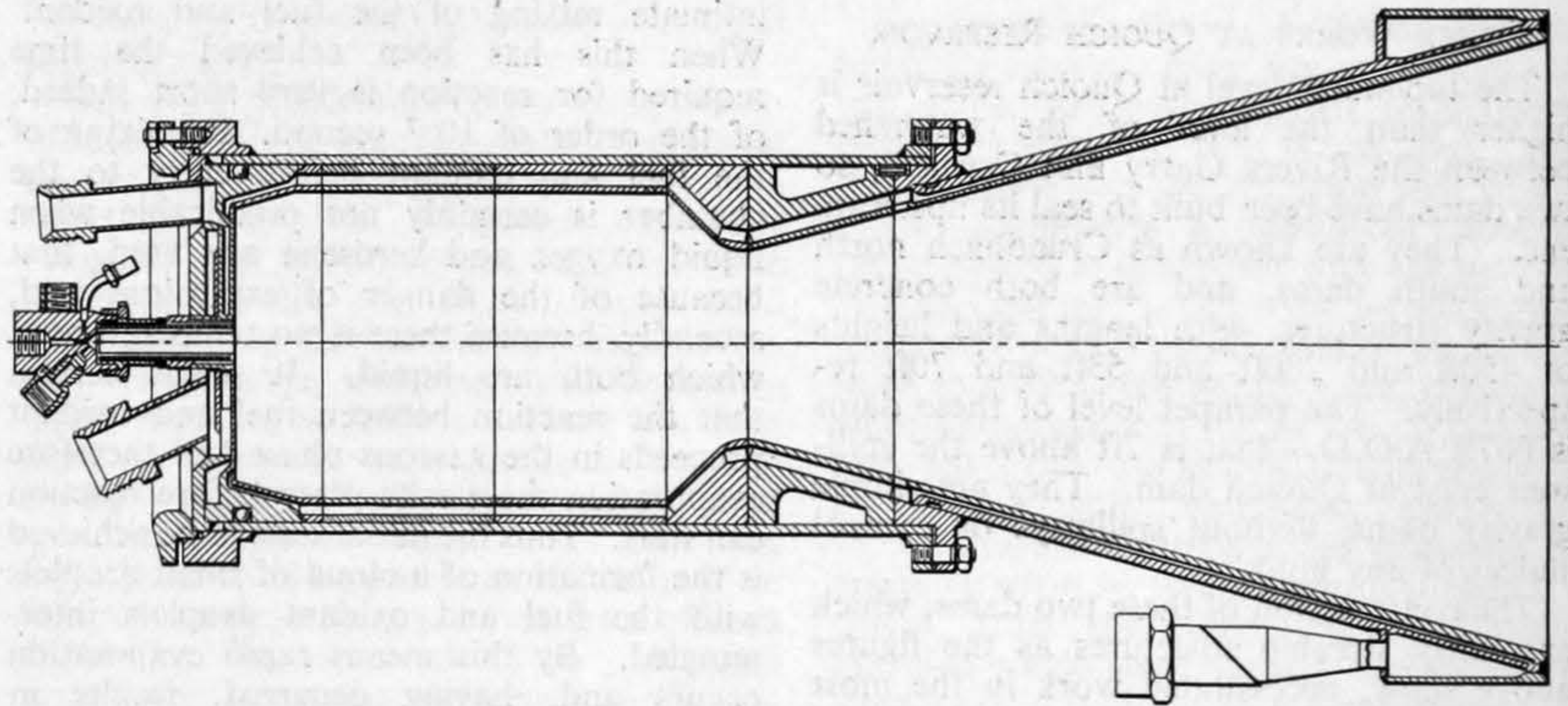


Fig. 2—Assembly of "hoop" combustion chamber

and methanol/water mixture and was part of an experiment to find the effect of combustion chamber size on S.I. (specific impulse). The usual way of expressing the "size" of a combustion chamber of a given thrust is by the quotient of its volume and throat area. This is known as the characteristic length, and for a throatless chamber is in fact the length from the face of the injector to the start of the divergent portion of the expansion nozzle. To our surprise a reasonably good S.I. was obtained with the "Snarler" throatless chamber, but it suffered from a form of unstable combustion known as "screeching." It was decided to try a throatless chamber of the "Screamer" size, partly because it eased the stressing problems at the inner wall, partly because it would be small in bulk and weight, and partly because it would be a comparatively simple chamber to make in its experimental form, when the expansion nozzle could be omitted. The experimental form was merely a double-walled tube of slightly larger bore than the throat of the conventional throated chamber. The early work was done on such a chamber,

types of injection holes consisted of "like-on-like" impinging, "unlike" impinging, and shower-head; the first two are self-explanatory, the third means that the jets were parallel to each other and with the axis of the chamber.

Various combinations of these were tried and the type finally adopted was the "like-on-like" impinging type.

Previous tests had shown that "unlike" impingement gave good results, provided that the point of impingement was not more than about 0.2 in from the injector face. If this distance were increased, erosion of the face occurred. It was difficult to produce an "unlike" impinging ejector on the inserted rig principle and at the same time to keep within the above limit. The "like on like" gave figures comparable to the "unlike" and was adopted.

The result that "like-on-like" impingement gave as high an S.I. as "unlike" impingement was surprising, as one might expect more rapid mixing from the latter. It is possible that this result was due to the

very low temperature of the liquid oxygen, which may have an adverse effect on the breaking up of the fuel by increasing its viscosity; also, this low temperature might have a chilling effect on the early stages of combustion which may not be so marked when the fringes of the two sets of jets burn first and are then able to supply heat to the remainder of the charge. Thus this effect may not be found when other propellant combinations are used.

In developing the coolant system to reduce the water flow it was found that while on some tests the chamber would run for several minutes at full thrust conditions without damage, on other tests the chamber would burn through within a few seconds of starting. As water pressure in the jacket triggered the admission of oxygen and fuel it did not seem possible that shortage of water was the explanation. After considerable investigation it was found that the presence of air bubbles in the water was the cause of the trouble; this was almost certainly aggravated by the use of a helical coolant passage, in which one would expect the air bubbles to scrub the inner wall due to centrifugal effect. The water system used on the test stand was considerably longer and more tortuous than would be expected on an aircraft. The trouble was overcome by careful bleeding of the water system before a start and by

using axial coolant passages in the chamber.

The latter change led to a difficulty. In order to maintain a reasonable coolant velocity of about 30ft per second the annular gap around the chamber became very small. This meant that a small distortion of the inner shell could reduce the gap to practically nothing, with the usual disastrous results. It was decided therefore to machine the inner shell from the solid, somewhat after the fashion of a splined shaft, the splines acting as distance pieces to control the width of the coolant passage to a minimum distance.

During the course of the development of the injector plate, film cooling was added at various stages along the inner shell, the depth of the coolant passage being reduced after each stage in order to maintain the coolant velocity. Water entered the cooling jacket of the expansion nozzle at the after end, flowed axially up it between laced guide wires, and then passed by external pipes to the forward end of the combustion chamber. It was then injected through the chamber walls in stages as film cooling, the cooling passage ending with the last stage just upstream of the beginning of the expansion nozzle. This became known as the "river in the desert" form of cooling.

[This chamber was illustrated in THE ENGINEER on page 118, July 27, 1956.]

## World Telecommunications

By SIR GORDON RADLEY

*At an ordinary meeting of the Institution of Electrical Engineers in London on October 4th, the new president, Sir Gordon Radley, gave the inaugural address for the session 1956-57. After making some reference to inland telecommunication, Sir Gordon turned to the main theme of his address, world telecommunication, abstracts of which are reproduced here.*

THE concept of a transatlantic telephone cable, having submerged repeaters at intervals to increase its traffic capacity, was first described to the Institution by Dr. Buckley in the 1942 Kelvin Lecture. Sir Stanley Angwin, in his Presidential Address the following autumn, took up the theme of transatlantic communication, and the first telephone cable system was completed last August. A general description of the design objectives for the system was given in a paper read to the Institution in November, 1954, and it is not my purpose to review the results obtained on the system this evening. That will be done in January, 1957, when papers by British and American authors, describing the cable and repeaters, will be read at a joint meeting between the Institution, the American Institute of Electrical Engineers and the Engineering Institute of Canada. The meeting will be conducted, appropriately, over the cable.

For the benefit of those members who have not followed recent developments in submarine cable technology very closely, it is well to recall that it is only the advent of the submerged repeater that has made the long submarine telephone cable possible. The attenuation of the high-frequency signals required to transmit one telephone channel, let alone a number of channels over a single conductor, is very rapid as the signals pass along the cable. In the Newfoundland-Scotland section of the new transatlantic cable the loss at the highest frequency transmitted, 164 kc/s, is about 1.6 dB per nautical mile—at this rate of attenuation the input of a 100MW generating set could not be detected by the most sensitive galvanometer more

than 150 miles away. The loss is made up by the insertion of a repeater with a gain of 65 dB—a power gain of over a million times—every 38 miles. The combination of cable and repeaters gives a system free from loss, but which depends on the continuous operation of a great deal of electronic equipment at the bottom of the ocean.

Completion of the project marks the opening of a new era in the growth of world communication. It would be appropriate, therefore, to review the usefulness to this end, of long deep-water cables equipped with repeaters. The development is revolutionary in its possibilities because the capacity of this kind of cable is likely to exceed that required to replace all the existing telephone and telegraph facilities on its route, and the intention of the American Telephone and Telegraph Company to lay a replica of the transatlantic system from the United States to Hawaii, half-way across the Pacific, in 1957 means that another big step towards the development of a global network of the new kind has already been taken.

The new development in world communication must be of very considerable interest to British engineers for a variety of reasons. In the first place the United Kingdom has not only a unique tradition in the manufacture of submarine cable, but also a manufacturing capacity which is unmatched in any other country and has been greatly increased and modernised in the last few years. Next, British research on thermionic valves, and British circuit techniques are likely to exert a major influence on submerged repeater practice during the next decade. Lastly, Cable and Wireless, Ltd., owns 150,000 miles

of submarine telegraph cable, more than half the world's total mileage. Communication facilities provided by telegraph cables are limited and expensive compared with what is inherent in a modern cable with repeaters, but the old and new facilities must exist side by side, or in combination, for many years.

In order to study the potentialities of long repeated submarine cable systems it is best to start from the traffic requirements, expressed in terms of the maximum frequency that must be transmitted over the cable. I have chosen 3 kc/s as the requirement for each telephone channel as a compromise between the 4 kc/s internationally standardised for circuits on land and any more economical arrangement that may be possible later using unconventional band-compression techniques which are being intensively studied. Eighteen telegraph, or telex, channels may be substituted for any one of the speech channels by the use of appropriate terminal equipment.

The relative merits of double and single-cable systems have been much debated between British and American engineers. The use of separate cables for the two directions of transmission makes for simplicity of repeater design, and the repeaters can be accommodated in flexible housings not much larger than the cable in diameter. A single cable, transmitting in both directions, is more adaptable and, if the number of circuits required is within its capacity, will always provide the cheaper system; it is clearly advantageous when a comparatively small number of circuits is required. With a single cable, "go" and "return" speech channels are separated on a frequency basis and the filter elements necessary to do this in each repeater add to the complexity of the circuit and very considerably to the space required. The more commodious rigid repeater housings which are comparatively difficult to handle are therefore regarded as essential with both-way cables.

Whichever kind of system is chosen, it is possible to work out an optimum design. As the diameter, and therefore the cost, of the cable is decreased, its attenuation increases and more repeaters are required for the transmission of the frequency bandwidth to carry the traffic.\* At the present stage it is probably easier to predict the electrical performance of a combination of cable and repeaters than the future price of either. In particular, the cost of submarine cable is very largely dependent on the price of the basic raw materials, copper, polyethylene and steel. The proper cost of repeaters is still difficult to determine; but it is safe to conclude that prices will remain high because of continuing high research and development charges and because of the care required in the control of manufacture and in the selection and testing of materials and components.

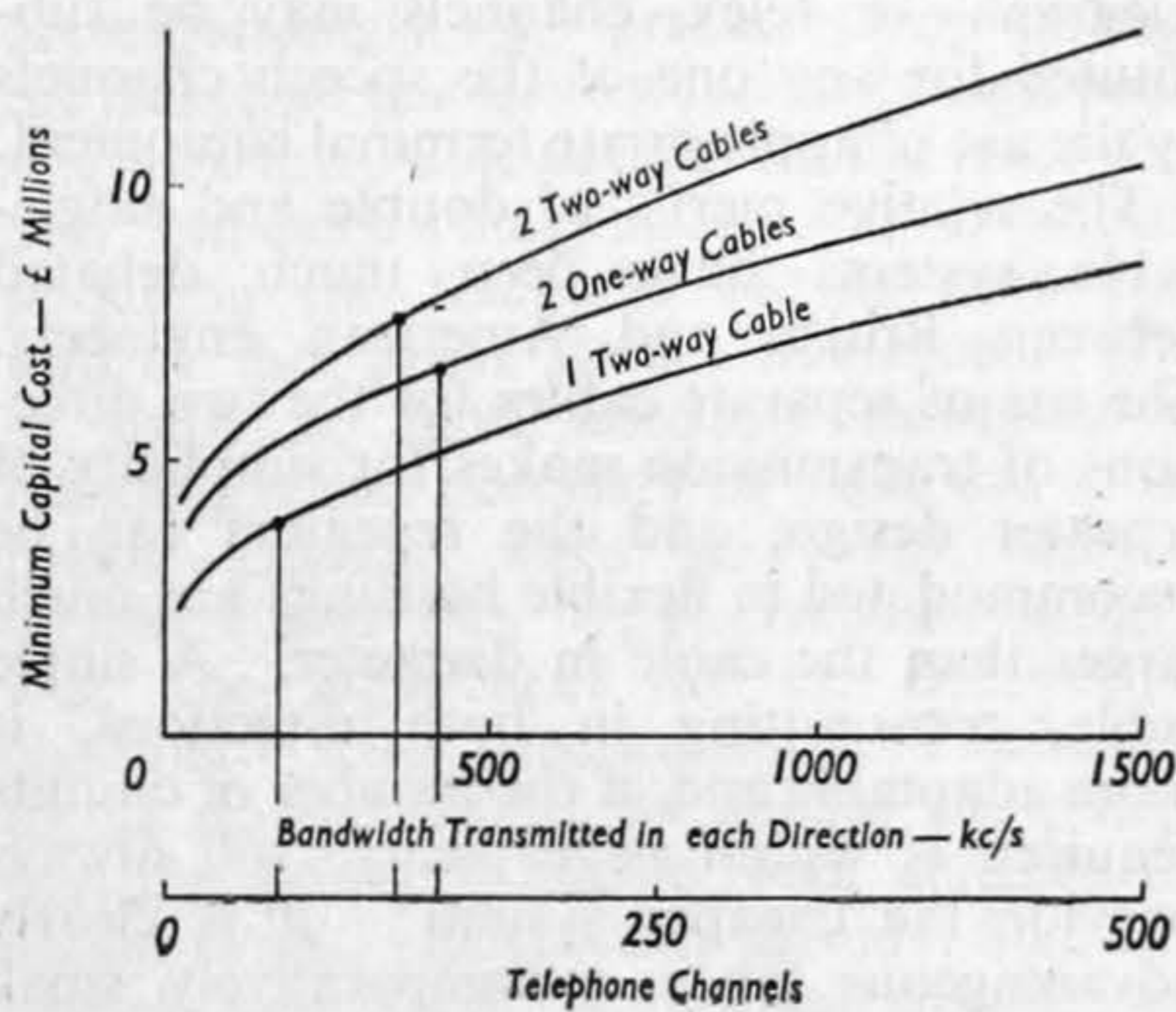
Fig. 1 shows the minimum capital cost of single and double-cable schemes designed to meet various traffic requirements on a route 2000 miles long. The traffic capacity is shown in terms of the frequency bandwidth available for each direction of transmission. The calculations on which these curves are based take into account the costs of the heavily armoured cable used at the ends of the system, where the cables are in comparatively shallow water, and also of the terminal installations. It must be emphasised, however, that the costs shown are not those of

\* For standard coaxial cable with polyethylene dielectric the attenuation varies approximately as  $\sqrt{f/d}$ , where  $f$  is the maximum frequency transmitted and  $d$  the diameter of the core. The working gain obtained from each repeater is limited because of restrictions on the minimum permissible input level and maximum permissible output level for satisfactory performance.

actual systems; the curves are only intended to indicate the variation and order of magnitude of costs.

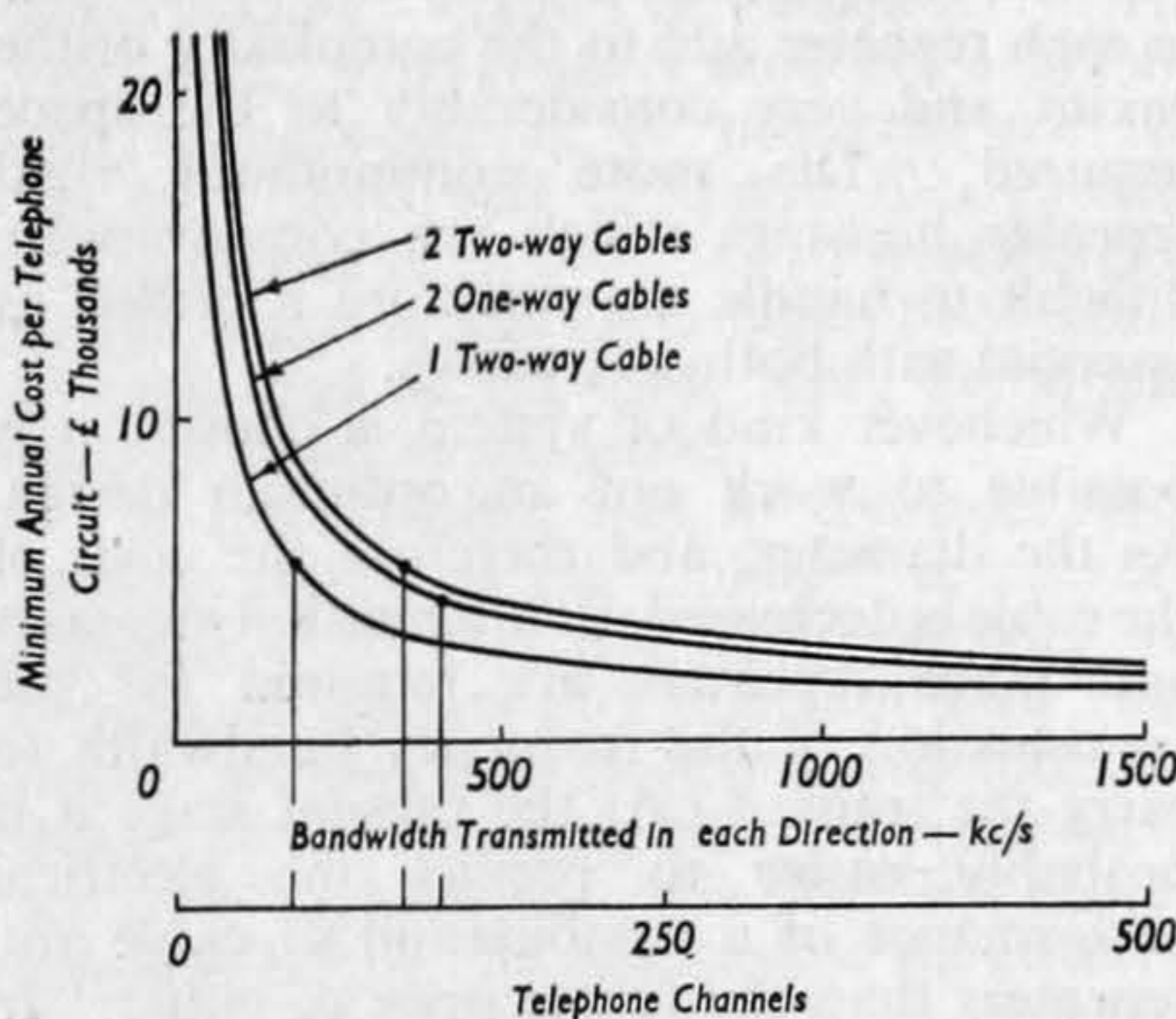
Annual charges are of greater importance than first cost, and to obtain these the cost of maintenance, including occasional repairs and replacement of repeaters, has to be added to the interest and depreciation charges on the various parts of the system. Fig. 2 shows the estimated annual cost of a telephone circuit in 2000-mile cable systems of different capacity. The assumption has been made that the system will have a life of twenty years, after which the total investment is written off; also that one repeater in every ten will have to be replaced in addition to the normal incidence of cable faults.

For the design data which have made Figs. 1 and 2 possible, I am indebted to



The three ordinates indicate limits of capacity set by present construction technique.

Fig. 1—Capital costs of cable systems: 2000 n.m.



The three ordinates indicate limits of capacity set by present construction technique.

Fig. 2—Annual costs of cable systems: 2000 n.m.

R. J. Halsey, who has carried much of the British technical responsibility in connection with the transatlantic telephone cable.

It will be seen that the cost per circuit falls rapidly as the capacity of the system is increased. A tenfold increase, from 10 to 100 circuits, decreases the cost per circuit by a factor of about 6; another tenfold increase to 1000 circuits would decrease the cost by a further factor of 4, or twenty-four times in all. It is clear, then, that the way to comparatively cheap circuits lies in using cables having a large traffic capacity. Economically, provision for all facilities, telephony, telegraphy, telex—and ultimately television—should be combined in one cable.

There are practical limitations to the kind of system we can build at present. These are set by:

- (i) The maximum voltage which can be applied to the system to energise the repeaters.
- (ii) The minimum spacing at which it is practicable to insert repeaters in the cable.
- (iii) The maximum size of coaxial cable it is practicable to lay and recover for repairs.

The second and third of these limitations depend on the depth of water in which the cable is laid. All three of them present problems—in high-voltage, mechanical or marine engineering, and it will be of interest to examine the three in turn.

The fifty-one repeaters in each of the new transatlantic cables are energised in series by a direct current fed along the centre conductor in common with the high-frequency speech currents. This warms the valve heaters and provides the anode voltages. A total driving voltage of about 4000 is required, the centre conductor and all the connected apparatus in the repeaters being 2000V positive to the sea at one end of the cable and equally negative at the other. Repeaters could certainly be adapted for 3000V working, and there is no real reason why 6000V should not be possible. With valves having practicable heater designs and using low anode voltages this would permit of repeater spacings of less than 15 n.m. on a 2000-mile cable and would cover all likely requirements, apart from television, for a long time to come.

During the last two summers, repeaters in flexible housings have been laid without incident at intervals of 38 n.m. across the Atlantic, one of them at least in a gale which would have made any cable-laying operation difficult. This kind of housing is capable of passing through the normal ship's cable gear during a continuous process of cable laying and adds very little to the hazards of cable operations. It is, however, not only inadequate for both-way repeaters, but provides no room for duplication of circuit elements or components in any repeater. Use of a duplicate amplifier, which is recent British practice, reduces the risk of failure and is particularly desirable if advantage is to be taken of new components or valves with only a short life history. It becomes necessary, therefore, to plan the use of rigid repeater housings generally. In shallow waters, comparatively large rigid housings have been successfully laid at intervals of 16 n.m. The methods adopted required the manual help of practically all the deck crew of the cable ship and are not suitable for operations extending over many days or in bad weather. Laying machines differing entirely from the proved and conventional drum have been suggested. Models of some have been built, and at least one has been installed on a cable ship. But there is no real experience yet as to how reliable they will be working continuously under adverse conditions at sea. Experience with rigid repeaters in deep water is very meagre.

Quite apart from any initial laying difficulties, however, replacement of any kind of repeater in mid-ocean may mean adding 5 or more miles to the cable length and a supplementary repeater. Until more experience has been gained, therefore, 20 to 30 n.m. should be regarded as the minimum spacing of repeaters in deep water.

Much has been learned about the laying and recovery of submarine cables during the past century, but the margin between success and failure often remains very small. The 1956 transatlantic cables are of the coaxial type required for telephony. They have a core diameter of 0.62in and weigh about 3 tons per mile in air. They were laid without difficulty at 2400 fathoms. The same type of cable will be used next year in the Pacific, where the depth will approach 3000 fathoms (3 miles). With fair weather conditions the recovery tension from this depth is about 70 per cent of the breaking strength of the cable and may approach the maximum permissible

load on existing cable gear. Movement of the ship in bad weather will rapidly increase these forces. Cable has to be recoverable if repeaters are to be replaced, and an operation started in fair weather may have to be completed in foul. Given suitable gear, heavier cable could be used in deep water, but, with existing gear, cable with 0.62in core should be regarded as the largest for planning purposes.

It is well known that in laying conventional cable, and to much greater extent in its recovery, stored turns in the armouring wires constitute a major hazard which is certainly not reduced when repeaters are present. Research has been undertaken on a form of structure with high-tensile steel core which is torsionally balanced. The cable has other attractions in respect of weight and cost.

The limits set by 20-mile repeater spacing and 0.62in diameter cable are shown in Figs. 1 and 2. Because of the separate limits, achievement of maximum traffic capacity may require departure from the cheapest design, but in most cases this does not greatly increase the cost.

In the present state of the art, transistor amplifiers would compare unfavourably with valve amplifiers in respect of power handling capacity and noise level and would be only marginally suitable in other respects. The art is, however, a progressive one, and when, as is likely, transistors of improved performance and proven reliability become available they will increase the prospects of building long cables with sufficient frequency bandwidth for the transmission of television.

The impetus given to the growth of communication between Western Europe and North America by the 1956 cable may well call for the laying of a second cable across the North Atlantic at no distant date of the greatest capacity technically possible. Eighty circuits in a single cable, or 200 in a twin-cable system, would be an objective only just outside the present limits of repeater spacing and cable diameter. If reasonably loaded with traffic at present call rates, either system would be profitable. The advances that are taking place will make still larger systems possible in a few years' time.

On other world routes the prospects are different. From a comparison of populations, circuit requirements to Australia and New Zealand are probably not more than between 5 and 10 per cent of those to North America. Twenty-four circuits provided over a single-cable system 12,000 miles long would require about 550 repeaters with an even higher standard of fault immunity than that postulated earlier. The annual charges on each circuit would be reduced if circuits were provided for part of the way in larger capacity cables. With costs as high as they would be, cable clearly cannot be competitive on cost with radio for the provision of small groups of circuits for very long distances. Except for the use of relay stations on some radio routes, the cost of terminal transmitters and receivers is about the same for all, and this has set a pattern of uniform charges to most destinations beyond Europe.

Much has been done to improve the reliability of long-distance radio circuits, and techniques have been developed whereby more channels can be accommodated in the high-frequency band (3–30 Mc/s), which has generally been used for such circuits. The limit to the number of long-distance circuits that can be used in this band makes it certain, however, that it alone cannot satisfy the growing need for world com-

munication. Neither has it been possible to achieve complete reliability. Despite the improvements, it does seem clear that the propagation of high-frequency radio waves is such that continuous communication cannot be realised over such difficult routes as the North Atlantic, or to the Antipodes.

Within the past few years considerable development has also been carried out on radio propagation using "scatter" techniques, whereby weak but consistent signals can be received well beyond the horizon. Experience suggests that links relying on forward scatter from the ionosphere or the troposphere may be more reliable than those provided by more conventional means. Unfortunately, very high transmitter powers have to be used, and highly directive, and therefore very extensive, aerial arrays are required at both ends.

Tropospheric scattering of ultra-high frequencies can be used to provide a broad-band path suitable for the transmission of television. The range is at present limited to around 200 miles, but it seems clear that successions of "scatter" links in tandem may contribute to the growth of international communication. Apart from the possible transmission of television, however, such methods do not appear competitive with the more conventional high-frequency point-to-point radio or cable on long, world routes.

The challenge to the communication engineer is to move towards the provision of cable facilities on the main world trunk routes on a scale which has hitherto been regarded appropriate only on land. He has increasing confidence in the use of electronic equipment in quantity at inaccessible points under the ocean. What is required is a means for laying in deep water the rigid housings for this equipment without all the hazards which attend such operations at present. Development of some form of mechanical gear for doing this as part of a continuous cable-laying operation is the immediate task.

A repeated cable from the United Kingdom to Gibraltar would appear to be a useful first step in building up communication facilities on routes other than the North Atlantic. Traffic to the Iberian Peninsula alone might not justify the investment, but the cable would have potentialities for further extension—to West Africa and South America via the Azores. A technical and economic study is being made.

### Chemical Research Laboratory

THIS year, October 2nd to 5th were the open days at the Chemical Research Laboratory at Teddington, and at the invitation of the Director we were able to see something of the work in progress. Many items noted last year were still being investigated, and in the corrosion of metals group these included prevention of corrosion, in aqueous solutions, under atmospheric conditions and underground. Work continues with boiler tube corrosion and an experimental circulating system is concerned with corrosion in circulating waters. In the inorganic group fifteen rare earth elements or lanthana having atomic numbers between 57 to 71 were on view, and also ion-exchange plant for separating them. A method of measuring the equilibrium between pyridine, piperidine and hydrogen was illustrated by the organic group, and a display showed some analytical applications of pentacyanoferrate complexes. The purification of metals, the cathode ray polarograph and the separation of rare earths by ion-exchange chroma-

tography were to be seen in the Hales building, and the method of metal separation by complexing elution from ion-exchange resins is an analytical tool which has been successful in the separation and identification of radioactive fission products. In the high polymers group chromatographic fractionation produced paper chromatograms which provided a rapid method of determining molecular weight distribution. Among the many items in the radio chemistry building there was a pilot plant for the extraction and recovery of uranium, in which ground ore mixed with water into a slurry was pumped to an air agitated leaching vessel and 50 per cent sulphuric acid added to maintain constant acidity and dissolve the uranium.

### Opening of Deep-Water Berths at Dar es Salaam

DEEP-WATER berths at the harbour of Dar es Salaam in Tanganyika were inaugurated by H.R.H. Princess Margaret at an opening ceremony last Monday. The harbour of Dar es Salaam is fully sheltered and the new berths, totalling 1800 ft are "up harbour" some 700ft from the existing lighter quays. The new quay wall is formed of concrete blockwork built in slicework at a slope of  $67\frac{1}{2}$  deg. with blocks weighing 9 to 16 tons. Each slice is  $4\frac{1}{2}$ ft in thickness and the weight of a complete slice amounts to 275 tons. The blocks were set on a rubble base 5ft in depth and surfaced with a layer of 2in of road metal. The block setting crane travelled on the top of the finished blockwork and had a reach of 45ft. The superstructure of the wall from +5.50 to +18.00 was formed of mass concrete and faced with concrete block ashlar. The depth of water provided at these berths is 30ft at low water and can be increased to 32ft in the future. The area reclaimed behind the quay wall has a depth of 835ft. Two transit sheds have been constructed—a two-storey building, 420ft by 150ft wide, and a single-storey shed, 975ft by 150ft. Both sheds have a rail loading platform on the landward side. One berth is operated by the Belgian Government under a concession and deals entirely with through traffic to and from the Belgian Congo. The entire scheme is a project of the East African Harbours and Railways Administration. The consulting engineers responsible for the deep-water berths are Messrs. Coode and Partners, and the main contractor is J. L. Kier and Co., Ltd.

### Manchester Association of Engineers

TEN days after the first number of this journal was published on January 4, 1856, a meeting of "employers, foremen and draughtsmen of the mechanical trades" was held in Manchester. At that meeting, it was agreed to form the "Association of Employers, Foremen and Draughtsmen of the Mechanical Trades of Great Britain." That somewhat cumbersome title was the name under which the Manchester Association of Engineers began its work, a work which has now been going on for a hundred years. The original title was retained for nearly thirty years, the change to the present name being made in 1885.

During the first two years, no records of the Association's activities appear to have been kept. The oldest surviving minute book begins in 1858, and from that and the subsequent records an interesting history of the Association has been prepared by Mr. A. C. Dean, a past-president. It is entitled *One Hundred Years of Engineering in Manchester*, and is being circulated

to commemorate the Association's centenary. In its early days the Association seems to have met on Saturday evenings at the Merchants' Hotel, Oldham Street, Manchester, where, "with simple refreshment," the members could talk informally about the experiences and problems which had confronted them "and probably gain full value from the friendly exchange of ideas." In his history, Mr. Dean notes that the objects of the Association were not specified in detail until 1864, when they were set out in the following terms:—"This Association was established in Manchester in the year 1856 for the purpose of bringing together those engaged in the direction and superintendence of Mechanical Works. For mutual improvement, increase of acquaintance and for promoting more frequent exchange of opinions on interesting questions constantly arising from the progressive nature of the mechanical trades. Also for bringing under the notice of members any subject or invention which from its novelty, usefulness or otherwise may be instructive or interesting. Further, to grant pecuniary assistance to such members as may require it, by providing superannuation allowance and rendering aid to members who through physical incapacity or accident may be unable to follow their usual occupation. And lastly, to assist members who are unemployed." As Mr. Dean remarks, the grammar of this may be a little uncertain, but the purpose is unmistakable! Actually, these objects have altered very little during the Association's first century, although from time to time they have been brought up to date and simplified. Meetings of the Manchester Association have now been regularly held throughout the hundred years, and since 1924 have taken place at the Engineers' Club. The list of presidents is an impressive one, which includes the names of many engineers whose achievements have reached much further afield than the city of Manchester. The first president was Mr. C. Lister, and the reigning president, who took office last week, is Mr. G. R. Adamson. He is the fourth member of the Daniel Adamson family to occupy the presidential chair.

Membership of the Association is open to all engineers occupying responsible positions, and for many years past has not been restricted to engineers in Manchester. It seems likely that the Association began with a membership of about a dozen; at the end of last session the total membership was 644. The first secretary—an honorary one—was Mr. T. Robinson, who held office for four years. It was then decided that the appointment should be a salaried one of £5 a year! The present secretary is Mr. G. M. P. McKellen.

The transactions of the Manchester Association of Engineers cover matters concerned with all branches of engineering. In its earliest days, the Association apparently relied for its discussions on subjects introduced at short notice, for the first printed paper in its records is one on "The Forging of Wrought Iron," which was presented in 1862 by Mr. James Bolas. According to a collection of extracts from the Association's early minute books, it was decided in 1862 that papers should be issued in pamphlet form at cost price, and "certain members of committee guaranteed the expenses for six months." In this matter, this journal was, unwittingly, of some assistance! The committee estimated that the annual loss on the printing of the papers was some £3, and it was therefore "decided to auction the Association's copies and bound volumes of THE ENGINEER and set the receipts against the loss on printing. In 1863, thirteen bound volumes were sold for ten shillings each, and an unbound volume for four shillings!" In congratulating the Manchester Association of Engineers on reaching its centenary in our own centenary year, we are happy to recall that episode as one of the numerous ways in which the technical Press has been able to assist and encourage the work of engineering societies.

The Association's official centenary celebrations have been taking place this week in Manchester. The programme included Mr. Adamson's presidential address last Monday; a civic reception by the Lord Mayor of Manchester on Tuesday, and a centenary banquet which was held last evening.

# LETTERS AND LITERATURE

## Letters to the Editor

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

### EQUATION OF FOOD AND FUEL

SIR,—Your issue of September 28th contains an editorial entitled "An Equation of Food and Fuel," mentioning some of my ideas about food production. It does not appear as if Sir Harold Hartley had touched on the crucial biological aspects of the use of fuel in food production. We might devise means for applying nuclear energy to propulsion of fishing vessels or to other purely mechanical aspects of gathering food; yet the biological necessity for using coal, sulphur or other fuel to promote the now necessary quantity and intensity of oxidation and reduction in the soil is inescapable and will continue to be so unless we are content to let the population of "civilised" peoples revert to what it was at about the turn of the century. Presumably such a reversion would not be accomplished without strife.

Though the amount of fuel used to make fertilisers and to provide mechanical power for procuring food forms only a small proportion of the total use of fuel, that small fraction is literally vital for the technologically advanced nations such as white peoples and Japanese. It would therefore be a mistake to dismiss its importance lightly or to assume that it can be left to look after itself among many other competitive uses of fuel. The essential thing is to understand that for about sixty years the peoples who have learnt to use, and rely on, fuel to supply an important part of their food have, for that reason alone, come into a relationship with the world that has no analogue or precedent in history. This new relationship has roughly paralleled the development of the aeroplane, and to be assured of an ample supply of food is at least as necessary as being able to fly. Yet one development has had much publicity and has been widely recognised; the other has gone unremarked.

The population gained by white peoples and Japanese (among the major Oriental nations) during the present century has been sustained by recourse to fuel. We are no longer dependent for food solely on what could be obtained from renewable resources; about a third of us could not exist without using a minimum of fossil fuel to sustain chemical and biological operations in and on the soil. Since non-food uses account for perhaps 99 per cent of all uses of fuel, the question how long a technically advanced population of the present size can be fed will be decided by the rate and intensity of non-food uses. What is done now by way of fuel conservation or greater erosion of fossil reserves will set the social pattern of the future. The sort of question which needs asking by the thoughtful is: supposing it feasible to establish a large satellite station for space travel, will that be wise if it involves consuming as much irreplaceable fuel as would keep the white races alive for several years?

I imagine that such debates about equi-

libria and point of balance will be congenial to engineers, and would make a change from considering fuel and its equivalents as merely sources of mechanical energy. No form of external energy can be a substitute for something suitable for putting between one's teeth. Energy from hydro or nuclear power can help to produce food only to the extent that the new power is set to release combustibles from being consumed to yield mechanical power. However attractive the idea of "harnessing sunlight" may appear, there is no hope of growing bigger crops by, for example, increasing the efficiency of photosynthesis so as to produce more food, without a corresponding recourse to fossil fuel.

HUGH NICOL

Chemistry Department, West of  
Scotland Agricultural College,  
Glasgow, October 6th.

### OUR ROADS ARE PERILOUS

SIR,—Your most interesting leading article under this title, in your issue of September 14th, paints a vivid picture of the task that faces the driver of a motor vehicle on a busy road. When one reflects, however, how many people undertake this task voluntarily and unnecessarily one begins to wonder whether it can really be so very exacting, after all. That it does not absolutely demand any superlative qualities of brain or physique becomes clear when one thinks of some of the people one knows to perform it without disaster.

W. A. TUPLIN

Sheffield,  
October 2nd.

[We agree. But it is not really the point. The problems set the driver of a vehicle (or a pedestrian) are not individually difficult to solve. It is the multiplicity of them that is the danger. Even in the simplest of arithmetical calculations human beings will sooner or later make an error. So they will on the roads. Reduce the number of individual calculations that have to be made arithmetically or on the roads and the number of errors will similarly be reduced, possibly *pro rata*. Additionally, the point may be noted that a great many driving misjudgments are made without disastrous consequences; and indeed the odds against any individual miscalculation leading to an accident appear to be very high. So even a very inefficient driver may still be able to boast an accident-free record.—ED THE E.]

### CALCULATION OF BACKLASH BETWEEN GEAR-TEETH

SIR,—I was very interested to read Dr. H. E. Merritt's letter on this subject and I agree that if one prepares in advance a sufficiently large number of curves to cover all possible cases, the time required for the evaluation of any quantity may thus be minimised. Evaluation of formula (13) in my article, even as it stands, is (I believe) more quickly possible than is the derivation of the same result by Dr. Merritt's method

with the aid of a curve for  $\psi_n=20$  deg. but the time required for evaluating (13) could be reduced to a negligible amount by use of a curve giving the value of  $z^2/6 \cdot 2(0 \cdot 125+z)(0 \cdot 5-z)$  as a function of  $z$ .

Developing this basic principle to the limit, it may be claimed for any method of calculating anything that it takes no time at all, if all possible cases have been worked out beforehand and especially if that preparatory work has been done by someone else.

W. A. TUPLIN

Professor of Applied Mechanics.

Sheffield,

October 2nd.

### AEROTHERMOPRESSOR

SIR,—This is in reply to the note of Dr. Gercke, appearing in THE ENGINEER of August 31, 1956, and commenting on the article "The Aerothermopressor" which was published in the issue of May 18, 1956. Dr. Gercke has quite rightly discovered an inconsistency in the equations. I am very sorry that there was a misprint in the manuscript from which the article was set in type. In Equation (1), the term

$$1 + \frac{k-1}{2} M^2$$

appearing in the denominator of the coefficient for  $dW/W$  should be replaced by unity. All the other equations in the paper are correct and are in accord with the corrected version of Equation (1).

ASCHER H. SHAPIRO

Massachusetts Institute of Technology,  
U.S.A.

October 2nd.

## Literature

*The Economic Consequences of Automation*, by PAUL EINZIG. Martin Secker and Warburg, Ltd., 7, John Street, Bloomsbury, London, W.C.1. Price 21s.

THIS work is an important contribution to the body of opinion on automation presenting, as it does, most of the arguments for and against the adoption of these new methods of production. It is straightforward, plain spoken and readable. It should be on the desk of every manager whose establishment is now, or will be, capable of employing automatic methods. It ought, also, to be in the hands of all trade union officials for it has much to say to them. Automation covers so many activities and, in this book, the author cuts a very wide swathe; if a mixed metaphor is permitted, he would appear to be driving a quadriga with a very spirited and difficult team. If, therefore, at times he indulges in a certain amount of repetition he must be forgiven, since this would appear to be essential to ensure that all the threads of a particularly difficult analysis are woven into a coherent pattern.

Dr. Einzig criticises those economists who, holding the view that automation is covered by the existing body of economic principles, refuse to admit the existence of any specific problems arising out of this new technology. He certainly has no doubts that the problems

are there; he lists and examines them thoroughly. Even if the reader does not accept all the argument he will have to agree that he has been given furiously to think. Two main conclusions emerge from the author's exploration into the economics of automation. He says: (1) "it is of vital importance, not only from the point of view of our prosperity, but even for our survival as free nations, to proceed with automation with the utmost speed" and (2) "that it has now become more important than ever to avoid a slump... in order to minimise this risk we must do our utmost to check the inflationary trend that has prevailed most of the time since the second world war."

The evil of over-full employment is dealt with realistically. Coupled with this there is a very critical survey of the causes tending towards the inflationary wages spiral. Dr. Einzig holds that automation "while mitigating the evil effects of over-full employment maintains the beneficial effects of full employment." He castigates employers who are guilty of hoarding labour and both employees and trade unions who have resorted to "feather-bedding" instead of permitting the free flow of labour to those industries who need it. "Feather-bedding," he points out, "may mean that the workers, instead of being dismissed during a boom when they could easily find alternative employment, have to be dismissed during a slump when there is no hope for their early re-employment." Summing up he says, "to the extent to which automation reduces... over-full employment it is an unmitigated advantage, not only from the one-sided point of view of the employers, but also from that of the community as a whole." There is some hard hitting respecting the wages spiral and its inflationary effect, but there is no mention of the desirability of a new wages structure which might well be the outcome of the situation thrown up by automation. While there is a possibility of unemployment arising from automation, if it proceeds too rapidly, there is a much greater danger of being under-sold through being too slow in the adoption of these methods. This is very clearly demonstrated.

The mechanics of inflation and deflation are discussed and, on the whole, the author comes down on the side of automation as a steadying influence. The chapter on "The Wages-Profits-Prices Triangle" is intriguing, particularly the argument that "any benefit labour derives from automation is essentially an unearned increment." There is also a suggestion that "during an inflationary period there is a strong case for setting aside the greater part of the benefit derived from automation in the form of blocked credits which would be released to wage-earners and shareholders as, and when, a declining trend developed in prices and in demand."

The author raises another most important issue—that of the possible threat of shortages of raw materials and of electrical power. "By accelerating the increase of production," he says, "automation has contributed, and is likely to contribute much more, towards the exhaustion of irreplaceable materials." This chapter should be carefully studied for it brings out the risk of political friction between the "have" and "have not" countries.

Dr. Einzig suggests that possibly "the best solution of the wages-profits-prices triangle would lie in the wide adoption of the formula applied in the Guaranteed Annual Wages Agreement introduced in the American motor industry in 1955—to establish a trust fund for the purpose of paying increased unemployment benefits to workers who may

be dismissed as a result of a setback in trade. Employers pay into that fund what they would otherwise have to pay in increased wages. This would moderate inflation during a boom and it would moderate deflation during a recession." This and the suggested blocked credits for shareholders might be the answer to the boom-slump swing of the pendulum. These suggestions should not be dismissed without very careful consideration for as the author remarks "it has now become more important than ever to avoid a slump."

Apart from the foregoing many other aspects of automation are discussed such as national defence, control (by Government) or freedom, balance of payment problems, fiscal considerations, monetary policy, business cycles, capital requirements and the advantages and disadvantages of the new methods. The author, quite rightly, says that, so far, there is relatively little factual material available for analysing the economic aspects of automation. He has, however, made the most of what there is and by linking his own great knowledge of the broader economic field to this material he has produced a lucid and logical statement that will be of inestimable value to the engineer. Perhaps one small complaint can be registered: for, whereas much credit is deservedly given, in the introductory chapters, to the great contribution made to automation by the U.S.A., no mention is made of the fact that Britain, in 1924/25, was responsible for the invention of that keystone of automation—the automatic transfer machine.

*The Festiniog Railway. Volume I: 1800–1889.* By JAMES I. C. BOYD, The Oakwood Press, Bucklands, Tandridge Lane, Lingfield, Surrey. Price 24s. 6d.

THE story of the Festiniog Railway forms, as it were, the centre piece of a nineteenth century industrial development of outstanding interest and poignancy—the rise, decline and collapse of a section of the Welsh slate industry. The reclamation of land in the Glaslyn estuary, the creation of an entirely new town and port, the establishment of shipbuilding yards are as much a part of the upsurge of prosperity in this corner of North Wales, as the gradual scarring of the mountainsides with slate quarries 15 miles or so up the Vale of Festiniog. To-day Portmadoc has found other means of livelihood, albeit on a much reduced scale; Blaenau Festiniog has not only the ghastly air of a once-beautiful country now irretrievably ruined, but a ruination not even redeemed by a modern, thriving industry. For the most part the workings at Blaenau are now idle.

Even though it did form the centre piece of a neatly-integrated, booming, local industry, the stranger to North Wales might be inclined to question if there could be anything special about a narrow gauge railway only 13½ miles long, single-tracked, which at the height of its activity owned less than a score of steam locomotives. But in many facets of its activity the Festiniog had a significance out of all proportion to its size, and to-day it is an object of veneration alike to the railway engineering historian and to those learned amateur enthusiasts who delight in delving into details that help to recreate the Victorian railway scene. Among both these species of enthusiast Mr. Boyd's book will be treasured. His first volume, which is the subject of this notice, brings the story down to the year 1889. It is a great story that he has to tell: how skilfully the line was engineered by James Spooner through very difficult country to provide an even gradient of about 1 in 85, to enable the

loaded slate trains to descend by gravity; how traffic grew to such an extent that locomotives were necessary; the introduction of the Fairlie type of double-ender locomotive—all these are highlights in an account told with a marvellous wealth of detail by Mr. Boyd. The historical portions are very fully documented; he takes us over the line chain by chain, as it were, missing no point of railway detail, or scenic vista. There are, as one would expect, dimensional details of rolling stock, in some cases with reproductions of the original drawings, and there are track plans with the signalling layout of every station, yard and crossing place. At the more important places, such as Duffws, the gradual enlargement of the layout is shown by separate plans at the different stages of development.

To say that the book is obviously a labour of love would be an understatement. Only those who have done any delving into railway history will appreciate the vast amount of research necessary to produce a book of this kind. And yet it is perhaps the author's very devotion to his subject that has prevented him from producing a classic. It is not a readable book. One dips in, here and there, extracting with interest and enjoyment the fascinating detail of one episode, or another; but it is an encyclopaedia, rather than a narrative. On this account particularly the absence of an index is a most serious omission, and one would urge the inclusion of an index to the complete work when the second volume comes to be published. But on every other score both author and publisher deserve the warmest congratulation. The book is beautifully produced, with a wealth of illustrations, some reproduced from very old and rare photographs. There is no doubt that the book will become the standard work of reference on the Festiniog Railway.

*Engineering Inspection, Measurement and Testing,* by H. C. TOWN, M.I.Mech.E., M.I.Prod.E., and R. COLEBOURNE, A.M.I.Mech.E., A.M.I.Prod.E. Odhams Press, Ltd., 96, Long Acre, London, W.C.2. Price 21s.

DURING the past few years many important developments have been made in precision equipment for inspection and measurement, particularly in optical and electronic devices. This book is intended to provide students with a concise history of the development of the recognised standards of measurement, and give a detailed insight into the latest methods and equipment used in inspection, measurement and testing. A wide variety of modern instruments are dealt with, and in each case a clear description of the basic design of an instrument is accompanied by notes on its method of use.

#### Books Received

*Rideau Waterway.* By Robert Legget. University of Toronto Press, Toronto. Price 40s.

*Dechema Monographien.* Band 28, Nr. 363–391. Verlag Chemie G.m.b.H., Weinheim/Bergstrasse.

*The Analysis of Structures.* By N. J. Hoff. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 76s.

*Lubrication and Bearings.* By F. T. Barwell. Butterworth's Scientific Publications, 88, Kingsway, London, W.C.2. Price 50s.

*Drawings and Dimensions.* By S. Parker. Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, London, W.C.2. Price 35s.

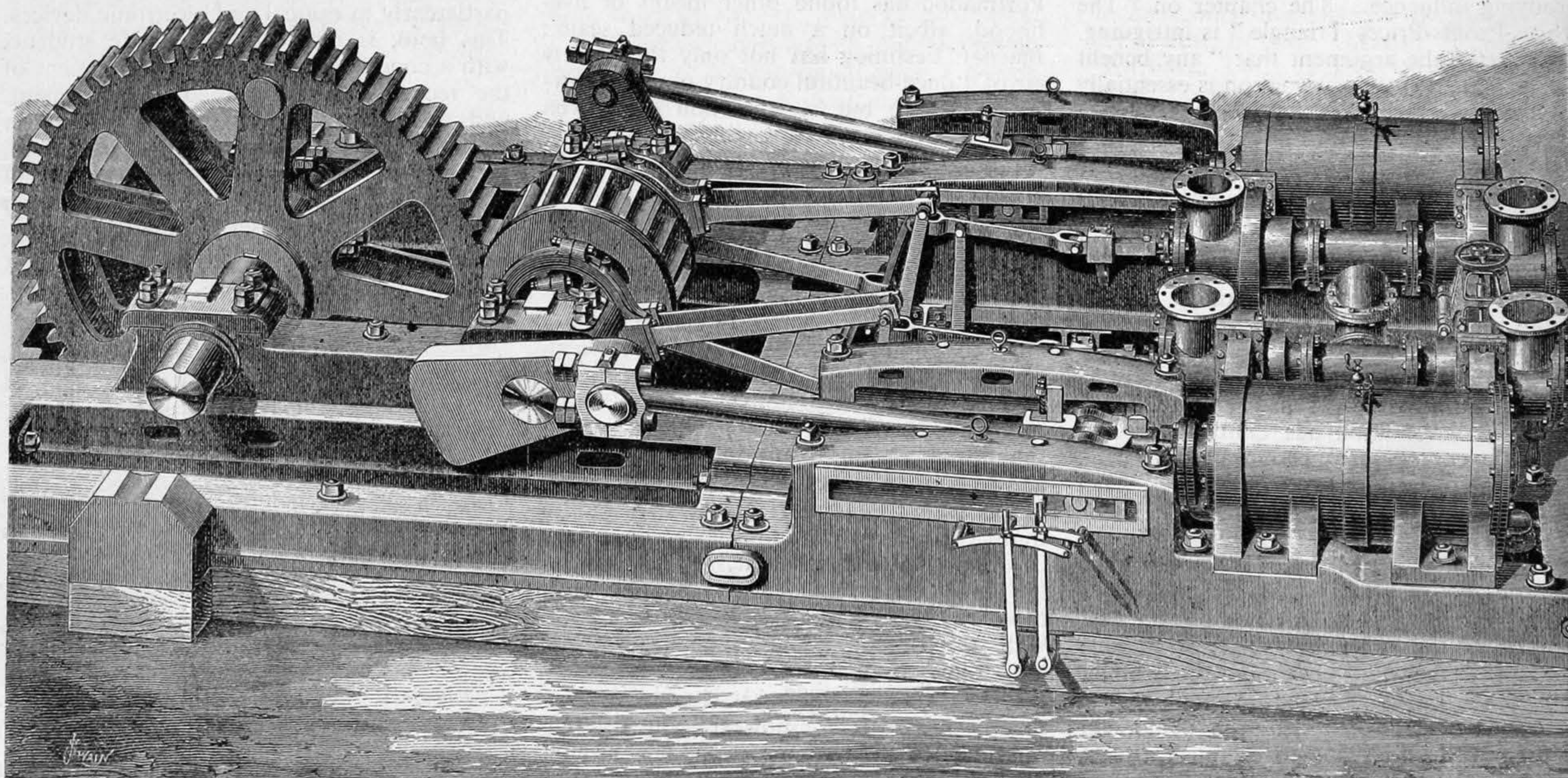
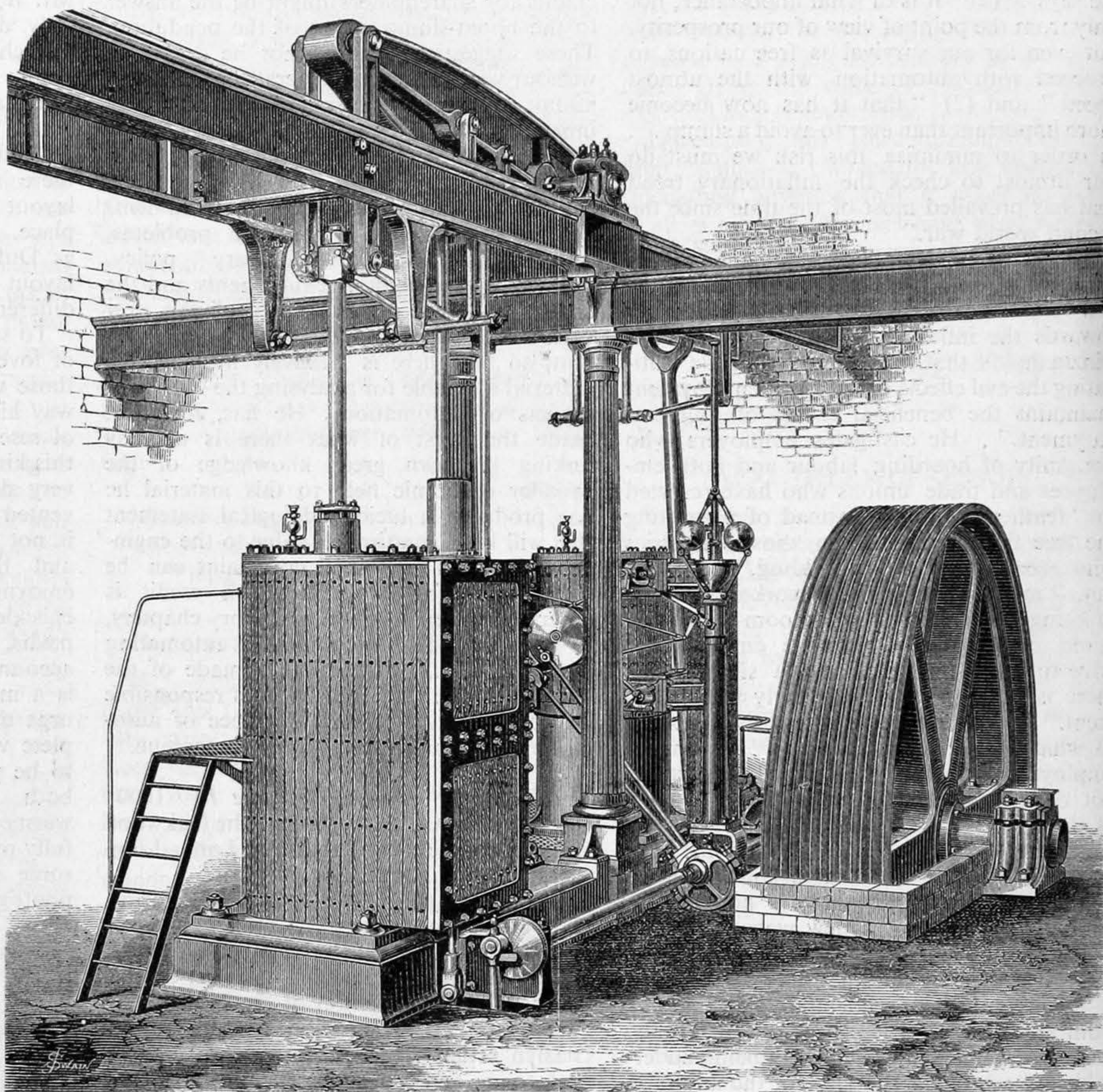
*Foundations Design and Practice.* By Elwyn E. Seelye. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 128s.

*Radio.* Vol. 3. By John D. Tucker and Donald Wilkinson. English Universities Press, Ltd., 102, Newgate Street, London, E.C.1. Price 12s. 6d.

# ENGRAVINGS OF 1877

The compound Corliss engine, which is illustrated in the right-hand engraving, was built by Douglas and Grant, of Kirkcaldy. A description, printed in our issue of January 26, 1877, says: "the high-pressure cylinder is 26in diameter, and 30in stroke, having Corliss valves and gear of the most improved description. There are separate eccentrics for the steam and exhaust valves, thus insuring a very perfect distribution of steam. These eccentrics are carried on a horizontal shaft, driven by mitre gear from the crank shaft; this horizontal shaft terminates in a disc, in which a pin is fitted, to give motion to the valves of the low-pressure cylinder, by connecting rods and a rocking lever under the floor. The low-pressure cylinder is 33in diameter, and 5ft stroke, and has two slide valves connected. The bed plate is very massive, 15in deep, and well proportioned, the brasses of the crank shaft neck being fitted into a slotted out recess."

In our issue of January 19, 1877, there appears a description of the reversing rolling mill engine which was installed at the Cleveland steel works, Eston. The works were built for Bolckow, Vaughan and Co., and the engine, shown in the engraving below, was installed by Thwaites and Carbutt, of Bradford. The cylinders were 36in diameter, and 4ft 6in stroke. It was explained that they were "cast of a special mixture of very hard and tough iron, the average thickness of the metal being 1½in." The steam ports had an area of 120 sq. in. Our description ends with the remark that "this is one of the largest, and certainly the heaviest engine of its class ever constructed in this country, the total weight of the engine and gearing being 137 tons."



# Controllable-Pitch Marine Propellers

*Controllable pitch propellers as manufactured by Escher Wyss A.G. are described, and details are given both of the working parts and method of operation. Further notes discuss the application of the propeller to marine propulsion and the economic advantages when used with diesel and turbine machinery.*

THE marine propeller with adjustable blades is almost as old as the ship propeller itself. Only fifteen years after Bessel's invention of screw propulsion for ships, Bennet Woodcroft took out a patent in 1844 relating to propellers with adjustable blades, and C. Bevis, about seventy-five years ago, already envisaged the present development in its basically right design. The technical difficulties inherent in these early constructions, however, proved to be so great that the variable-pitch propeller was soon abandoned; subsequent attempts to overcome these difficulties were hardly more successful until 1934, when Escher Wyss, Ltd., of Zürich, succeeded in producing a controllable-pitch propeller.

The fact that the ideas of British marine engineers first materialised in a satisfactory way in Switzerland, i.e. in a country not particularly concerned with maritime problems, is explained by the long experience of Swiss constructors with hydrodynamic machinery. In this particular case it was the experience gained in the design of water turbines with adjustable-pitch runners which caused Escher Wyss to employ the principal elements of pitch control as used in Kaplan turbines for the largely coinciding operating conditions of controllable-pitch marine propellers. Experience gained in the construction of water turbines has also been made use of for improving the characteristics of the propeller; in spite of the comparatively large hub diameter of the controllable-pitch propeller the hydraulic losses due to swirl are only slightly higher than those of fixed-pitch propellers. The first types of controllable-pitch propellers, designed more than twenty years ago, having a hub diameter to tip diameter ratio of about 35, had peak efficiencies only 2 or 3 per cent less than fixed-pitch propellers, with a ratio of about 0.20. To-day, with considerably reduced hub diameters and improved blade profiles developed according to the modern aerofoil theory, controllable-pitch propellers have practically the same maximum efficiency as fixed-pitch propellers but a considerably higher efficiency at part loads.

At a recent visit to the engineering works of Escher Wyss A.G., at Ravensburg (Germany), and Zürich, we had the opportunity of seeing at various states of assembly a number of controllable-pitch propellers ranging from screws for high-speed naval craft to those for ocean-going tugs. We observed with special interest the machining of individual blades for propellers as well as for Kaplan turbines, the

profiles of which are shaped, both on the pressure and on the suction side, on electronically-controlled copying millers. A trip on the Zürich lake, on board the 350-ton M.S. "Linth," a passenger vessel of the Züricher Dampfboot A.G., fitted with two 450 h.p. non-reversible, two-stroke diesel engines directly coupled with controllable-pitch propellers, demonstrated this form of ship propulsion for passenger vessels running to a fixed time table. By suitable adjustment of the pitch through remote control from the bridge the ship could be quickly stopped and again accelerated at landing stations, allowing the helmsman to make up for occasional unavoidable delays. Supplementing the action of the twin rudders by reducing or sometimes reversing the pitch of the appropriate wing propeller facilitated the coming alongside, a considerable advantage for a ship which, at the peak of the season, sometimes has to do more than 100 berthing manoeuvres a day.

The complete board installation of an Escher Wyss controllable-pitch propeller comprises four main components:

- (1) The propeller itself, with the blade adjusting mechanism mounted inside the hub.
- (2) The inboard-mounted hydraulic servo-motor for actuating that mechanism.
- (3) The hydraulic control system and
- (4) One or several transmitters for operating the pitch adjustment by remote control.

The principle and the design of the controllable-pitch propeller itself are extremely simple and, as already mentioned, employ basically the same constructional elements as the blade adjusting mechanism of a Kaplan turbine. The propeller blades can be turned about their radial axes, so that the angles between the individual blade sections and the shaft are altered by equal increments. The fact that a rotation about a constant angle alters the pitch of the outer sections more than that of the inner ones has only a negligible influence on the propeller efficiency.

The blades—as a rule—have a total pitch range from full ahead through zero to full astern of about 45–50 deg. In the case of sailing vessels fitted with auxiliary engines the pitch range is frequently increased to 110 deg., i.e. from 90 deg. ahead to 20 deg. astern. The 90 deg. angle, known as the "feathering" position, is to be used to prevent "windmilling" of the propeller when the auxiliary engine is not in operation. Fig. 1 shows a sectional view of the hub of a four-bladed propeller for a medium-sized tug. The hub and the blades are cast either of steel-

bronze or steel; the use of non-corrosive steel, having a tensile strength of about 40–45 tons per square inch and an impact resistance of about 280ft-lb per square inch, has proved particularly useful. Propeller blades of such material have a high degree of safety to corrosion attack, it is claimed; they are considered especially suitable for ships operating in rough harbour conditions or where ice is likely to be encountered.

In Fig. 1 the propeller hub *A* is bolted to the driving flange of a coupling keyed to the after end of the hollow tail-shaft which constitutes the drive to the inboard-mounted servo-motor unit. At the after end the hub is covered by a detachable tail fairing *B*, removal of which gives access to the pitch-adjusting mechanism. The retention of oil in the propeller hub and the exclusion of sea water is effected by synthetic rubber seals and the oil pressure is maintained at a higher pressure than that of the water by mounting the oil feed tank above water level.

The blades are either made integrally with the trunnions or, as shown in Fig. 2, are attached

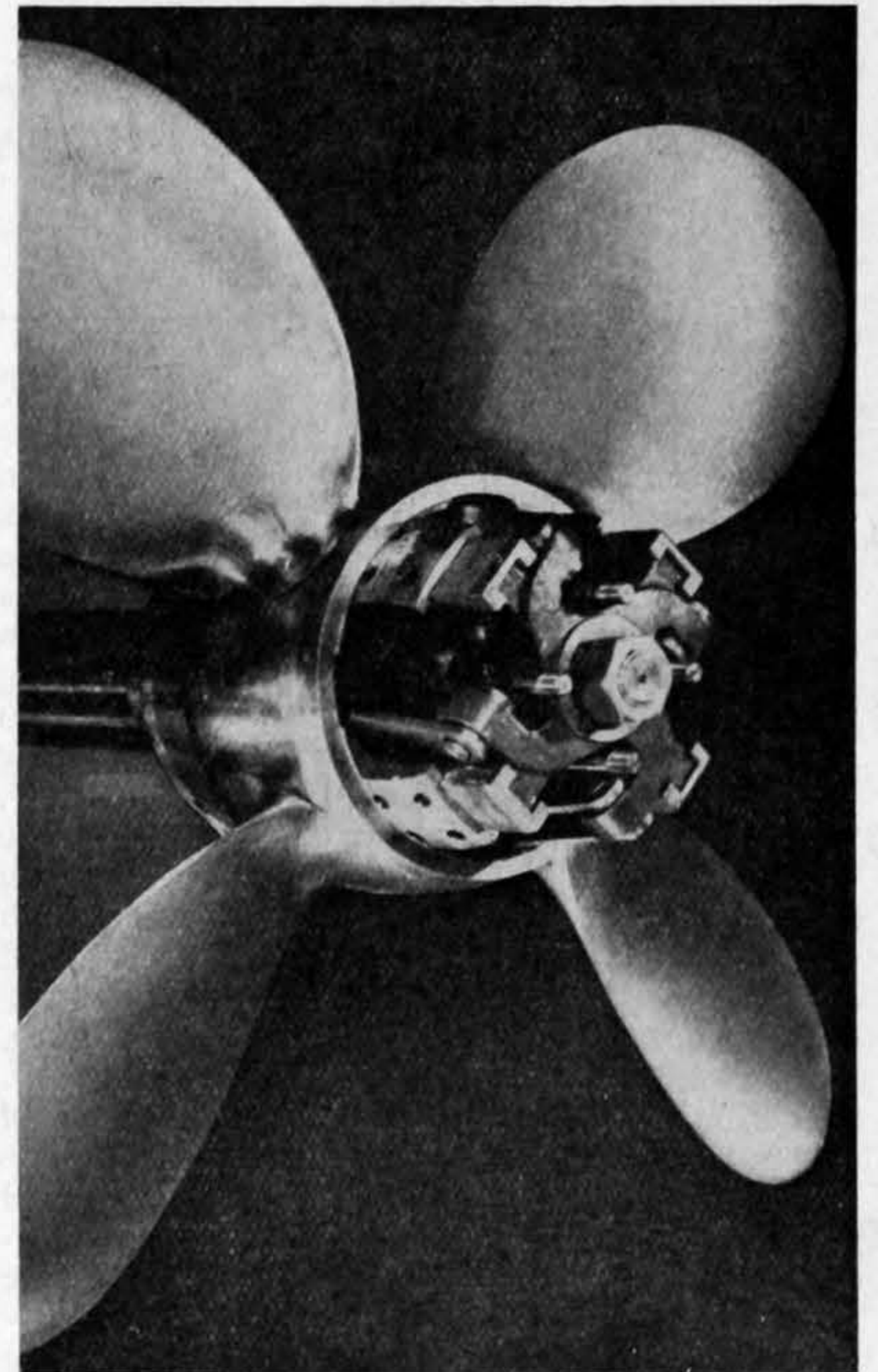
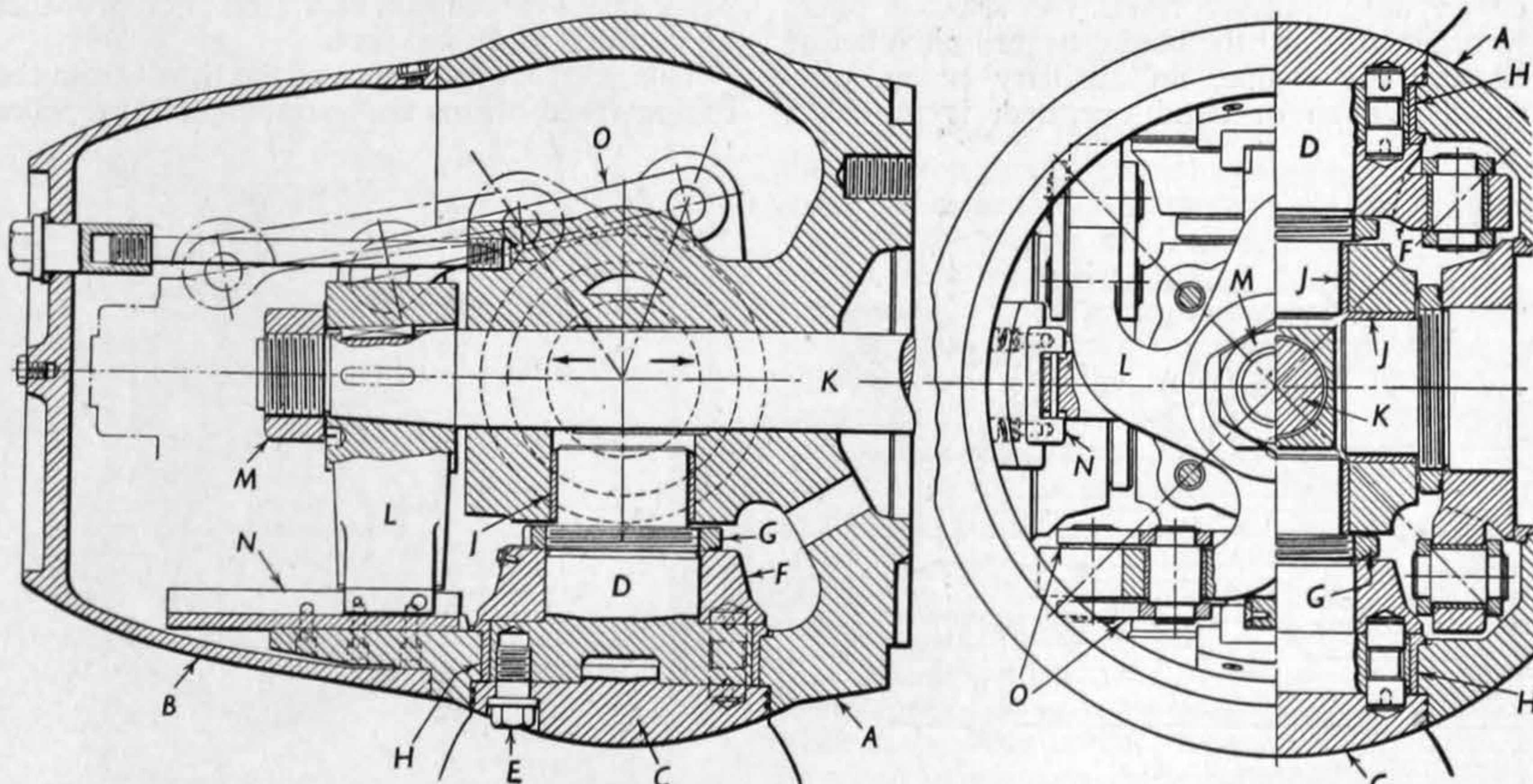


Fig. 2—Controllable pitch propeller with tail cone removed



A, propeller; B, tail cone; C, blade root; D, trunnion; E, bolt; F, crank arm; G, ring nut; H, outer bearing; J, inner bearing; K, adjusting rod; L, crosshead; M, nut; N, guide rails; O, twin linkage.

Fig. 1—Sectional details of hub of four-bladed propeller for installation on a medium-sized tug

to the latter by bolts. Each blade root has a cylindrical extension *C* with annular grooves for the synthetic rubber seals and is fixed to its trunnion *D* by bolts *E*. The bolts are designed as the weakest parts of the assembly so that they can break at a severe impact without causing any harm to the bearings or the pitch adjusting mechanism. The trunnion carries the crank arm *F* which is located axially by the ring nut *G*. The torque reactions between the trunnion on the one hand and the blade root and the crank arm on the other hand are taken by dowels. On either side of the crank arm each blade assembly is supported by two bronze bearings, one *H* carried in the rim of the hub and the other one *J* in the centre boss. These bearings are amply dimensioned to take the considerable loading caused by the thrust which, in case of large propellers might amount to more than 15 tons for each individual blade. The centrifugal load is transferred by the crank arm *F* to a shoulder of the outer bearing *H*.

The hub centre boss contains a bore for the rod *K* which, running inside the hollow propeller tail-shaft, connects the pitch-adjusting mechanism with the inboard-mounted hydraulic servo-motor. Keyed to this rod and secured by the nut *M* is the crosshead *L* which slides on the detachably-mounted rail guides *N* of the hub. Each arm of the cruciform crosshead is connected by a twin linkage *O* with the

corresponding crank arm in such a way that a linear displacement of the rod *K* effects a rotary movement of all blades. Fig. 2, showing a controllable-pitch propeller after removal of the tail cone demonstrates the control mechanism.

The servo-motor which actuates the above mentioned pitch-adjusting rod basically consists of a double-acting hydraulic cylinder which, interposed between the hollow propeller tail-shaft and the intermediate shaft from the engine, rotates in unison with these shafts and forms a part of the transmission (Fig. 3). Oil pressure, supplied by a shaft-driven pump is admitted to one side or the other of the rotating cylinder through passages in the bearings, thereby actuating a piston which is connected with the pitch adjusting rod.

Fig. 4 shows a section of the servo-motor and the hydraulic control mechanism. The

concentric position induces an eccentricity which, in conjunction with the centrifugal force, causes the balls to move up and down the bores of the rotor, thereby acting as plungers. The pump stroke and, thereby, the delivery varies with the relative eccentricity, and the direction of the oil flow changes according to the position of the control casing, i.e. whether the axis of its bore is located above or below the axis of the rotor. The pump, apart from two spring-loaded non-return valves *P* in the passages leading to the oil reservoir, has no other valves, the oil flow being controlled by ports drilled in the stationary shaft which serves as intake and delivery valve for all the individual pump cylinders contained in the rotor. Oil drawn from the oil reservoir is induced into the pump cylinders through a central bore at one end of the stationary axle and delivered to the servo-motor through another bore at the other end of the axle. When the direction of the oil flow is reversed, the corresponding ports and passages of the axle also reverse their specific functions and oil pressure is supplied to the other side of the servo-motor cylinder. Fig. 5 shows the main parts of the oil pump.

Referring again to Fig. 4 which shows the piston of the servo-cylinder in the zero-pitch position, it will be seen that one end of the bifurcated structure carrying the pump control casing rests on a lever keyed to the control shaft *Q*. The other end of the structure is supported by the bell-crank lever *R*, which, linked with the piston of the servo cylinder by the rods *S* and the sliding muff *T*, constitutes the restoring device. For the purpose of selecting an intended ahead or astern pitch the control shaft is turned either directly or by remote control in the appropriate direction about a predetermined angle. This causes the bifurcated structure to turn about its pivot on the lever *R*, thereby either lifting or lowering the axis of the pump control casing relative to that of the pump rotor. The pump accordingly starts building up oil pressure, the rate of delivery and the direction of the flow being controlled by the relative position of the two above-mentioned axes. Oil is supplied to one side of the servo cylinder, causing the piston to travel in the selected direction. The piston travel, transmitted through the rods *S* and the sliding muff *T* on the forward drive shaft, moves the bell-crank lever *R*, thus turning the bifurcated structure about its fulcrum on the control shaft *Q*. The movement ceases as soon as the pump casing has resumed its original zero stroke (coaxial) position and the delivery of the pump stops. In case the propeller should "wander" without any movement of the control lever (for instance, through leakage losses in the hydraulic system), the restoring device automatically resets the selected pitch. In order to adjust the blades to zero pitch before starting the engine, an auxiliary pump, electrically driven or hand operated, is provided.

Provision is also made for converting the controllable-pitch propeller to a fixed pitch in the event of any failure.

The selection of the required pitch—as already mentioned—can be effected manually or by remote control. In case of small vessels the control lever of the servo mechanism is generally linked with a corresponding lever in the wheelhouse by rods or cables. In bigger ships pneumatic or, more frequently, electric transmitters, coupled with pitch indicators, are employed. This method of remote control ensures operation of the pitch-adjusting mechanism over any desired distance and allows the installation of several transmitters—for instance, from the wheelhouse, the after deck and the bridge wings—to suit navigational requirements.

Since the first introduction of the controllable-pitch propeller in 1934, Escher Wyss has equipped a considerable number of vessels with this new form of ship propulsion. The main advantages claimed for the superiority of the controllable pitch compared with the fixed pitch are adaptability to varying service conditions, greater economy and ease of manipulation.

The fixed propeller is designed either to suit the specific operational requirements of one particular ship or to meet the rough average of its performance. In either case, a slight deviation from the design compromise results in a reduction of the maximum efficiency. The adjustable-pitch propeller, on the other hand, is designed from the outset to maintain a fairly constant efficiency over a wide range of operating conditions. These conditions are defined by two factors, the speed of the ship and the corresponding propeller thrust, and are influenced by such variables as hull resistance (laden or light, clean bottom or fouled, &c.), by weather and water conditions, and by any objects in tow such as barges, fishing nets or minesweeping equipment. While the thrust of a fixed-pitch propeller depends entirely on its rotational speed, the thrust of a controllable-pitch propeller can be increased or reduced at will simply by turning the blades, i.e. by altering their active angle of incidence. By increasing this angle the thrust is also increased, and the ship travels faster at the same shaft revolutions per minute, the effective power of the engine, of course, being greater. Adjusting the blades in the negative sense has the opposite effect; sufficient negative adjustment makes it possible to utilise the braking effect of the propeller and to go astern without altering either the direction of rotation or the speed of the engine.

The practical effect of the difference between the fixed and the controllable-pitch propeller of a 200 h.p. fishing boat is illustrated in Fig. 6. This diagram shows that, at a speed of 3 knots corresponding to the trawling operation, the thrust available with the controllable-pitch propeller is 26 per cent greater than with the fixed-pitch propeller. Similar conditions apply to other fishing vessels as motor-driven drifters and trawlers, and, in particular, to harbour and river tugs. In case of these latter vessels the bollard pull obtainable with a controllable-pitch propeller might exceed that of a fixed-pitch propeller by as much as 50 per cent.

This great independence of the thrust from the engine speed makes the variable-pitch propeller

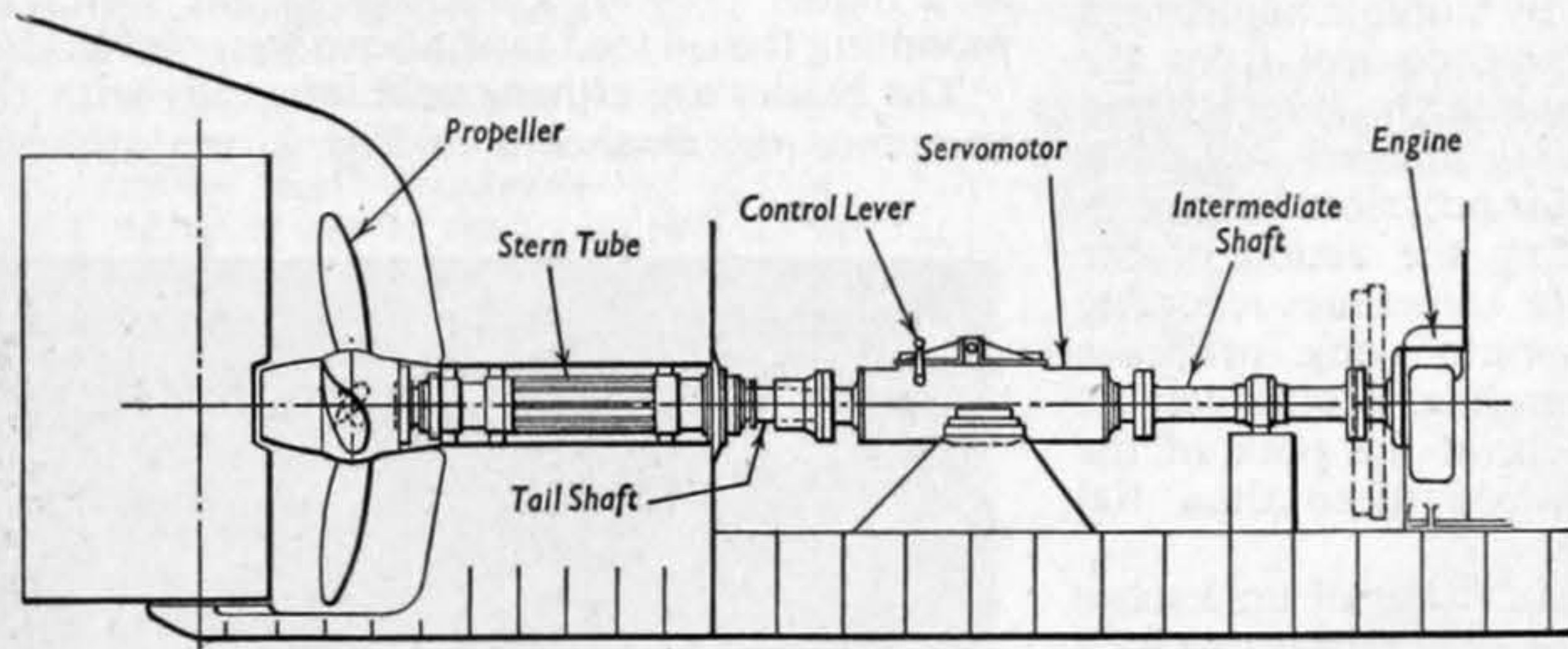
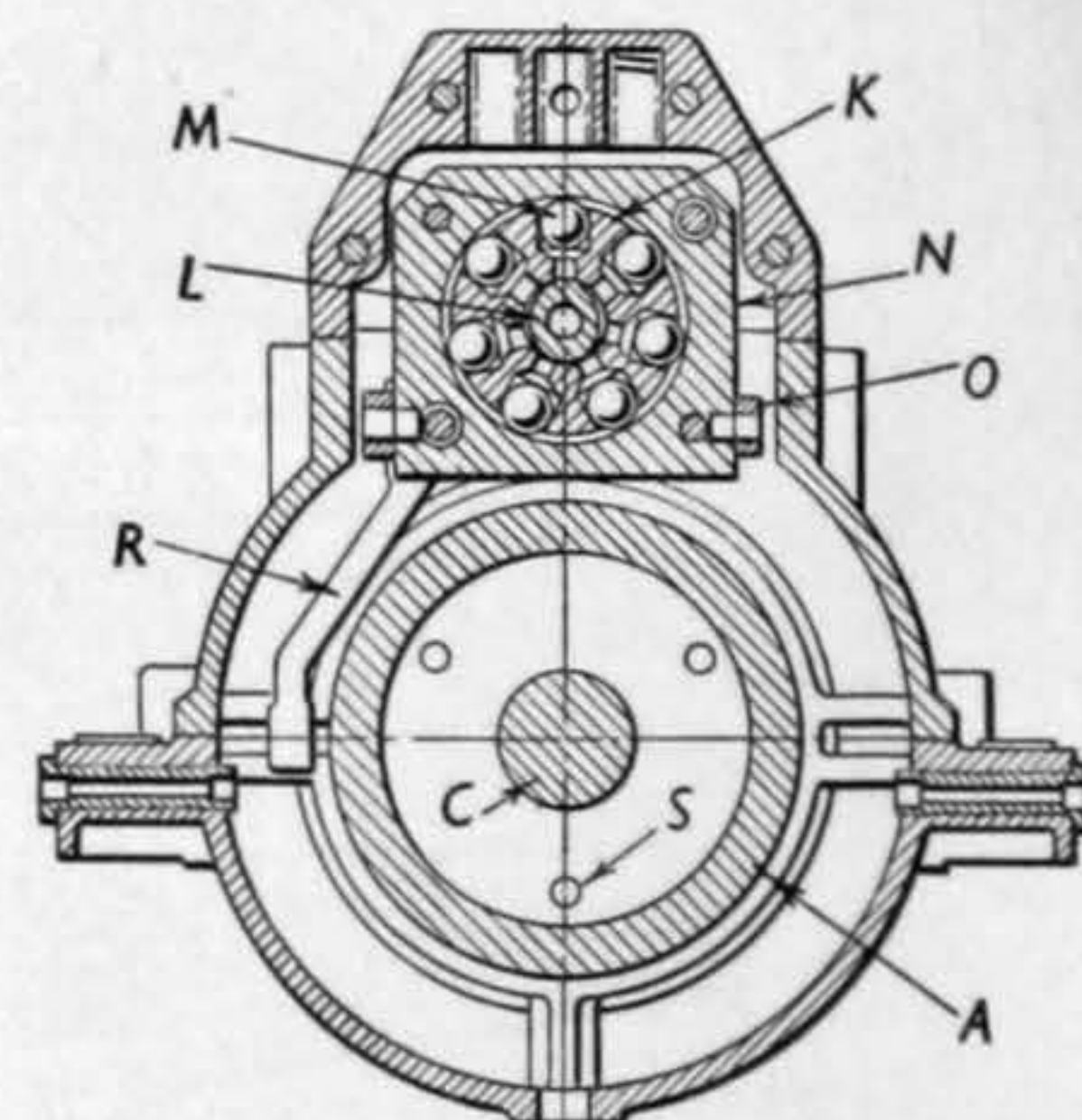
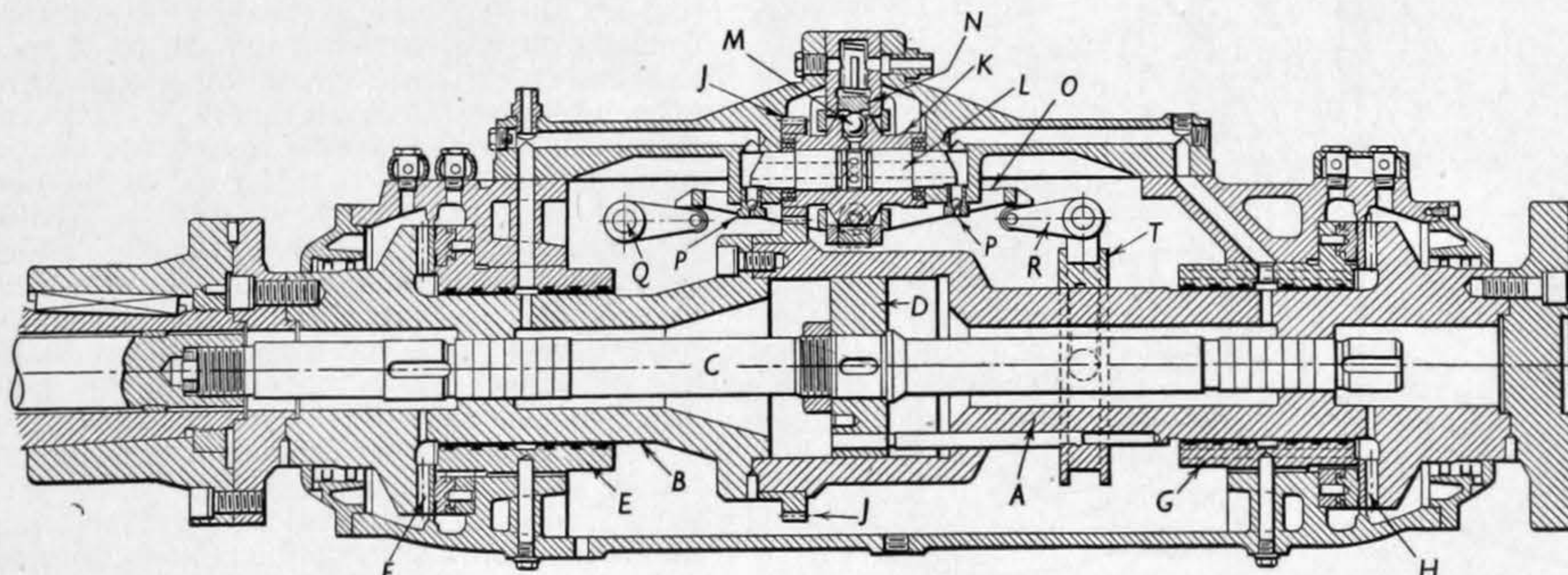


Fig. 3—General arrangement of stern gear

hydraulic cylinder is formed by a hollow extension of the forward drive shaft *A* which is bolted to a flange of the after drive shaft *B*. Both these shafts have cylindrical bores in which the rod *C* of the piston *D* is free to slide; rod *C* is joined to the pitch-adjusting rod contained in the hollow propeller tail-shaft. The rotating servo cylinder is carried on either side in two plain bearings *E* and *G*, the propeller thrust being taken by two built-in thrust bearings *F* and *H*. These bearings as well as the complete hydraulic control mechanism are mounted in a strong casing which also serves as an oil reservoir. An additional header tank is generally supplied, and an oil cooler is optional equipment.

The oil pump, arranged at the top of the casing, is driven by a gear *J* keyed to the after drive shaft. The continuously-running seven-cylinder radial pump has a variable stroke, and oil pressure is only supplied when the servo-motor is called upon to maintain a selected pitch. The cylindrical pump rotor *K*, running on a stationary axle *L*, has seven radial bores in which steel balls—instead of plungers—are free to move in a radial direction. When the pump is running the balls *M*, under the influence of the centrifugal force, bear against the cylindrical bore of the control casing *N*, which surrounds the rotor. The bore of the casing is bigger than the diameter of the rotor, and the casing is mounted in a bifurcated bridge-shaped structure *O* so that the position of the bore axis can be varied relative to the axis of the stationary axle *L*. As long as the bore of the casing remains concentric with the rotor, the balls, bearing upon the bore surface, simply maintain a rotary movement and no delivery takes place. Any deviation, however, from this

piston of the servo-cylinder in the zero-pitch position, it will be seen that one end of the bifurcated structure carrying the pump control casing rests on a lever keyed to the control shaft *Q*. The other end of the structure is supported by the bell-crank lever *R*, which, linked with the piston of the servo cylinder by the rods *S* and the sliding muff *T*, constitutes the restoring device. For the purpose of selecting an intended ahead or astern pitch the control shaft is turned either directly or by remote control in the appropriate direction about a predetermined angle. This causes the bifurcated structure to turn about its pivot on the lever *R*, thereby either lifting or lowering the axis of the pump control casing relative to that of the pump rotor. The pump accordingly starts building up oil pressure, the rate of delivery and the direction of the flow being controlled by the relative position of the two above-mentioned axes. Oil is supplied to one side of the servo cylinder, causing the piston to travel in the selected direction. The piston travel, transmitted through the rods *S* and the sliding muff *T* on the forward drive shaft, moves the bell-crank lever *R*, thus turning the bifurcated structure about its fulcrum on the control shaft *Q*. The movement ceases as soon as the pump casing has resumed its original zero stroke (coaxial) position and the delivery of the pump stops. In case the propeller should "wander" without any movement of the control lever (for instance, through leakage losses in the hydraulic system), the restoring device automatically resets the selected pitch. In order to adjust the blades to zero pitch before starting the engine, an auxiliary pump, electrically driven or hand operated, is provided.



A, forward drive shaft; B, after drive shaft; C, piston-rod; D, servo piston; E, after bearing; F, after thrust bearing; G, forward bearing; H, forward thrust bearing; J, pump drive gear; K, pump rotor; L, rotor axle; M, ball plunger; N, pump control casing; O, bridge carrying control casing; P, non-return valve; Q, control shaft; R, bell crank lever; S, restoring rod; T, sliding muff.

Fig. 4—Sections through servo mechanism showing details of the hydraulic control mechanism

useful for all ships operating under variable conditions, as maximum speed can always be maintained by adjusting the pitch so that the product of engine output and propeller efficiency attains an optimum. Apart from the usual practice of varying the ship's speed at constant engine speed, there also exists the possibility of maintaining constant ship's speed at varied engine speed. This might be important in order to avoid certain critical engine speeds without materially altering the ship's speed. It is also useful in cases of ships, fitted with diesel engines,

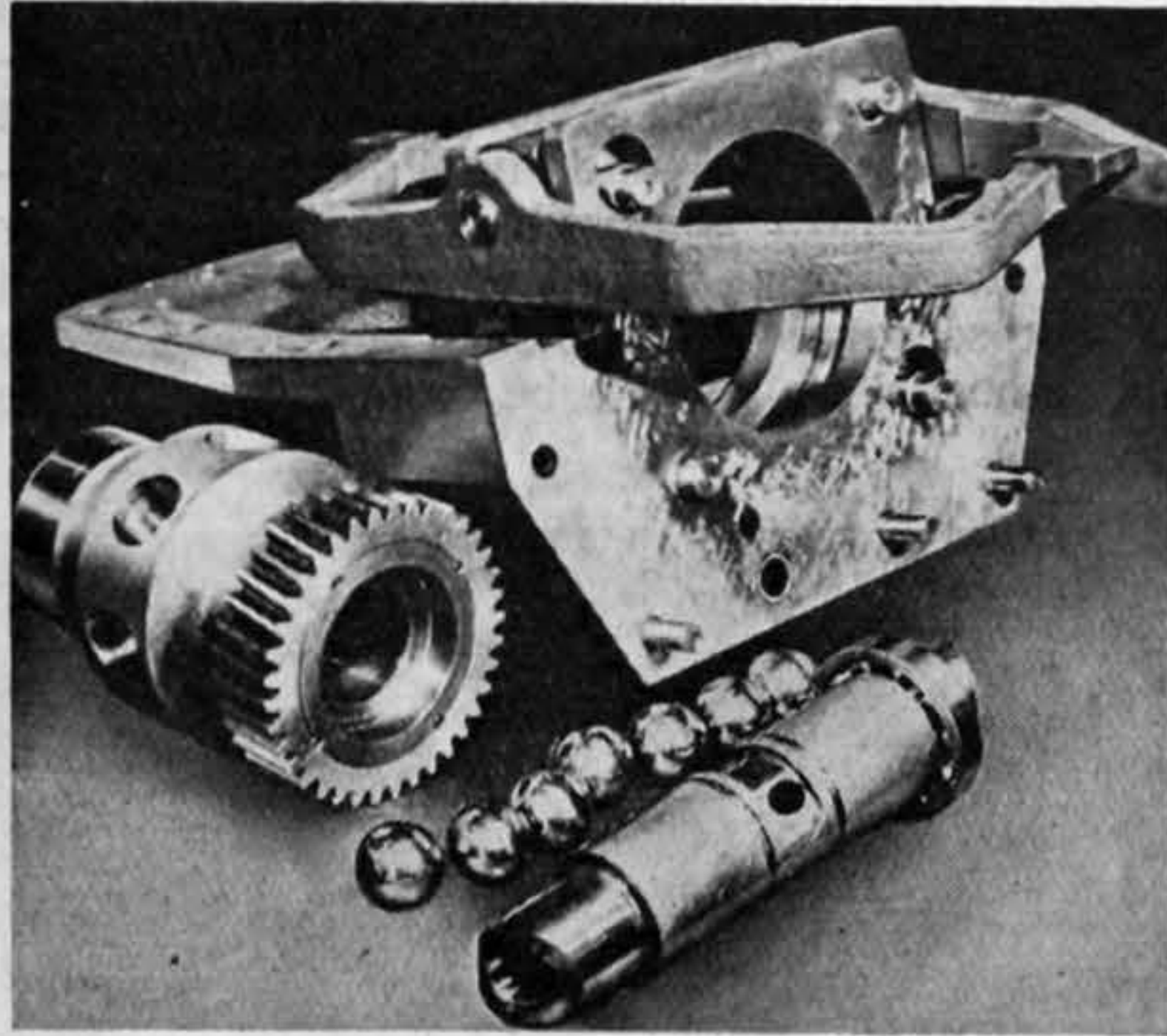


Fig. 5—Main components of oil pump

especially those of the supercharged type, which have an optimum fuel consumption only within a limited torque range. When the controllable-pitch propeller is in the neutral position it allows the machinery to be started up at no load and also permits the engines to be kept running whilst the ship is stationary. It can be completely reversed in a few seconds without stopping and reversing the engine, an advantage which not only reduces the time for executing these manœuvres, but also eliminates the detrimental effect of the cold starting air on the hot cylinder liners and piston crowns of the engine. A high-speed diesel installation with reduction gearing and controllable-pitch propellers offers the same advantages in regard to ease of manipulation as a diesel-electric installation, but without the inherent disadvantages of the latter, namely, the comparatively low overall efficiency and the increased weight and initial cost.

Considerable improvements in economy are also possible by combining steam turbine drive with adjustable propellers. This arrangement eliminates the sudden changes of temperature and also the delay followed by the immediate reacceleration of high-speed rotors that occur when going astern. By removing the astern turbines approximately 30-50 per cent space can be saved, with a corresponding reduction in weight, and the turbine becomes as simple as

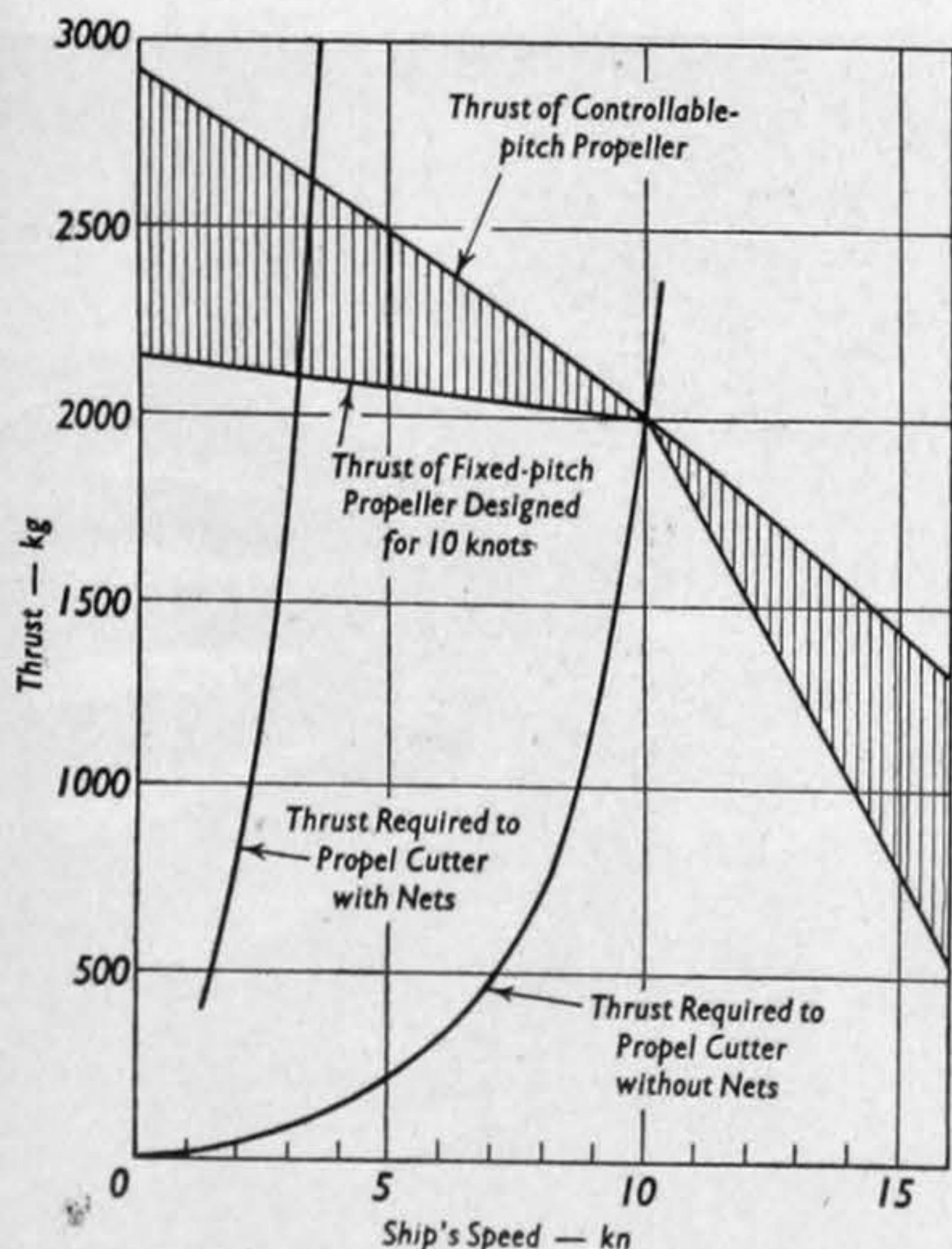


Fig. 6—Gain in propeller thrust when using a controllable-pitch propeller for a fishing cutter of 200 h.p.

an ordinary constant-speed turbine for stationary power plants.

Considering that the first propeller with adjustable-pitch blades was invented more than a century ago, it may appear strange that ship-builders and marine engineers have been slow to adopt this form of propulsion, in spite of the amazing benefits which aviation has derived from airscrew pitch adjustment. It may well be that further knowledge acquired in the field of aerodynamics might prove helpful in this respect, for the physical laws applying to ships, aircraft and turbine engineering entail numerous inherent affinities.

The Escher Wyss engineers maintain that, backed by twenty years' experience in this particular field of hydrodynamics, it is now possible to analyse theoretically the operating conditions of a controllable-pitch propeller with sufficient accuracy, so that a high degree of efficiency can be guaranteed.

### Low-Power Marine Diesel Engines

SINGLE-CYLINDER and two-cylinder diesel engines, both air and water cooled, intended for propulsion units for lifeboats, fishing vessels, cruisers and similar small craft, are now in production by Petters, Ltd., at Staines. These new engines, which are known by the mark AVA or AV respectively, followed by the numeral 1 or 2 according to the number of cylinders, are intended for heavy duty applications under all climatic conditions. They are available with three forms of transmission gear, namely, reverse and reduction, reverse, and clutch and reduction, which have been given the following designations:—"RMR," "RM" and "MR," respectively. All the engines are cold-starting, vertical, totally enclosed, compression-ignition, four-stroke units, having a bore of 80mm by 110mm stroke, and a compression ratio of 16.5 to 1. The single-cylinder model develops 6 b.h.p. at 1800 r.p.m., and the two-cylinder, 12 b.h.p. at the same speed on a twelve-hour rating. Our illustration shows a Mark AVA 2 MR twin-cylinder, air-cooled diesel engine fitted with clutch and the standard 2 to 1 reduction gear.

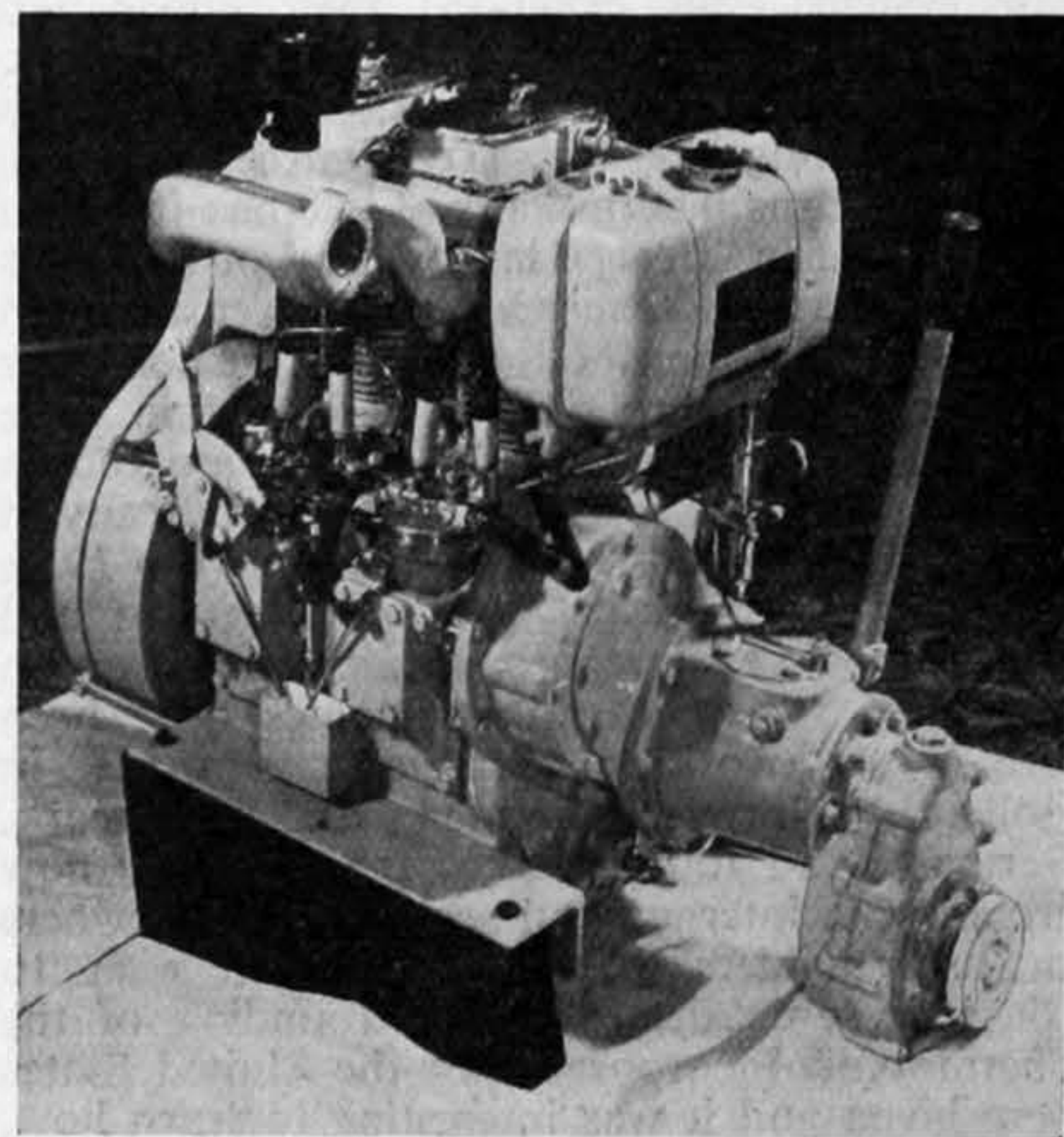
The general specification for both forms of engine is the same except that the air-cooled units have heavily finned cylinders and cylinder heads to provide adequate cooling, whereas the water-cooled engine has a cast iron cylinder block, fitted with removable wet liners, and cylinder head, with adequate cooling passages. The crankcase is of cast iron and has white metal bearings, while the connecting-rods are "H" section forgings having thin wall precision bearings of which the top half is copper-lead lined, and the bottom half white metal lined. The aluminium alloy pistons have a hemispherical bowl in the crown and three compression rings, the top one of which is chromium-plated, and one scraper ring. The valve gear is totally enclosed and pressure lubricated, and there is a centrifugal governor mounted on the camshaft gear wheel, which permits a speed variation from 500 or 600 r.p.m. up to a maximum of 1500 or 1800 r.p.m.

Fuel is gravity fed through a fabric filter and the injection pump is operated by a rocker gear from the camshaft, and there is a button filter fitted in the nozzle holder. Lubricating oil is drawn from the sump through a full-flow gauze strainer by a pressure pump and delivered through the crankshaft to the gear end large end bearing, main bearing, intermediate bearing in twin-cylinder engines and reversing gear when fitted. External pipes convey the oil to the rocker gear, and to the flywheel end main bearing in single-cylinder engines, while the flywheel end large end bearing in twin-cylinder units is lubricated from the flywheel end main bearing through a hole in the crankshaft.

In the air-cooled engine air is forced over the cylinder and cylinder head by a flywheel fan, while in the water-cooled range water is circulated by a belt-driven, separately mounted gear pump. Oil-wetted air cleaners are fitted and the installation angle is 10 deg. for the single-cylinder and 8 deg. for the twin-cylinder models and includes an allowance for bow lift.

Both air and water-cooled twin-cylinder engines have been approved by the Ministry of Transport and its Swedish counterpart, for class "B" lifeboats. In passing the tests the air-cooled engine was sprayed with water after running for half an hour and was also run for two hours in a room in which the air temperature was 140 deg. Fah. and the humidity 95 per cent. When fitted in lifeboats the engine can be tested and maintained, without lowering the boat into the water or making special deck arrangements, and can be started while the lifeboat is still in the davits to enable the boat to make a quick getaway.

We recently had the opportunity to inspect the range of these engines and to take part in trials in which a lifeboat built by Mechans, Ltd., and another provided by Watercraft, Ltd., demonstrated the performance of the air-cooled unit in such craft. The dropping of a boat, with its



Twin-cylinder air-cooled engine fitted with clutch and reduction gear

engine already running, from davits was also demonstrated. The managing director, Mr. D. K. Fraser, in discussing the production programmes, revealed that most of the engines manufactured by the company were exported either directly or indirectly.

### Continuous Automatic Swarf and Oil Separator

A CONTINUOUS automatic machine for separating oil from swarf is now being supplied in four sizes by Sharples Centrifuges, Ltd., Woodchester, Stroud, Glos. The smallest size of these separators is capable of treating 1 ton of crushed steel swarf or 0.5 ton of crushed aluminium swarf per hour, and the largest model up to 8 tons of steel or 3.9 tons of aluminium swarf an hour.

Each machine is a compact, self-contained assembly, the body of which is supported from three pendulum bearings which prevent the transmission of vibrations to the foundations. Crushed swarf is fed, by gravity, into the perforated rotating basket of the machine and falls into the centre chamber of a hydraulically-operated feed and discharge ram assembly. This ram is reciprocated vertically, its stroke being about equal to a quarter of the basket depth. The rate of ram reciprocation is adjustable in accordance with the material being treated and is usually about ten to twelve strokes a minute.

As the swarf is carried round and travels up the wall of the rotating basket the oil adhering to it is thrown out by centrifugal force through the perforations and flows down into a collecting channel below. De-oiled swarf is raised by the top of the ram on its up-stroke and is discharged over the top edge of the basket. As the ram again descends a further quantity of oily swarf is deposited in the basket. Cleaned swarf drops through an annular chamber round the outer part of the machine and is discharged from its base.

# Air Conditioning and Ventilating Development

*Since the second world war there has been a considerable expansion in the demand for air conditioning and improved standards of ventilation, and in order to provide an international service Thermotank, Ltd., has formed companies in Europe and the United States. An extensive research section is engaged on the solution of problems related to the improvement of technique and performance.*

IT was in 1901, some four years after the completion and testing of the first Thermotank unit and three years after the designing and installation of the first air heating and ventilating units on board ship, that A. W. Stewart and his brothers W. M. and F. C., founded the Thermotank Ventilating Company. During the intervening years the company not only developed new systems, but expanded their application beyond the marine field to the textile industry, railway rolling stock, aircraft, office buildings and the mining industry. To-day, the company, now known as Thermotank, Ltd., has its main works at Helen Street, Glasgow, and other works at West Drayton, Liverpool and Newcastle upon Tyne. In addition, the interests of the company were extended abroad by the formation of a South African company in 1936, an Indian company in 1948, and an American company in 1950. Since the jubilee of the company in 1951, an Australian company has been set up and attention paid to developing trade with European countries. To that end companies have been formed or working arrangements made in Holland, Norway, Sweden and Denmark, Germany and Italy, so that the company now provides an international service for shipowners and shipbuilders. During a recent visit to Glasgow some details of the founding of the Thermotank Incorporated in the United States were given and it was interesting to learn how, from very small beginnings, three members of the Glasgow technical staff succeeded in gaining the contract to equip the General Motors Technical Centre, which was opened by President Eisenhower at Detroit in May last, and the Ford Administration Building. An overall review of the work of the various countries shows that about 75 per cent of the output from the works in the United Kingdom is destined for the marine industry and that in other European countries the major interest is also marine, while elsewhere in the world some 95 per cent of output is installed in offices, laboratories and industrial plant.

As already mentioned, the first air heating and ventilating units were installed on the S.S. "Kostroma" in 1898, while the first air-conditioning installation was fitted on the "Kumano Maru" in 1903. Since those days there has been considerable progress in design and performance,

and, since 1946, a gradual development and increasing demand for the air conditioning of ships. This has expanded from the air conditioning of public rooms in passenger liners to embrace the whole of the accommodation and the crews' quarters. Modern installations now provide for individual control in each cabin and automatic

tioned air through a single line of ducting terminating in louvres or diffusers. Each unit contains a centrifugal air circulating fan, finned tube cooling and heating heat exchanger, air filters, and a moisture eliminator.

The main elements of the "Thermo-Reg" system are similar, but it provides independent temperature control for any number of separate rooms and operates on the twin duct principle, one of which carries heated air and the other cooled air. Temperature and volume of the air supply is controlled by a louvre or by a bulkhead mounted control panel having a knob which operates, by means of flexible cables, two small valves, one in each duct. In the third or "Therm-U-Reg" conditioning system a single line duct system is employed and individual room temperature control is possible. Conditioned air is circulated at an initial temperature adjusted to suit seasonal requirements, and there is an air re-heater of finned tube design, fitted to the



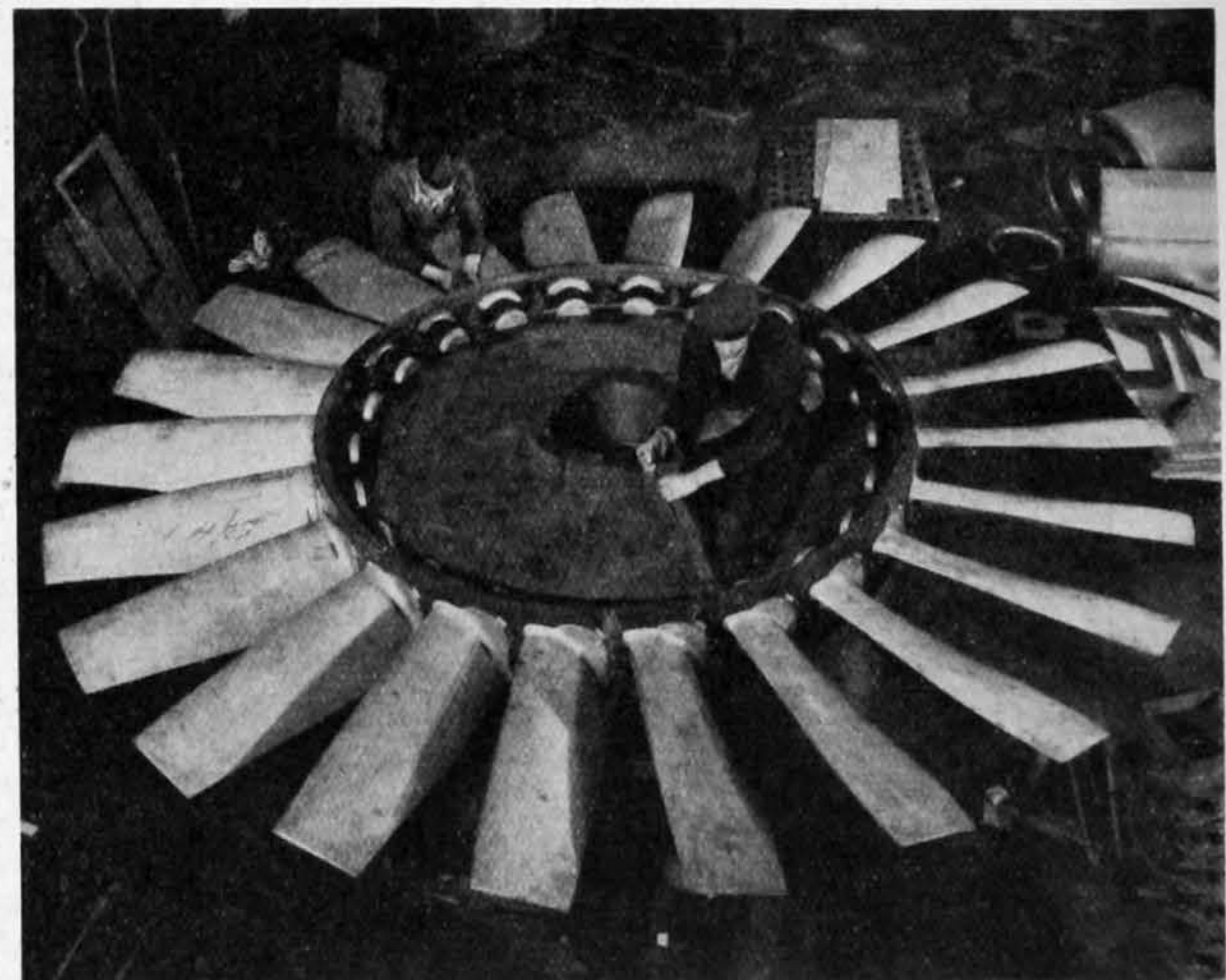
"Lumenated" ceiling in crew's mess room in the "Bergensfjord"

regulation, no matter through what climatic conditions the ship may be passing. Several designs of ventilation units are produced by the company and perhaps the most common form of installation is the standard air-conditioning system with central units. This consists of a number of central air-conditioning units each serving a group of cabins and circulating condi-

tioned air through a single line of ducting terminating in louvres or diffusers. Each unit contains a centrifugal air circulating fan, finned tube cooling and heating heat exchanger, air filters, and a moisture eliminator. To enable air conditioning to be introduced



Type "S" thermo-units being assembled



Assembly of fabricated rotor of 160in diameter for five-stage mine ventilating fan

into selected spaces, "Thermo-Units" are available in sizes having cooling capacities ranging from 8000 to 15,000 B.Th.U. per hour. There are two designs each consisting of a sound and heat-insulated cabinet containing a motor-driven assembly of double-inlet, forward-curved centrifugal cased fans and a finned heat exchanger. The type "D" unit operates on the direct expansion system with Freon 12, while type "W" has chilled water or brine circulating through its coil. The fifth system is by means of self-contained "Thermo-Unit" type "S" air conditioners, which operate on a.c. or d.c. supply and are available in three sizes having cooling capacities of 12,000, 24,000 and 36,000 B.Th.U. per hour respectively. Each cabinet is fitted with a multi-cylinder, vertical, single-acting Freon 12 compressor, a shell and tube pattern condenser, a finned air cooling coil, a double-width double-inlet centrifugal fan, and a metallic wool filter. Our illustration shows a number of these units being assembled.

During a visit to Thermostat, Ltd., we were able to make a tour of the works and to see some of the units, outlined above, being built. It was of interest to note that for the production of the sheet metal parts the company were using an optical projection method similar to the optical laying-off system adopted by a number of continental shipyards for the marking of plates and sections. In this particular instance the drawings are reproduced at one-quarter full size on a standard size of a transparent plastic sheet, which has been colour-washed, by a scribe. The marked sheet is then placed in a projector mounted in the ceiling of the projection booth and the image projected on to a steel sheet. This has a maximum size of 6ft. by 4ft and is held in position on the marking off table by magnets; aluminium alloy sheets are clamped in position. The sheets vary in thickness from 24 gauge to  $\frac{3}{16}$  in and the projector can be adjusted to correct for the thickness of the workpiece.

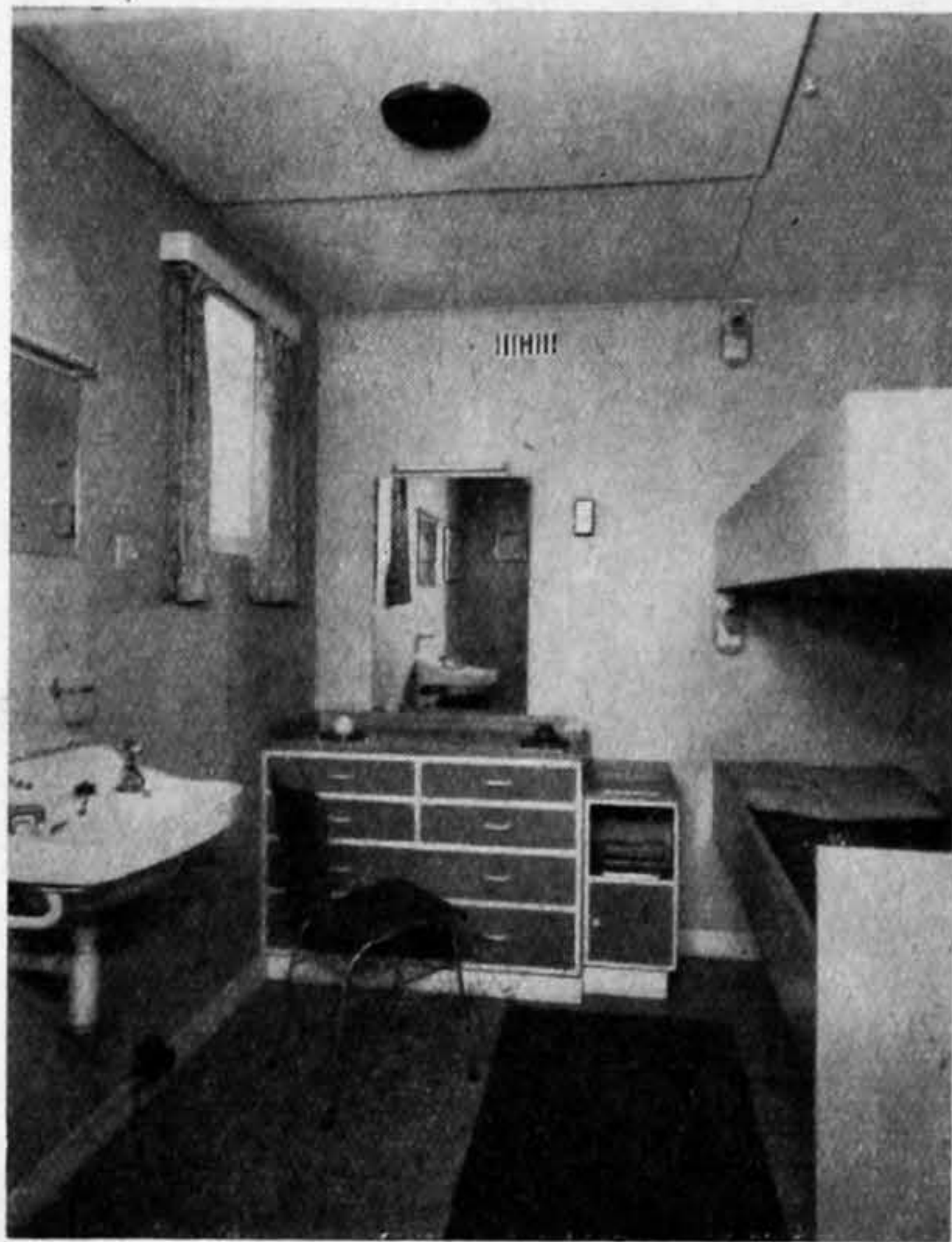
Although many installations have to be made to measure, production lines are organised and it was noted that there was a production line for apprentices where they learned their trade by following a job through from start to finish. As one would expect, there was a full complement of sheet metal working machines and a well-equipped light machine and engineers' shop, and also a tool room where moulds were being made for the machines making plastic parts, such as punkah louvres. It may be noted here that a company, Thermostat Plastic Engineering, Ltd., has been established to produce glass reinforced rods, bars, tubes and sheets for the building, electrical, packaging, aircraft and oil industries, as well as for ship fittings. Another piece of equipment seen in the tool room was a machine designed for corrugating translucent vinyl plastic sheets, which form part of the lighting system evolved by Lumenated Ceilings, Ltd., a member of the Thermostat group. The sheets, supported in a light framework, form a false ceiling and diffuse the light so that there are, it is claimed, no high spots or shadow although the intensity of lighting ranges from 20 to 200 lumens per square foot. Dust settlement is retarded by subjecting the sheets to an anti-static process. The first ship to have this form of ceiling installed on board is the Norske Amerika Line liner "Bergensfjord," and our illustration shows the ceiling in the crew's mess room.

Although the greater part of the company's products forms part of the air-conditioning and ventilation systems for ships, nevertheless a considerable amount of equipment is manufactured for mining, transport, general industrial installations, and for aircraft. These range from small units to large diameter fans for mine ventilation, and our illustration shows the rotor being assembled of a 160in diameter fan, which is one of a pair of three-stage fans, each of which is designed to handle approximately 500,000 cubic feet of air per minute when driven by a 1000 h.p. motor.

An important section of the organisation is the research department, and in the well-equipped laboratories and test rooms intensive research is pursued into all aspects of marine and land ventilation problems, to improve technique and apparatus. There is a 4ft by 3ft wind tunnel in which, in conjunction with the British Shipbuilding Research Association, investigations

are carried out on superstructure design and shape, and on the shape of funnels in order to remove the smoke nuisance. Photographic records of the eddy flow of waste gases are made with the aid of a stroboscope which can throw forty flashes, each of three-millionths of a second duration, per second. Fan performance is checked in a 40ft test tunnel where speed and sound intensity are measured, while an electro-dynamometer records the power absorbed.

To solve problems relating to air conditioning there are research cabins which are available for shipowners and shipbuilders to carry out practical tests in order to establish the specification considered suitable for the service conditions under which a particular ship will operate. Three chambers are employed and in the outer space the temperature and humidity can be adjusted to simulate the conditions likely to be encountered during a voyage. During trials the test party, dressed in tropical kit, spend about thirty minutes becoming acclimatised and then pass



Experimental cabin for air conditioning research

through an airlock to the air-conditioned cabin. While in the cabin the "effective" temperature is slowly lowered until comfortable conditions are achieved and it is from this data that the performance required of the air-conditioning plant is determined. In the cabin, of which we reproduce a photograph, are the usual furnishings and several ventilating fittings to demonstrate a number of alternative ways of obtaining and controlling conditions. Included is the recently developed "Coronet" ceiling air terminal which can be easily adjusted, by moving the lower wheel, to provide a draughtless mixing of the incoming air with that of the cabin or a downward stream of air. Also demonstrated is a section of perforated ceiling and a bulkhead diffuser grill.

A number of examples of ducting were on view and included ducting having an internal insulation lining of foam plastic, which ensures that the insulation cannot be damaged and reduces the liability to sweat. Sample lengths of flexible ducting and of plastic ducting extruded in P.V.C. material were on view. Two forms of automatic damper control were also demonstrated, the potentiometric model consisting of a room pattern thermostat, control panel and damper motor and the electronic model consisting of two room thermostats, one electronic panel containing two independent stages of control and two damper motors. The potentiometric control has been adopted for part of the air-conditioning scheme on the Canadian Pacific liner "Empress of England," while the electronic control is to be fitted on the Cunard liner "Sylvania." The company is intending to extend its activities further, possibly by forming a subsidiary to deal with acoustics, and to specialise in suppressing noise in ventilating systems.

## Industrial Research Laboratory

A NEW company known as British Oxygen Research and Development, Ltd., has been formed by the British Oxygen Group of Companies to establish research and development work as a separate activity equal in status and importance to the operating companies in the group. The new company has taken over the group's research centre at Morden, which was first opened some ten years ago and has since its inception steadily increased its facilities and widened its scope of pure and applied research. Its activities range from medicine to metallurgy and from organic chemistry to mechanical engineering, and the staff of about a hundred scientists and technologists includes specialists in physical and organic chemistry, chemical engineering, metallurgy and mechanical engineering.

The work of the organisation at the Morden centre is arranged under five principal sections concerned with basic research, chemical products, gas applications, gas separation and engineering, and the groups in each section work independently or in conjunction according to the particular requirements of the work in hand. Work on industrial gases naturally occupies an important place in the activities of the company, and both theoretical and practical investigations are in progress on new methods of production of atmospheric gases. Studies are also constantly in progress to improve the methods of storage, transport and handling industrial gases. The practice of distributing oxygen in liquid form is being used more widely and investigations have been, and are still being, carried out to find means of reducing the losses which occur during transport and transfer between vessels. Other investigations are in hand to improve evaporators in which gaseous oxygen is generated from liquid at the works of large users and also of means of handling liquid nitrogen and liquid argon more efficiently and economically.

A laboratory has been laid down for the study of acetylene production and handling, and in this building there are six specially designed test chambers. Experiments can be carried out in these chambers with a plant remotely controlled by an operator situated outside and observing conditions through an armour plate glass window. A sliding section of the roof of each chamber can be opened when an experiment or test reaches a critical stage to relieve the effects of an explosion should it occur. These safety precautions are particularly necessary as acetylene is an explosive gas at a pressure above about 9 lb per square inch. Work in this department also includes laboratory and semi-technical scale investigations into the possibility of making acetylene from hydro-carbons, or of making carbide more cheaply.

Other investigations currently in hand include the development of new processes using inert gas shielding for welding processes, devising new metallurgical processes based upon the use of oxygen, ways of making use of the low temperature and relative safety of liquid nitrogen, and gas cutting processes.

## Prefabricated Storage Building of 100ft Span

THE "Arcon" series of prefabricated buildings, marketed by Taylor Woodrow (Building Exports), Ltd., has been increased by a design of larger span. The so-called "Widespan" building has a clear span of 100ft and is made with heights of 14ft 6in, 20ft 6in or 27ft. The building follows the same general design as others in the Arcon series. The roof comprises a number of Warren-braced arch ribs of welded tubular steel, tied at springing level. The arch is built from four straight chords and these quarter-ribs form the prefabricated units and are joined together on the site. The weight of steel in the roof structure is stated to be under 2 lb per square foot of covered area, which is claimed as a marked improvement over "traditional" design.

The "Arcon" buildings now also include a building, designed according to modular theory, with a flat roof with "monitor" roof lighting.

## Demonstration of Military Vehicles

THE Society of Motor Manufacturers and Traders and the Ministry of Supply recently held a demonstration of military vehicles at the Fighting Vehicles Research and Development Establishment, Chertsey, Surrey. A stretch of road barred with stone setts 2½ in high was used to demonstrate the virtues of independent suspension: a Rootes 1-ton combat vehicle led a 4×2 Bedford 1-ton truck on to the course, and accelerated away from it when the wartime vehicle became uncontrollable—at every speed the behaviour of the independently sprung vehicle

injection, has been uprated to 510 b.h.p. at 2800 r.p.m. A hydraulic coupling is carried on the engine and drives through an open propeller shaft to the gearbox, which, being mounted on the frame, is remotely controlled by levers with very short travels. The auxiliary box has three ratios and the main five forward and reverse. To reduce the demand for skill in operating the latter a friction clutch is included in the nose of the gearbox, which is automatically opened when the selectors are moving into and out of gear; synchromesh is incorporated. No clutch



30-ton heavy artillery tractor. The articulated subframe, giving 2ft of wheel travel, can be seen and, dangling below the axle, one of the air pressure and temperature instrumentation leads. The outrigger bearing for the walking beam appears between the rear wheels

reflected the classical excellence of the design. The rigid axle vehicles, present in great preponderance, were defended by a three-axle Thornycroft, which tackled a length of 1½ in setts with a two-beam-axle trailer bouncing behind it. A rigid frame 500 c.c. solo adhered strictly to a straight course at right angles to the setts.

Another demonstration took place on a series of test gradients. Only the TRW Triumph, a 4×4 "Big Bedford," and the armoured vehicles climbed more steeply than 1 in 4. Gear changes on the slope were confined to preselective transmissions. Entertainment, at least for the spectators, was provided at a wading pit with 7½ ft of water. Methods of communication used by second crew members conning vehicles included pieces of string and intercommunication sets. An Alvis "Saracen" armoured personnel carrier floated with a remarkably high freeboard, but climbed out misfiring. A "Centurion" tank was rendered buoyant by a surrounding waterproof fence that was retracted mechanically when no longer needed; in the water it was propelled by twin screws driven off the track sprockets and situated close together behind the hull. Besides the differential speed control available through the transmission, yaw could also be generated by pivoting both screws in unison. The propellers could be folded upwards out of the way, being joined to the transmissions simply by dog clutches. In all these demonstrations, civilian as well as Service drivers took part.

Apart from the combat vehicles, the majority of the vehicles on display were readily recognisable relatives of civilian products. Exceptions were a forward control four-wheel-drive Thames, and the most powerful vehicle present, the Leyland 30-ton tractor, illustrated above; grossing 42 tons, it has an "average maximum" speed of 35 m.p.h. It is powered by an eight-cylinder o.h.c. Rover "Meteorite," which, by the use of fuel

pedal is necessary; both brake and throttle pedals appear to be more convenient for operation by the right foot. From the gearbox further open shafts lead to the front and rear differentials. A conventional front suspension is mounted on a sub-frame pivoted about the longitudinal axis; this carries also the hydraulic power steering ram. The other differential is

mounted rigidly in the chassis and drives two further reduction trains; these end opposite the outriggers that carry the walking beam gearcases. An interesting detail here is that the air brake actuating mechanisms are contained within the extended ends of these cast beams.

Similar but smaller walking beams, but sprung, appear on the several 10-ton Leyland 6×6's. The most interesting of these is the recovery vehicle illustrated below, on which all services are hydraulic; the exception is pneumatic braking, presumably to accommodate existing trailers. The winch has a line tension of 20 tons, and needs no overload protection beyond the relief valves in the hydraulic system. A large sprag anchor, raised and lowered by power, allows pulls of 40 tons directly against the tractor. The large rotatable pulley over which the cable is led by a sprung roller facilitates running the cable out at any angle, including forward through guides on the front bumper. The crane slews through 240 deg. and luffs up to 45 deg.; the jib is extensible from 10ft to 18ft. At maximum radius the lift is 1½ tons and the maximum lift is 15 tons with the jib stayed. For heavy lifting the vehicle can be supported by four screw-jack-adjusted legs, seen stowed, but with their square feet visible behind the wheels and under the front of the platform.

These 10-ton Leylands called for more power than the standard "B" series of engines could provide, and are equipped with the "B.81," an unsupercharged version of 6500 c.c. instead of 5675 c.c. and giving 215 h.p. instead of 160 h.p. at 3750 r.p.m. A "sprint" edition of this large-bore straight-eight provides 240 h.p. at 4000 r.p.m. for the fire crash tender on the six-wheel drive Alvis chassis, an "average maximum" speed of 50 m.p.h. being claimed at 14 tons gross. Main propulsion engines, other than the "B" series, which were on show, are listed in the table on page 519.

The engineering exhibition included engines of this series with a cartridge starter and a "Swing-fire" unit, consisting of a petrol combustion heater warming the engine coolant and the water in a battery heater. Other engines shown were a fuel injection version of the 9-litre four-camshaft Jaguar V-8 and a mock-up of a 24-litre o.h.c. V-8 for tracked vehicles, to be developed both in spark and compression ignition forms. Displayed also were hubs including compound epicyclic reductions, and the "Chobham" constant velocity universal joint, in which pivoted sliding pads replace the conventional steel balls; it runs satisfactorily in hypoid gear oil. Many examples of power control mechanisms were to be seen; included was a brake power valve for the Alvis six-wheel chassis, in which a kite-shaped balance beam was used to



Heavy recovery tractor, showing the hydraulic motor, driving the crane hoist drum and the crane operator's cab

Main Propulsion Engines for Military Vehicles.

| Maker       | Swept volume, litres | Torque, lb-ft at r.p.m. | Power, b.h.p. at r.p.m. | Description                   |
|-------------|----------------------|-------------------------|-------------------------|-------------------------------|
| A.E.C.      | 11.3                 | 510 at 1100             | 150 at 1800             | 6-cylinder diesel             |
| Albion      | 10.454               | 475 at 1100             | 160 at 2000             | 6-cylinder petrol             |
| Austin      | 3.995                | 180 at 1400             | 92 at 3200              | 6-cylinder petrol             |
| Bedford     | 4.927                | 220 at 1200             | 114.6 at 3200           | 6-cylinder petrol             |
| Bedford     | 3.519                | 164 at 1000             | 75.9 at 3200            | 6-cylinder petrol             |
| Commer      | 4.752                | 220 at 1200             | 95 at 3000              | 6-cylinder petrol             |
| Ford        | 3.920                | 165 at 2000             | 92 at 3500              | V-8 petrol                    |
| Leyland     | 9.8                  | 410 at 900              | 133 at 1800             | 6-cylinder diesel             |
| Leyland     | 11.1                 | 450 at 1200             | 150 at 2000             | 6-cylinder diesel             |
| Meadows     | 10.35                | 475 at 1400             | 181 at 2400             | 6-cylinder petrol             |
| Morris      | 4.196                | 174 at 1000             | 72 at 2750              | 6-cylinder petrol             |
| Rover       | 1.997                | 93 at 1500              | 52 at 4000              | 4-cylinder petrol             |
| Rover       | 18                   | 800 at 1200             | 285 at 2000             | V-8 petrol                    |
| Rover       | 18                   | 860 at 1460             | 510 at 2800             | V-8 petrol injection          |
| Rolls-Royce | 12.17                | 490 at 1275             | 185 at 2100             | 6-cylinder diesel             |
| Thornycroft | 11.32                | 520 at 1000             | 180 at 2200             | 6-cylinder petrol             |
| Triumph     | 0.499                | 19.2 at 3100            | 17.8 at 5000            | 2-cylinder petrol, air-cooled |

obtain proportioned pressures in the independent hydraulic systems for the front and the centre and rear wheels.

On a chassis dynamometer a Leyland "Super Beaver" was demonstrating the ability of the 0.680 direct injection engine to run on 70 octane gasolene. Apart from setting forward the pump rack to compensate for the reduced specific gravity of the fuel, no modification had been made other than a spill pipe from the pump

casing to ensure that it was continually full of cool petrol. No difference from normal could be detected in the running of the engine, other than the harshness of the knock when the pneumatic governor increased the fuel sharply at low revolutions per minute. It was stated that, in the experience of the Establishment, diesel engines could be made to accept petrol without much difficulty, and in some cases the smoke-limited output was increased.

## Precision Internal Grinding Spindle

PARTICULARS have been received from Reilly Engineering, Ltd., Walnut Tree Close, Guildford, Surrey, of the Offen-Reilly "Servomatic" high-speed internal grinding spindle now going into production, which will eventually be available in seven sizes for wheels from  $\frac{5}{32}$ in to 2in diameter. This design of spindle is fitted with "hydrostatic" bearings and is driven hydraulically to provide a steplessly variable range of speeds from 120,000 to 150,000 r.p.m. in the smallest size, and 10,000 to 15,000 in the largest wheel size.

The makers point out that the so-called "hydrostatic" bearing used for the spindle is based on well-known principles of hydraulics. The construction of this combined journal and thrust bearing can be seen in one of the illustrations on this page. The bearing at each end of the spindle has a conical inner face on which there are six "teardrop" shaped pockets A formed by ridges. In each of these pockets there is a small bore in which a calibrated nozzle is fitted and through these jets access is given to a groove B in the cylindrical outer surface of the bearing. In one of the pockets there is a second or auxiliary hole leading to a second groove C adjacent to the groove B. When the spindle is running fluid is supplied to the jets in the holes at a supply

pressure which may be from 1500 lb to 3000 lb per square inch. The auxiliary hole, through the second groove is connected to a pressure gauge which shows either the absolute or the relative pressure of fluid in the pocket as well as variations of pressure. The ridges or "lips" of the pockets are narrow—of the order of 0.010in to 0.015in—and they are ground and lapped truly conical and mated with the conical ends D of the spindle at either end.

The assembly consists of a shaft, or spindle,



Internal grinding machine fitted with hydraulically driven grinding spindle and electronic tachometer

with conical ends, each of which is supported by the bearing described above. When assembled, there is axial play of up to 0.001in, depending, of course, on the size of the spindle and bearing, and this axial play on a 90 deg. cone would give a radial clearance of roughly 0.0007in. When the bearings are pressurised the spindle takes up a position between the cone faces, so there is roughly 0.0005in play or gap at each end between each bearing cone and spindle cone surface.

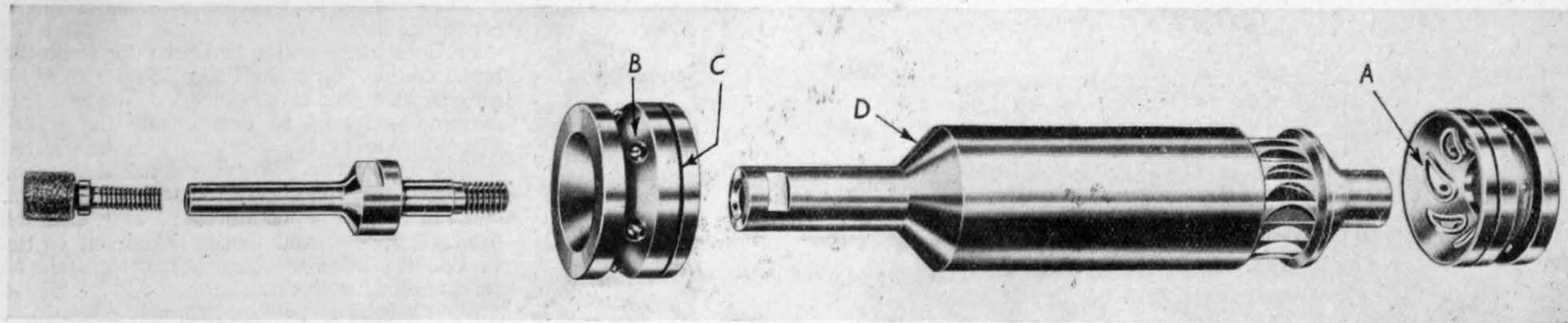
Each pocket can then be regarded as a pressure vessel, the pressure port being the calibrated nozzle, while the 0.001in (or smaller) gap between the cone of the spindle and the lips of the pockets functions as discharge port. When the spindle is rotating in perfect balance, all pocket areas being equal, and all gaps between lips and cones having the same value, the pressure in all pockets will be identical. When this state of balance is disturbed, say, by pressure at the end of the spindle (i.e. by a cut being taken by the grinding wheel), the spindle is slightly displaced and tends to widen the gap between the pocket and the spindle on that side and to close the gap on the opposite side. The fluid pressure then becomes unequal in opposing pockets, exerting a restoring force on the spindle. It has been found, under grinding conditions, that a fully effective restoring force is achieved for a deflection from the ideal centre of rotation of only 25 micro inches (0.000025in), even when taking heavy cuts, or face grinding with the spindle. The axial rigidity of the spindle is such that it is stated to be easier to break the quill than to damage the bearing.

To ensure vibrationless running the spindle has a completely hydraulic drive, comprising fluid jets impinging on a turbine wheel integral with the spindle itself. To reduce any unbalance, or side thrust due to torque reaction, twin jets diametrically opposed have been arranged to drive the turbine.

One of the major problems during development of the spindle was the collection of spent fluid, both from the bearings and the turbine, mainly because it was thought essential to offer a spindle of small diameter, to be interchangeable with most conventional spindles. This problem was eventually solved by utilising some small portion of the excess energy of the fluid. The teardrop shape of the pockets imparts the desired direction and velocity to the fluid discharged.

To provide accurate indication of spindle speed the firm has also developed a compact electronic tachometer which can be seen in use with the spindle on the machine in our first illustration. The pick-up of this tachometer can be fixed to the grinding spindle itself, without interference when grinding, as it is only about  $\frac{3}{8}$ in wide. The indicating unit is a box of small dimensions, together with its photo-electric pick-up. It is calibrated from 10,000 to 200,000 or 1000 to 20,000 r.p.m., each division representing 2000 or 200 r.p.m., according to which scale is selected. A very simple means of speed control is incorporated in each spindle assembly. In some instances there can be calibrated on the spindle itself a scale which is accurate to within  $\pm 5$  per cent once the spindle is warm. In other cases, the use of the electronic tachometer obviates the necessity for calibration.

There is a bearing pocket pressure gauge on the side of the spindle, the needle of which flickers to give immediate indication when the wheel contacts the work and comes to rest when sparking out is completed.



Component arrangement of hydraulically driven precision-grinding spindle with "hydrostatic" bearings

## Cold Hydraulic Ship Frame Bender

THE form to be built into a ship calls for individual treatment of the frames to which the shell plating is riveted or welded. To bend these frames, generally consisting of ordinary angles, bulb angles, channels or tee bars, to shape, they are heated in a furnace and then bent and bevelled to a template on a bending slab and set by the frame squad, using mainly manual methods. The use of a furnace is expensive and both it and the bending slabs occupy a large amount of space, while there is a considerable period of standing-by time on the part of the frame setters, while the frame is heated to the correct temperature.

Current procedure, it is stated, results in relatively low output and high cost and to improve the economics of this particular shipyard operation the Scottish Machine Tool Corporation, Ltd., Glasgow, has developed a ship frame bending machine which will work ship frames cold. This means that the furnace is no longer necessary and, since the frames, with certain exceptions, are bent in pairs, the output is high, while the number of operators is reduced. The "Bennie" frame bender has an overall length, including the hydraulic gear, of 23ft, a height of 5ft 4in, an overall width of 8ft 9½in, a total weight of 25 tons, and is powered with one main pump motor of 25 h.p. and four 1 h.p. auxiliary motors. The total effort at the ram is approximately 300 tons and its length of travel is 18in. Sections having a moment of inertia up to 1040in<sup>4</sup> can be manipulated in the machine and this translated into sizes of sections is as follows :

|                 |  |
|-----------------|--|
| Channels ...    | One pair from 6in by 3in to 17in by 4in by 44 lb |
| Bulb angles ... | One pair from 6in by 3in to 15in by 4in          |
| Angles ...      | One pair from 6in by 3in to 10in by 6in          |
| Bulb flats ...  | One pair up to 12in                              |
| Flat bars ...   | One pair up to 17in by ¾in                       |
| Tee bars ...    | One bar from 5in by 3in to 9in by 9in            |

It will be noted from the above that only one tee bar can be worked at a time. A standard range of tools is provided with the machine and these include front face and top and bottom packing tools for bending and bevelling, up to 10 deg., the range of channels and similar equipment for dealing with bulb angles. Two pairs of special flat-faced claws are provided for working 12in bulb flats, and two thin-faced tongue pieces for the lighter sections, together with the necessary packing pieces.

Massive cast steel levers grip the sections and hold them rigidly together during bending, as do two pairs of claws which, however, bear lightly in the frames to avoid causing damage.

There is a tongue piece between the claws and the entire claw can rotate about a vertical pin and so accommodate itself to different curvatures. A roller, with a vertical screw adjustment, on the back of each claw supports the frame at the correct height. In addition to the claws there is a central tool, mounted on a screw in the end block and located immediately in front of the gripping levers, which can be advanced or withdrawn as required.

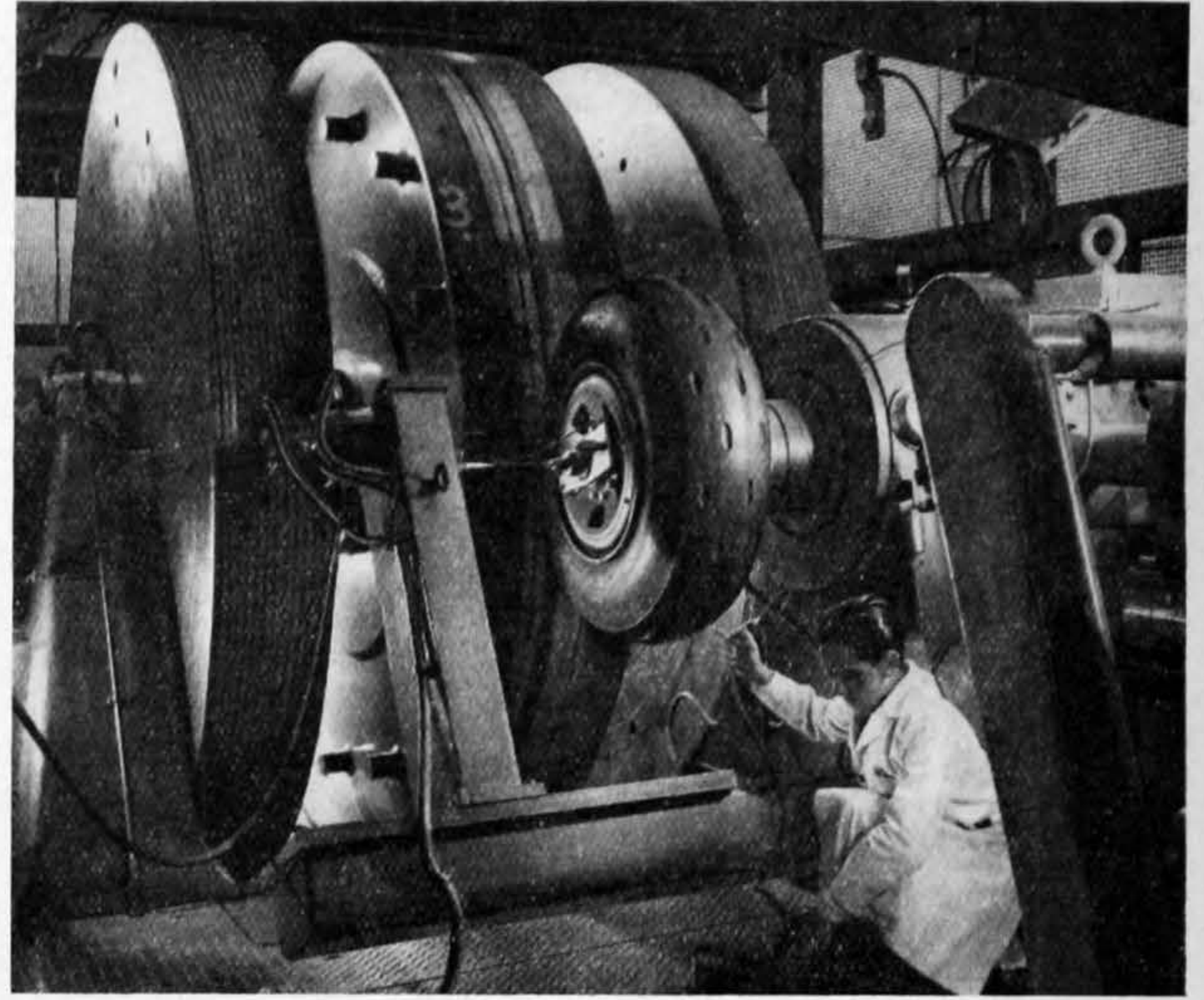
Movements are made by an electric motor fitted with a limit switch and the screw, which is of high tensile steel and square threaded, has a large square face in which various tools can be mounted. The main cylinder and the semi-steel end block are both keyed and bolted to the bedplate. The hydraulic load which is taken by the bed and two tie bars can be sustained for as long as is necessary for the frames to acquire permanent set and pressure relief valves guard against overloads.

The illustration below shows two machines in the frame shop of Alexander Stephen and Sons, Ltd., in which a pair of channels, clamped back to back, are being bent and bevelled simultaneously. When the hydraulic pressure is applied the gripping levers secure the frames and

carry them against the tongue pieces between the claws, causing them to close and hold the sections in place. The gripping levers continue to travel forward and engage on the outer flanges, thrusting them over to the required angle of open or shut bevel. At this point the nose between the gripping levers contacts the inner flanges and prevents further movement of the levers relative to the frames. With the central tools locked pressure continues to be applied until the sections are bent to the correct radius, and is then released. In this manner the frames are passed through the machine and any local adjustment required is made on the floor.

## Aircraft Brake Testing

AT Coventry, the aviation division of the Dunlop Rubber Company is now using a large dynamometer to test the performance of brakes assembled into their wheels and tyres. The case of an aircraft landing is simulated by running the flywheel up to a rim speed rather greater than the touch-down speed, applying the wheel to



The temperature of a tyre being taken after its brake has stopped the flywheel of the testing machine

the rim with the appropriate force, and retarding the flywheel from the correct rim speed by means of the aircraft brake. The required energy throughput is simulated by varying the mass of the flywheel: thirty plates, each weighing 1.18 tons, can be clamped to the wheel to give a maximum mass of 45 tons. The accelerating drive is a 400 h.p. d.c. motor, and a peak speed of 200 m.p.h. can be given to the rim of the 10ft diameter flywheel. This corresponds to an energy of  $66 \times 10^6$  ft-lb, or an aircraft weight of 22 tons.

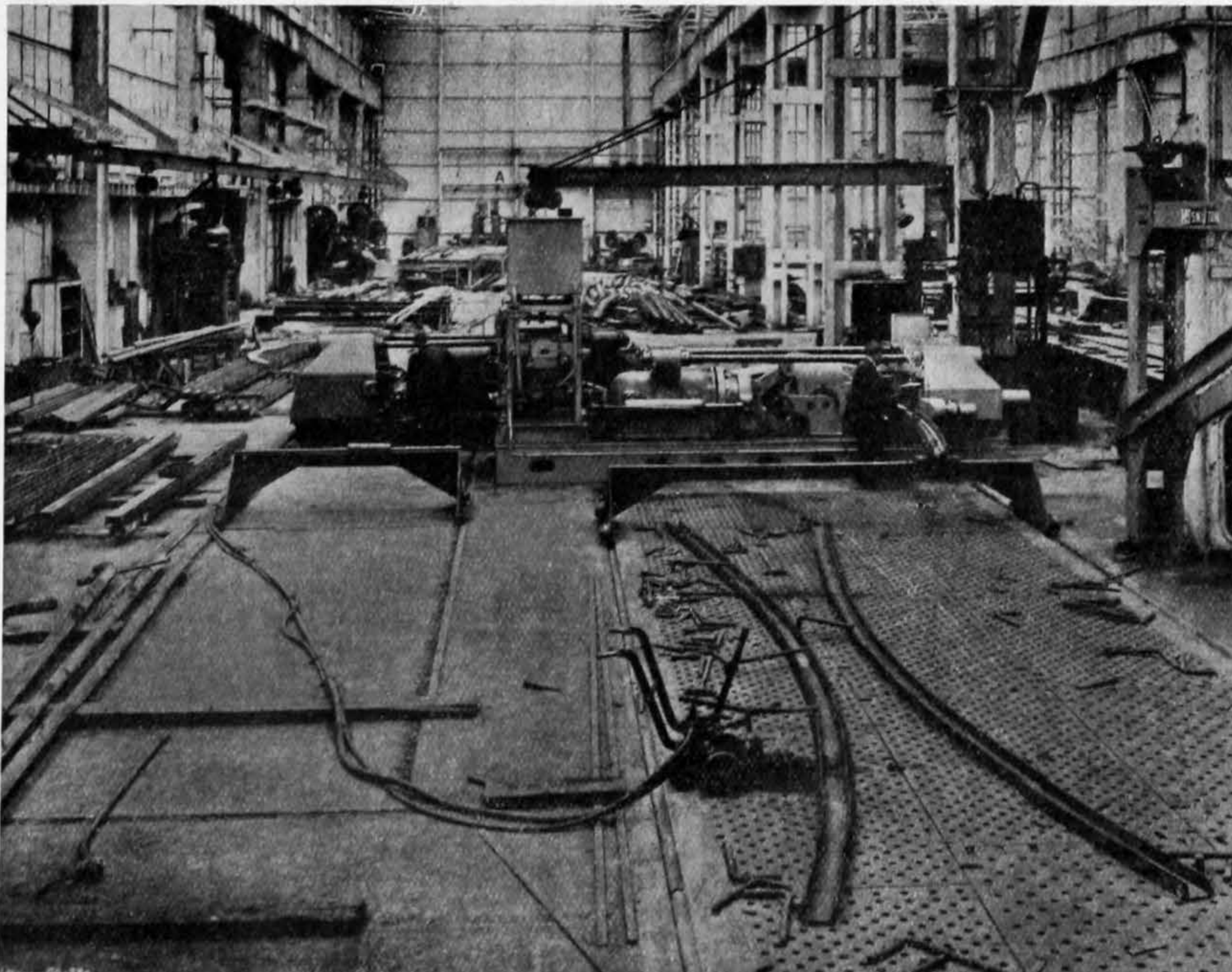
On each side of the flywheel is a moving carriage to carry the wheel on test; it is driven by a large pneumatic ram. The larger carriage can accept wheels up to 67½in diameter and exert loads up to 70,000 lb; the other works up to 25,000 lb.

The machine is fully instrumented; continuous indication of brake pressure and torque, wheel speed and load, and flywheel speed are presented, and oscillograph records of torque, pressure and wheel revolutions on a time base are preserved. In addition, riders sliding on scales show the tyre deflection under load.

We were shown two demonstrations of the machine in action. First, a "Britannia" wheel assembly, with a total volume of 6½ cubic feet, decelerated the flywheel from 127 m.p.h. with a dissipation of 1320 h.p.; the load was 13,500 lb and the drag 3880 lb. Then a high-performance unit for a supersonic aircraft was used; this, although occupying only 2½ cubic feet, absorbed 1640 h.p. The load was 13,500 lb and the drag 3930 lb; the brakes were applied at 157 m.p.h. The need for a narrow tyre in such applications is illustrated by an inflation pressure of 275 lb per square inch.

Previous brake testing had been done with the brake coupled by a shaft to a smaller flywheel running at higher revolutions per minute. This machine was used to demonstrate the ability of a "Viscount" brake to deal with the rejected take-off emergency. Within seconds the copper discs rose through cherry red to bright orange, and ran at that temperature, sparking, until the flywheel stopped and flames licked out of the brake; it is not a requirement that the brake be serviceable after this test.

Such machines as these, though expensive—the large machine weighs 160 tons and rests on 180 tons of concrete—are not only indispensable for a realistic study of brake behaviour, but also



A pair of frame-bending machines in a shipyard frame shop

highly economic for development testing. For instance, C.A.A. requirements specify that a brake must survive 100 normal landings without any replacements; such a test would consume time and money extravagantly if performed with a real aircraft. The large dynamometer is arranged to carry out repetitive tests automatically for such cases as this.

### Heat Transfer Panels

A METHOD of combining a tube and a sheet so as to provide a large surface area for heat transfer, now being used by the Metals Division of Imperial Chemical Industries, Ltd., is to form the tube as an integral part of an aluminium panel while rolling to the finished gauge. Because the process obviates localised welding or brazing, heat transfer conditions are consistently good and the appearance of the sheet is pleasing.

The process starts from a photographed drawing of the required tube arrangement. Any arrangement which can be drawn on paper can be produced in the final aluminium sheet; multiple paths and tube junctions are no more difficult to produce than straight tubes. A sheet commences as two separate sheets of "Kynal" P.10 aluminium, each thicker than the final sheet. The pattern of tubeways, compressed in one direction to allow for subsequent elongation, is silk-screened on to one sheet, using a special "stop-weld" ink. A second sheet is then placed against the printed one so that the printed surface is sandwiched between the two sheets, which are then cold rolled together. Owing to the very high contact pressure produced during this operation, the two sheets weld except where the "stop-weld" is present.

To ensure full strength in the weld the sheets are then annealed, during which process recrystallisation of the metal structure occurs. Micro-sections show that the finished product is virtually one homogeneous sheet, the crystal structure extending across the junction between the two original sheets. The "stop-weld" ink, which must withstand high rolling pressures, vaporises at the annealing temperature and escapes from the unwelded portions between the sheets where the passageway reaches the sheet edge. The pattern is designed to provide this outlet for the vapour, and when the sheets are removed from the furnace each passageway is clean and ready for forming to its final dimensions.

The passageways are formed by inflation at very high pressures, the sheet being placed between the flat platens of a hydraulic press during the operation. By this means, tubes of accurate and uniform height are produced (as illustrated below) and the walls are work hardened. Because the platens are quite flat, and the same platens are used in each instance, no costly die sinking operation is necessary.

Provided that a reasonable bend radius is used, the sheets can subsequently be bent across the passageways without filling the tubes. Simple bending techniques can be employed, recesses

being made in the bending tool to clear the passageways.

An important application of these heat transfer sheets, for which several thousands a month are already being produced, is in domestic refrigerator evaporators. The ease with which complex tube arrangements can be provided enables designers to grade the temperature of the refrigerated shelves and compartments to present the optimum conditions for storage of various foods. The absence of any residues in the tubing is important, as very small quantities can cause contamination of the refrigerants and damage the compressor. For refrigerator units needing connection to a copper or steel tubed system, a flash-butt welded copper/aluminium attachment tube can be supplied ready for welding to the "Kynal" heat transfer sheet.

The maximum dimensions at present being supplied are: length, 100in; width, 15in; with normal thickness 0.06in.

Other applications may require heavier gauge materials and larger passageways, but the flexibility of the process offers the designer greater freedom than conventional methods of plate heat exchanger construction.

### Body-Building Sections

A SERIES of extruded light-alloy sections for building commercial vehicle bodies has been produced by Northern Aluminium Company, Ltd. These sections enable a platform or drop-side body to be assembled with a minimum of costly labour. The extrusions number six: floor planks, flat or ribbed; crossbearers, intermediate or front and rear; and side raves, platform or dropside. There are also floor-holding clips and a drop side framing member to complete the body.

In the accompanying illustration the method of assembly can be discerned. The floor planks interlock, and the extreme side planks are the same as the others. The intermediate cross-members are of "J" rather than channel section, so that two floor-holding clips can be used at each joint for greater stability. It can be seen that no drilling is needed when planking the platform, an advantage if ever a plank has to be replaced. The clips are held together with standard nuts and bolts, the hexagon bolt head locking in the floor clip. The front and back cross-members incorporate a floor capping strip angle and shroud plate. The side raves cover the exposed edge of the planking and give a neat appearance; sockets for side supports can be seen. These and the framing member have shallow grooves along lines where it may be necessary to drill holes.

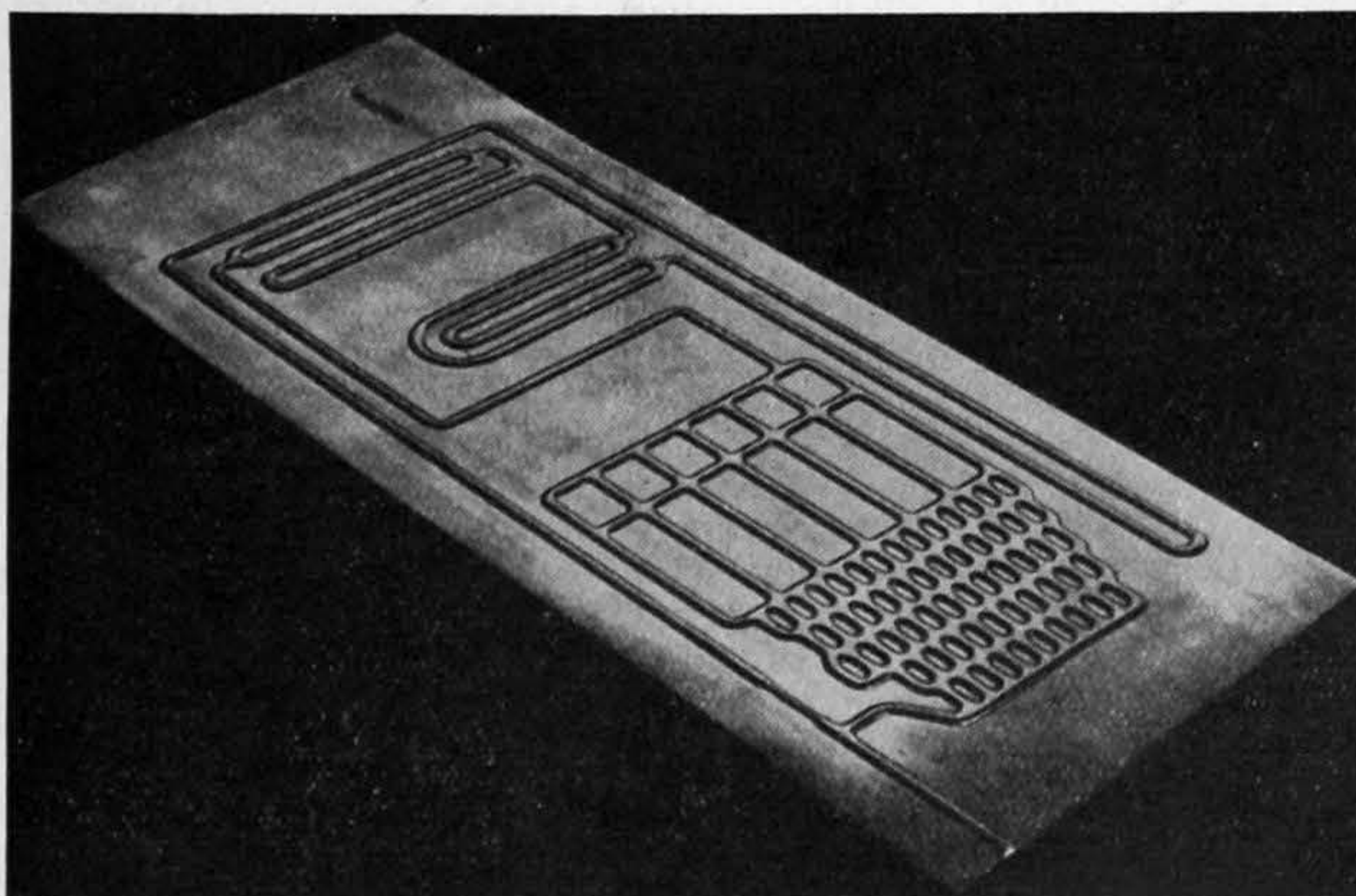
The extrusions, which are obtainable from E. J. Holmes, Ltd., 113-115, North Street, Romford, Essex, can be supplied cut to the appropriate length for the proposed body.

### Pitch Fibre Pipes for Sewerage

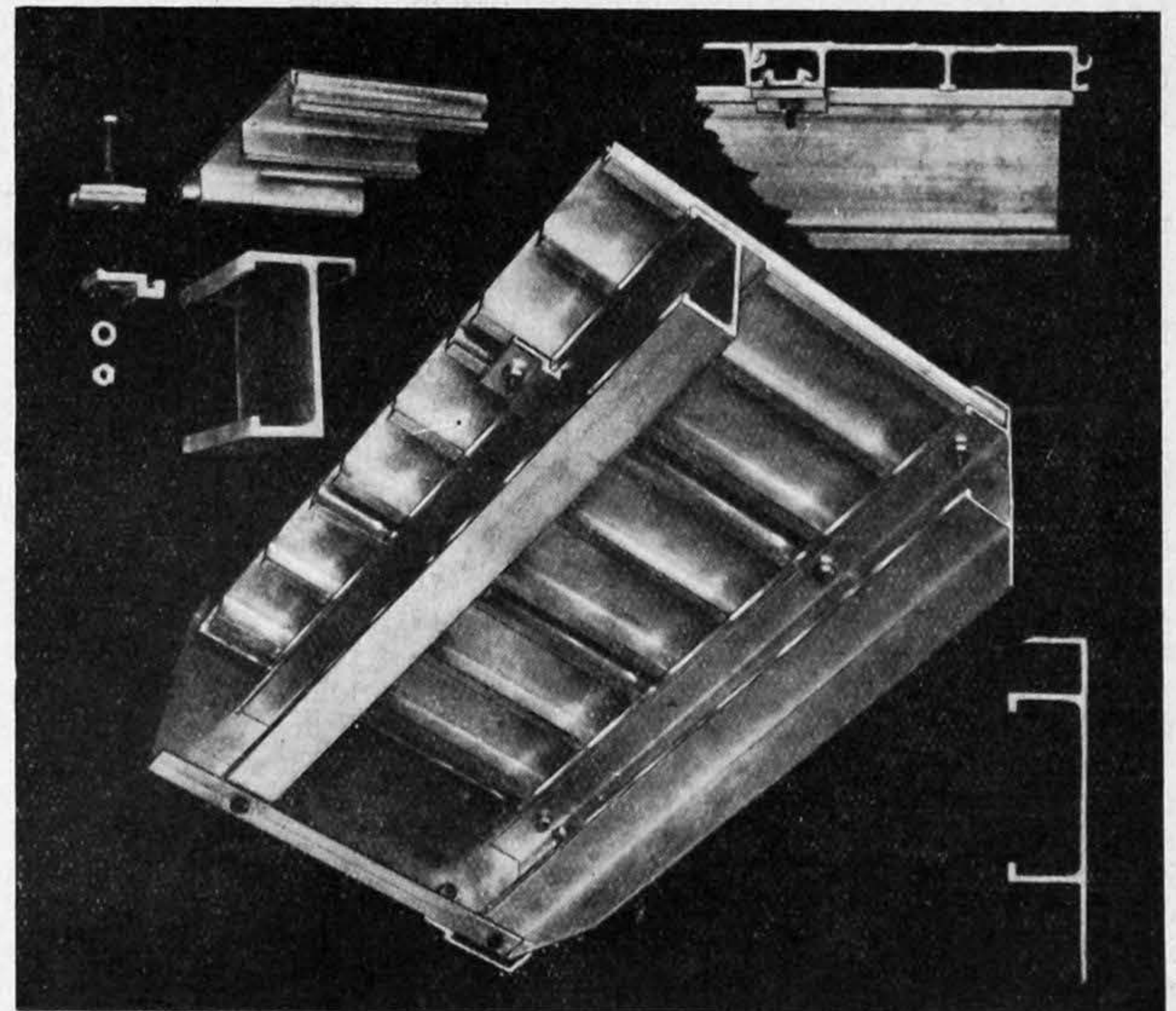
PITCH fibre pipes and cable conduits are now being made by Union Fibre Pipes (Great Britain), Ltd., Tolpits, Watford, Hertfordshire, a subsidiary company of the Universal Asbestos Manufacturing Company. These pipes are made from a sort of *papier mâché*, heavily impregnated with pitch. In their manufacture, old newspapers are churned in water and the resulting sludge is fed at a controlled rate to a forming machine. The sludge is kept in the right condition by passing it over baffle weirs and bubbling air through it. A vacuum roll turns with its lower part immersed in the sludge bath, and by virtue of the effect of the reduced pressure maintained inside the roll, it continuously picks up a thin film of solid material. A second, mating, roll rotates higher up, clear of the bath, with a slightly higher vacuum maintained across its surface, so that the film of material transfers to it. A "former" for the pipe—a light alloy tube which is small in diameter compared with the vacuum rolls—is held in position by guide rolls, at the top of this second vacuum roll. The material passes naturally from a rough to a smooth surface, so the film gradually builds up on the former as the machine rotates. Manufacture is in 8ft lengths, with diameters of 2in to 6in.

Batches of formers, with the wet material newly-placed on them, are then put into the drying ovens, which they pass through (the ovens operate on a continuous flow principle) in about eighteen hours, temperatures not far below boiling point being maintained. Then the fibre pipes are stripped from the formers and placed in a vacuum chamber; hot pitch is introduced *in vacuo*, a treatment which impregnates the pipes to the extent that 75 per cent of the final weight is pitch. The last operation is to machine the ends of the pipes to a 2 deg. taper. The pipes comply with B.S.S. 2760, 1956.

Joining the pipes is simple: a machined collar (also with 2 deg. tapers) is fitted between them and they are knocked together with a hammer. Special collars allow junction with stoneware pipes: pipes can be cut, and the ends machined, on site. The pitch fibre pipes have a significant structural strength and a jointed run of pipe has a degree of flexibility and strength which is unknown with stoneware; a length of three or four jointed pipes, each 8ft long, can be lifted without breaking the joints. Thus, concrete haunching can be omitted, and it is recommended that the pipes should be laid on a 1in bed of sand. We are informed that the cost of laying and jointing these pipes is very slightly in excess of the cost for laying and jointing comparable best quality stoneware pipes, but the omission of the concrete haunching allows a considerable economy to be made.



Heat transfer sheet with closed passages between two aluminium plates welded by rolling together



A length of lorry body made up from extruded sections. Top left shows a length of the "J" section cross bearer, with a floor plank and a floor-holding clip; top right shows the plank profile and its method of attachment, and bottom right the combined end cross bearer, floor capping angle and shroud plate

# Industrial and Labour Notes

## Report on the Gas Industry

The seventh annual report of the Gas Council, which has just been published, shows that the gas industry had a net surplus of £531,628 in the year ended March 31st last as compared with nearly £2,500,000 in the previous year. Of the twelve area boards, eight showed a surplus for the year and four a deficit. The gross revenue of the industry was just under £346,072,000, of which £195,500,000 came from the sales of gas, £105,700,000 from the disposal of by-products, and £28,500,000 from sales and hire purchase of appliances.

It is stated in the report that during the year under review the industry required the equivalent of some 2,000,000 tons of coal less than it would have needed at the production efficiency of 1948. The coal gas made per ton of coal carbonised increased from 74.8 therms in 1954-55 to 75.2 therms in 1955-56, and the respective overall production efficiency increased from 75.7 per cent to 76.8 per cent.

The industry made more gas by carbonisation and less in carburetted water gas plant in order to improve coke supplies during the year, and the quantity of gas bought from coke ovens substantially increased. At gasworks some 2084.9 million therms of coal gas, 367.3 million therms of water gas and 30.8 million therms of other gas was made. Some 409.9 million therms of gas was purchased from coke ovens and 8.3 million therms from oil refineries. The 27,841,000 tons of coal used in gas manufacture during the year cost nearly £138,406,000, including its transport and handling, and the increase in coal prices in July, 1955, added an average of 12s. 6d. a ton to the costs of the gas industry.

The schemes for closing down of obsolete and uneconomic gas plants enabled a record number of ninety-seven works to be closed down during the period under review, and on March 31, 1956, there were 688 plants in operation as compared with 1050 at vesting date in 1948. The gas sold during the year totalled just under 2649 million therms of which industrial sales accounted for 751 million therms, commercial sales 395 million therms and domestic sales 1350 million therms. The average income per therm of gas sold to consumers was 17.87d. compared with 16.58d. in the previous year.

## Dock Labour

On Monday evening, Mr. F. H. Cave delivered his presidential address to the Institute of Transport. The address was entitled "The State of the Ports," and the greater part of it was devoted to a consideration of the dock labour situation. Mr. Cave expressed his conviction that, in this country at the present time, dock labour was the weakest link in the chain of port operations.

He went on to recall the conditions which prevailed prior to the formulation, in 1947, of the scheme which is administered by the National Dock Labour Board. The functions of the National Board, Mr. Cave explained, which were fulfilled either directly or through local boards, were: to register the necessary number of dock workers and the approved employers in each port; to allocate dock workers to employers as required, either on a weekly or casual basis; to pay the earnings due to the workpeople from the employers and supplement those earnings by an agreed payment if no work was available; to exercise disciplinary functions in respect of workers reported by the employer for unsatisfactory conduct, and to provide welfare and training facilities for the workpeople. But it should be noted, Mr. Cave added, that, although the Board supplied the workers to the employers and exercised all disciplinary functions in the industry, it was not concerned either with rates of pay or working conditions. The docks industry, he continued, had never had an enviable reputation for peacefulness, and in days gone by it was not to be wondered at. But since 1947 it had been governed by a system which gave the workpeople's representatives equal representation with the employers on the administering boards, and still the industry was bedevilled with trouble

and disputes. Quoting statistics from the recent report of the Devlin inquiry into the working of the dock labour scheme, Mr. Cave said that, since 1947, the man-days lost through disputes in the docks had been three and a half times as great as those in shipbuilding, four times as great as those in coal mining, and nearly twenty times as great as those in engineering. There had been six major strikes and about thirty smaller ones, apart from minor disputes.

Mr. Cave went on to suggest that there could be no ordinary employer-employee relationship in the dock industry as at present organised. The factor that distinguished the dock industry from practically every other great industry, he said, was that the overall amount of work to be done, and consequently the demand for labour, varied from day to day. It was quite outside the control of any employer and it would therefore appear to be in the employer's interest that there should be a reservoir of labour on which he could draw as he required. The employers had an "unregulated reservoir" until 1940, since when it had been subject both to limitation and regulation, but the men from it still only obtained casual employment. He wondered whether, indirectly, employers had not paid too high a price for that facility. A casual system of employment could only be to the benefit of employers in times of unemployment and even that advantage, such as it was, had been reduced very considerably by the introduction of a controlled register and minimum wage. Mr. Cave said he doubted whether it could ever be to the real interest of the workpeople, nor could it be expected to attract the best class of recruit. It was probably not generally realised even inside the industry, he commented, how great an adverse influence the casual labour mentality had on efficiency.

A great change would have to come in the "mental approach" by employers, trade unions and workers alike, Mr. Cave said, if in place of casual employment regular employment was to be achieved. The first thing, he urged, to be faced by employers as a condition of regular employment was that the employer-unit must be of a certain size, to which must be allied an appropriate number of employees. The actual size could not be determined by rule of thumb as it would vary with the size and layout of the port, the kinds of ships to be worked by the employer, and even with the size of the workers' register. But, Mr. Cave asserted, it must be of sufficient size to engage on a weekly basis sufficient men to meet the employers' normal requirements—and that did not mean minimum requirements. The larger the employer-unit, Mr. Cave commented, the greater the flexibility, and the more readily could a certain margin of workers be absorbed, though he thought there was a practical limit as to size. There were definite indications, he said, that the best output could be obtained in a unit employing not more than about 2000 men.

## Railway Productivity

The British Transport Commission has stated that teams representing various grades of British Railways' staff are to visit France and Holland during the next two months. These visits are part of the Commission's policy of encouraging the study of new methods and techniques in railway operation, with a view to improving productivity. The teams are being selected jointly by the regional managements of British Railways and the trade unions.

The first two teams are already on the Continent, one in France and the other in Holland. The team in France has been drawn from motive power departments. Its itinerary includes visits to the S.N.C.F. diesel depot at La Plaine, the Villeneuve St. Georges depot, the Paris-Lyon electric locomotive depot, and the Aubrais depot at Orleans. The team visiting Holland consists of British Railways' clerical staff. Its programme includes an examination of the Netherlands Railways' organisation. One of the visits is to the training school at Utrecht.

Another team, which will go to France next week, will represent British Railways' operating and commercial departments.

## Exports and Standards

Just over two years ago, the British Standards Institution set up an export panel, under the chairmanship of Mr. J. L. S. Steel. Its function is to advise the B.S.I. on how it can best assist the export trade. The panel has now compiled a statement on the policies it advocates concerning international work on standards.

The statement explains that the work on international standards has greatly increased in recent years, and that, at the same time, there has been a rapid growth of national standards in overseas countries. The development of internationally agreed standards in a world where national standards are rapidly increasing in scope and number, the statement continues, is obvious good sense. It provides the opportunity to secure the unification of basic requirements in national standards, and so to reduce the disparities which would become increasingly difficult to international trade.

The B.S.I. export panel believes that this country, with its dependence on exports to a variety of markets, "will gain much more than it will lose by a policy aimed at securing the international acceptance of common standards for basic features." Because of this, the statement goes on, the export panel thinks it essential that this country should participate actively in the work of the committees of the International Organisation for Standardisation and the International Electrotechnical Commission. In advocating that policy, however, the panel does not question the long-established policy of Commonwealth co-operation on the alignment of standards. It has been shown on many occasions, the statement adds, that "where we have already a well-conceived and widely accepted British standard our influence on the international recommendation is so much the greater. For this reason, and generally in the interests of export trade, our standards must be prepared taking full account of practices overseas; we cannot expect British standards to be accepted abroad merely for traditional reasons. But if British standards can be embodied in international recommendations they gain a wider validity and an increased value for British industry. We should, therefore, not be slow in developing British standards in any field which is likely to be the subject of international consideration."

## The Civil Service

According to the annual report of the Civil Service Commissioners for the year ended March 31st last, the total number of candidates dealt with was 104,502, compared with 115,865 in the preceding year. The report says that, although the number of successful candidates in open competition rose from 6236 to 8264, in many classes the Commissioners were unable to fill all the vacancies in spite of measures to improve recruitment. Those measures included a better information service to universities and schools, and the use of the General Certificate of Education as an alternative to the Commissioners' own examinations.

As to the professional classes of the service, the report says that once again there was difficulty in recruitment to almost all posts in the engineering and technical fields. There was no lack of applicants for most posts advertised, it is stated, but their general quality was poor. The selection of a short list of candidates for interview was frequently a difficult task, the report comments, and to ensure that no likely candidate had been overlooked, it was necessary to interview many applicants who in a stronger field would not have been short-listed. But the Commissioners "were concerned to notice how many candidates fell short of the standard of basic technical knowledge implied by the qualifications they held. Many of those recently qualified seemed to have retained a disturbingly small store of lasting knowledge."

# Institute of Metals Autumn Meeting

THIS year's autumn meeting of the Institute of Metals was held in Germany by invitation of the Deutsche Gesellschaft für Metallkunde. On September 17th and 18th, the meeting was held in Stuttgart jointly with the German sister Institute, and during this period and during the remainder of the week, a number of visits took place to works and laboratories, which were continued in the Frankfurt area on September 24th and 25th. A description of some of the works and laboratories visited will be found later in this article.

Members and guests assembled in Stuttgart on September 16th, where in the evening an informal gathering was held at the recently opened Liederhalle. The joint meeting commenced the next morning at the Liederhalle, when those assembled were welcomed by Professor Dr. Max Hansen, president of the Deutsche Gesellschaft für Metallkunde, who was in the chair, and by Dr.-Ing. W. Bader, Rektor of the Technische Hochschule, who spoke on behalf of the Technical University and the City of Stuttgart. The session continued with the presentation of the German Institute's Heyn Medal to Dr. G. V. Raynor, Professor of Physical Metallurgy, University of Birmingham. The medal was also presented to Dr. W. J. Kroll, Corvallis (Oregon), whose award had been announced at last year's meeting of the Deutsche Gesellschaft für Metallkunde at Klagenfurt, but who had been unable to attend on that occasion.

The meeting then split up, the Institute of Metals and the Deutsche Gesellschaft für Metallkunde continuing in separate sessions.

After dealing with official business, the Institute of Metals held a discussion on the theme "Fatigue of Aluminium and its Alloys," based on four papers recently published in the Institute's *Journal*.\*

The Deutsche Gesellschaft heard a lecture by Dr. G. Wasserman on "Age Hardening Research and Practice," in which the speaker reviewed the progress made in this field over the last fifty years, since Alfred Wilm's chance observation in September, 1906—possibly on the same date as the lecture, September 17th—of the age-hardening of a sample of "Duralumin." The lecturer concluded with a brief exposition of age-hardening in alloys.

The second speaker, Mr. A. H. Roberson, spoke about "A Descriptive Study of Consumable-Electrode Arc: The Pressure Dependence of their Burn-Off Rate," and illustrated his remarks with a number of very striking film sequences taken at the U.S. Bureau of Mines.

After lunch at the main restaurant Killesberg, members and guests of the Institute of Metals proceeded on various works and laboratory visits in or near Stuttgart and a sightseeing tour of the city. At the afternoon session of the Deutsche Gesellschaft für Metallkunde, lectures were given by Dr.-Ing. U. Zwicker on "Age-Hardening of Titanium Alloys," and by Messrs. W. Dickenscheid and J. H. Seemann on "Micro-Tensile Tests in the Investigation of Cold-Working Effects on Naturally and Artificially Age-Hardened Duralumin." Dr.-Ing. K. Detert spoke on "Natural Age-Hardening," Dr. E. Raub on "Age-Hardening and Segregation in Platinum-Iridium Alloys," and Dr.-Ing. G. Reinacher on "Improvement of the Age-Hardening Properties of Silver-Copper Alloys by Means of Additives."

In the evening a reception was given at the

Kurhaus, Bad Cannstadt, by the Government of Baden-Württemberg.

The morning of Tuesday, September 18th, was spent by the Institute of Metals participants on further technical visits, while a scientific session took place in the afternoon.†

The Deutsche Gesellschaft für Metallkunde, after attending to official business, held morning and afternoon scientific sessions.‡ In the evening, a concert was given by invitation of the Deutsche Gesellschaft, at the Residenz, Ludwigsburg. The Stuttgart chamber orchestra, under its conductor Karl Münchinger, played a canon by Johann Pachelbel, "Concertino in G," attributed to G. B. Pergolesi; "Antiche Danze ed Arie," by Ottorino Respighi, and Mozart's "Eine Kleine Nachtmusik." The evening ended with a banquet at the Liederhalle, Stuttgart, which concluded the joint meeting.

## MAX-PLANCK INSTITUT FÜR METALLFORSCHUNG, STUTTGART

The Institute for Metals Research was established in 1921 by the then Kaiser-Wilhelm-Foundation, now the Max-Planck-Foundation. Its object is the promotion of the theoretical and practical aspects of metallurgical research. In this it is greatly helped by its good relations with industry, and its close connection with the Technische Hochschule, where professorships are held by the heads of the Institute's three departments, Drs. Köster (director), Glocker and Dehlinger.

Although such close outside connections are maintained and some industrial research is done under contract, this does not affect the independence of the research work. Like the other Max-Planck Institutes, the Institute is maintained through a grant from the parent foundation, which, nowadays, is largely state-supported, about 10 per cent only of its income deriving from direct contributions from industry. Under the statutes of the foundations, the director of each institute is left an entirely free hand in the planning of his research programme within the means which can be made available.

The Institut für Metallforschung was transferred from Berlin to Stuttgart in 1934. Both buildings of the institute, which were completed in 1935 and 1939, respectively, were completely destroyed during the war. They have since been rebuilt and a third and larger building has recently been added.

In the carrying out of research by the individual workers, specialisation is kept to a minimum. It is, of course, the case that a worker whose line of research requires the use of a very specialised technique becomes particularly experienced in that technique, and in the handling of the apparatus or instruments concerned, which in many instances he has had to build himself. If another research worker needs to use the same technique or apparatus, he receives assistance and information from the expert, but carries

† The following papers were discussed:—"Experiments on the Semi-Continuous Casting of Bronze," by E. C. Ellwood, J. C. Prytherch and E. F. Phelps (*Journal, Inst. Metals*, May, 1956); "Atmospheric Corrosion of Aluminium Alloys in a Large Chemical Factory and their Protection by Painting," by W. D. Clark (*Ibid.*, October, 1955), and "The Stress-Corrosion of Certain Aluminium Alloys," by H. K. Farmer and U. R. Evans (*Ibid.*, July, 1956); Mr. A. H. Roberson (Chief, Branch of Process Metallurgy, U.S. Bureau of Mines) showed his film "A Descriptive Study of Consumable-Electrode Arcs: The Pressure Dependence of their Burn-Off Rate."

‡ The subjects discussed were: E. Gebhardt, "Observation of Gas Absorption and Degassing of Tantalum by Means of Conductivity Measurements"; Th. Heumann, "New Observations relating to the Kirkendall Effect in Single and Multi-Phase Diffusion"; K. Schubert, "Structural Phenomena in Superstructure Phases"; F. Binder, "X-ray Determination of the First Signs of Fatigue Failure"; L. Graf, "Observations on the Growth of Electrolytically Deposited Silver Dendrites"; W. Hofmann, "Application of a Short-Gauge Measuring Apparatus for the Investigation of Structure Changes"; F. Assmus, "Manufacture and Application of Special Structures of Ferro-Silicon"; A. Knappwost, "Determination of the Minimum Size of Weiss Domains by Means of Observing the Segregation of Super-Saturated Mixed Crystals"; E. Scheil and E. Wachtel, "Magnetic Investigations of Copper-Manganese Alloys."

out his own experiments himself. This helps to prevent an undue degree of specialisation and preserves each worker's responsibility for his own research.

## STAATLICHE MATERIALPRÜFUNGSANSTALT STUTTGART

The Stuttgart State Materials Testing Station was founded by C. von Bach, the present director being Prof. Dr.-Ing. E. Siebel. Still in its pre-war premises, the station is at present nearing the limits of its capacity. The Stuttgart station specialises in the investigation and testing of metals and structural components, the emphasis being on pipework, pressure vessels and boilers.

With modern trends in boiler design being towards temperatures of 650 deg. Cent. and over, and 800-900 deg. Cent. in gas turbine work, the investigation of the behaviour of metals at high temperatures receives a great deal of attention. The laboratory possesses equipment for the creep-testing of bar specimens, and tests, including time-strain measurements, are being carried out on steels, as well as on aluminium and titanium alloys. The use of triple specimens (with three different diameters on one piece) greatly increases the testing capacity.

Another field in which much work is being done is the design of boiler shells. Here it is largely a question of determining the influence of apertures and connections, and the gain in strength which results from redistribution of stresses through plastic deformations.

The design of flanges and joints is also the subject of investigation, full-scale models of flanges being tested in bending with or without internal pressure, and under conditions of steady or cyclic loading.

In a fundamental investigation of thermal stresses, a thick-walled tubular specimen is internally water cooled while the metal is being heated by means of an induction coil operated at 10 kc/s. The outside temperature is measured by a total radiation pyrometer. Results have been obtained showing the effects of the previous history of the specimen and the different behaviour in fracture of austenitic and ferritic steels (internal and external cracking, respectively).

Among the testing machines, many of which were arranged for automatic cyclic loading and equipped with recording instruments, there were some large fatigue testing machines made by Carl Schenck G.m.b.H., Darmstadt. Although the testing of plastics proper is not the concern of the Stuttgart Institute, this kind of work being concentrated at Darmstadt, the laboratory does carry out work on glued metallic joints, including fatigue tests.

Research into phenomena of friction and abrasion encompasses a large field, ranging from such things as sand blasting and the rubbing of piston rings against cylinder liners, to the behaviour of different lubricants as measured in ball bearing test rigs, and the wear resistance of woven floor coverings as measured in rigs which simulate the actual conditions of use.

The institute possesses a laboratory for non-destructive testing equipped for X-ray and gamma-ray radiography, magnetic crack detection and ultrasonic testing. Among the field tests which are now being carried out are tests on water pipes of 1300mm diameter and 22mm wall thickness, belonging to the 156km long supply line from Lake Constance to Stuttgart, which is at present under construction.

The Staatliche Materialprüfungsanstalt Stuttgart is the materials testing station for Baden-Württemberg and as such comes under the Central Materials Testing Institute at Berlin-Dahlem. Similar institutes are maintained in the other Länder of the Federal Republic. With the exception of Dortmund, they are each affiliated to a technical university, the director of the institute holding, at the same time, a university professorship.

## BURKHARDT UND WEBER K.G., REUTLINGEN

The foundation of Burkhardt und Weber K.G. Maschinenfabrik, Reutlingen, goes back to the year 1888, when Louis Burkhardt and Johannes Weber founded the firm of L. Burkhardt and Weber. The former had received his technical

\* "The Slip-Band Extrusion Effect Observed in Some Aluminium Alloys Subjected to Cyclic Stress," by P. J. E. Forsyth and C. A. Stubbington (Serial No. 1611, April, 1955); "Experiments on Aluminium Crystals Subjected to Slowly Alternating Stresses," by N. Thompson, C. K. Coogan and J. G. Rider (Serial No. 1658, November, 1955); "Some Metallographic Observations on the Fatigue Failure of Bare and Clad Aluminium-Copper Magnesium Alloy Sheet," by J. J. Sebesty and A. R. Edwards (Serial No. 1683, April, 1956); "Structural Changes During the Fatigue of Some Aluminium Alloys," by T. Broom, J. H. Molineux and V. N. Whittaker (Serial No. 1695, June, 1956).

education at the Mauser works, Oberndorf, while the latter had been with Escher-Wyss, Ravensburg, Gebr. Sulzer, Winterthur, and other firms abroad. Beside the manufacture of cane guns which Burkhardt had introduced, the firm made small machine tools, various instruments, and certain textile machinery, such as sewing and crotchetting machines. When, after a few years, the manufacturing capacity had to be enlarged, it became possible to undertake the manufacture of larger machine tools, notably novel designs of drilling machines, milling machines and cold saws. The basis for the manufacture of milling machines was the patented milling attachment for lathes which was already in those days being built in large series, while the manufacture of ball bearings for use in the factory's products was a notable achievement. The basic design considerations of those years with respect to drilling and milling heads, and also cold saws, have influenced later developments ever since.

After L. Burkhardt had to leave the firm in 1894, owing to ill health, Johannes Weber became sole proprietor and continued until his death in 1920. The firm was then transformed into a private company, the management being taken over by Mr. Louis Weber, who, since its further transformation into a limited partnership in 1936, manages the affairs of the firm as a personally liable partner.

The idea from which stemmed the main line of development was the principle of combination of serially built machine tool units into electrically programmed and hydraulically-operated special machine tools. Since those machines could, if required, be dismantled and their constituents reassembled into new units, the system became economical even in small-series production. One field which the firm has pioneered is the welded construction of stands and bases for special machine tools. Another is the multi-spindle cutting of threads.

The second world war brought heavy damage from air raids and was followed by the total loss of the modern equipment through dismantling. As a result, the factory had to be rebuilt and completely re-equipped. Since then, Burkhardt and Weber have made important contributions to production technique by building the first completely automatic transfer lines for large series production. The construction and assembly of large transfer lines, and the increasing volume of output necessitated in 1951 a further extension of the works by the addition of a new building which nearly doubled the available floor space.

#### INSTITUT DR. FÖRSTER, REUTLINGEN

The present premises of this firm, which were completed earlier this year, have some 40,000 square feet of floor space, and house a staff of about 100 people. Production consists in the main of instruments for non-destructive testing and precision measurement, magnetic tests and surface roughness measurements. The institute was founded six years ago by Dr. Förster, who since the middle thirties had been engaged on research on various techniques of electronic measurement which have found a wide field of practical applications since.

Among the instruments which the visitors were able to see were quality test gear for ferrous and non-ferrous materials, including crack detectors and sorting machines; instruments for measuring the thickness of foils, platings and paint coatings; gear for the measurement of magnetic fields, metal detectors, and instruments for size measurements, including multiple testing and statistical control.

Also demonstrated was an instrument for the very accurate determination of Young's modulus and damping decrement of metallic or non-metallic test pieces. With this instrument it is possible to take readings also at high temperatures (up to about 1000 deg. Cent.). The values of the natural frequency and damping decrement of the test piece are shown on an electronic counter. The principle consists in exciting a rod-shaped specimen to resonance by means of an electronic oscillator and maintaining the vibrations by means of feed-back. The number of vibrations during exactly ten seconds is counted with an accuracy of 0.01-0.001 per cent, after

which the counter automatically resets and the reading is repeated. For damping measurements the feed-back is cut out and the number of vibrations are counted which occur until the amplitude has fallen to  $1/e$  of a certain initial value. Not only the fundamental but also the harmonic transverse vibrations and torsional vibrations can be obtained, permitting a derivation of Poisson's ratio. The importance of these measurements lies in the fact that the constants are functions of structural changes within the specimen, such as recrystallisation and changes near the surface, such as corrosion (which alters the effective dimensions of the specimen). These changes may thus be observed.

#### CARL ZEISS, OBERKOCHEN

With the evacuation of Thuringia by American forces in the summer of 1945, and the establishment of Russian control, the boards of directors of the two key firms of the Carl Zeiss Foundation—Carl Zeiss and Jenaer Glaswerk Schott and Gen.—were evacuated to the Western occupation zones. Following the nationalisation of the undertakings at Jena by the East German authorities, and the placing of the Foundation under a Commissioner, the directors applied, on July 30, 1948, to the Government of the Land Württemberg-Baden to register the offices of the Carl Zeiss Foundation at Heidenheim (Brenz). Subsequent legal action undertaken in West Germany by the district council of Gera, as administrators of the Jena foundation, sought to show that the transfer was *ultra vires*. The plaintiffs demanded that the firm Carl Zeiss/Oberkochen should be struck off the register of companies and its trade mark transferred to the East German firm, and that the directors should stop all activities on behalf of the Heidenheim Zeiss Foundation. The action failed.

The firm of Carl Zeiss was originally founded at Jena in 1864. The scientific design of its instruments is due to Professor Ernst Abbé (died 1905), who became the partner of Carl Zeiss. Later Dr. Schott, who had discovered new methods for making optical glass, was brought in. The firm is owned and controlled solely by the Carl Zeiss Foundation. When it was first re-established at Oberkochen in the premises of a former aircraft factory, it commenced with the manufacture of spectacles. Since its working drawings were in the hands of the American authorities, its production had to be developed from the beginning. The company now employs some 4200 persons; expansion is still continuing. Companies in the Zeiss group include Zeiss Opton G.m.b.H., Oberkochen; Zeiss Ikon A.G., Stuttgart (with works in Stuttgart, Kiel and West Berlin); M. Hensoldt and Söhne A.G., Wetzlar; R. Winkel G.m.b.H., Göttingen; Anschütz and Co., G.m.b.H., Kiel; Gauthier G.m.b.H., Calmbach, and, as a newcomer, Voigtländer A.G., Brunswick.

#### WIELAND-WERKE A.G., VÖHRINGEN (NEAR ULM)

A bell foundry at Ulm, which had been in existence since about 1570, was bought in 1820 by P. J. Wieland, and adapted and extended for the manufacture of brass sheet and wire. A branch factory at Vöhringen, 13 miles to the south, was opened in 1864. This site was chosen because of the water power which was available from the River Iller. A limited company was formed in 1919. At the present time the works cover an area of 45 acres, with 2200 persons employed at Vöhringen and 1600 at Ulm.

The company produces semi-manufactures in copper, aluminium, nickel and their alloys, and the visitors were able to see the rolling mill, strip mill, and the wire and rod-drawing departments, as well as the extrusion presses and the continuous casting plant. A large Schloemann extrusion press was installed two years ago; it develops up to 2700 tons, at a cylinder pressure of 240 atmospheres gauge.

The works possess and still operate the first German extrusion press built by Krupp Grusonwerk in 1901. This is a 925-ton press working on a cylinder pressure of 475 atmospheres gauge.

Also still in operation is the original plant for the continuous casting of brass in sections up to 500mm by 125mm, built by Junghans in 1933. The works also carry out continuous cast-

ing of copper and of light alloys. Total output is about 4000 tons per month of heavy metals and alloys, and about 800 tons of light alloys.

#### TELEFUNKEN GESELLSCHAFT FÜR DRAHTLOSE TELEGRAPHIE M.B.H., ULM

The Ulm works is one of the factories of the Telefunken group, and supplies one-third of the receiver valves as well as all cathode-ray tubes, oscillograph tubes and transistors manufactured by the group. The factory, which possesses a valve research laboratory, at present covers  $7\frac{1}{2}$  acres. On completion in about two years' time it will cover about 10 acres; about 2700 people are currently employed.

The firm of Telefunken was founded in 1903. In 1917, its factory in the Friedrichstrasse, Berlin, under H. Rukop, began the mass production of valves (1000 receiver valves and over 100 transmitter valves per day). This venture had been preceded by small-scale laboratory production.

All kinds of electronic valves have been produced since. The development of television tubes dates from 1930, when Telefunken showed television in public for the first time. The development, interrupted in 1939, was resumed ten years later in the works at Ulm (valves) and Hanover (receivers). The first post-war German television transmitter, destined for Hamburg, was delivered by Telefunken in 1951, and a 10kW transmitter was erected at Langenberg at the end of 1952. When, therefore, television officially started at Christmas, 1952, there were several transmitters ready for operation.

In the manufacture of television tubes, many special problems arise. The glass parts are rather fragile and rather bulky, necessitating special means of mechanical handling. Greatest cleanliness is required in the manufacture of the fluorescent screen, since the phosphors can be poisoned or spots can be caused, even by small amounts of impurities. The volume to be evacuated is a thousand times larger than that of a receiver valve, and much longer pumping times are required. Provision must be made for gradually cooling the large glass parts in order to relieve thermal stresses set up during the jointing, degassing and pumping processes. Finally, should one of the tubes implode during manufacture, other tubes are liable to be damaged unless efficient protective measures are taken.

#### PRODUCTION OF TELEVISION TUBES

At the new Ulm factory for television cathode-ray tubes, which was opened last year, the tubes move from one stage of production to the next on endless overhead conveyors provided with forks which can carry tubes of each of the three standard sizes (36cm, 43cm and 53cm diameter). These conveyors descend to working level only at the various loading and take-off stations, so that traffic is unhindered. A floor space of 3200 square metres is provided, the height of the building—which is carried out in reinforced concrete with a steel-framed roof—is 7.50m. Such a large height is required partly because of the machines which are being used, partly in order to keep the building reasonably cool, since much heat is given off by the various ovens and by the heated tubes. A cellar extends under the whole of the floor space and in it are housed the water processing plant, air conditioning equipment for the main hall, substation and emergency substation, and the cloakrooms, lavatories, and shower baths for the personnel. For certain rooms where dust-free air is required separate fully automatic air conditioning plant has been installed.

When fully expanded, production from this factory will be 50,000 tubes per month, requiring three production lines working in parallel. Much of the machinery is of special design and was developed by the firm and built in its own workshops.

The ovens are electrically heated throughout, necessitating a 5000kVA substation (which also supplies some of the remainder of the factory). Should the main supply fail, certain key plant is automatically switched over to an emergency 600kVA supply from an independent turbo set at the power station.

For obtaining water of the high degree of

purity required, selected water from wells is pumped through plant of 15 cubic metres per hour total capacity in which all salts are removed. The degree of purity is checked by conductivity measurements.

The principal manufacturing problem with television cathode-ray tubes derives from the presence of the screen and its sensitiveness to impurities. As a first step, therefore, the glass bulbs, on arrival from the glassworks, are passed through a machine which washes the inside with a jet of 10 per cent hydrofluoric acid and then thoroughly rinses the glass.

For depositing the fluorescent screen a suspension of phosphors in waterglass is poured into the tube. By inoculation with electrolytes a mixture of silicic acid and phosphors is deposited which solidifies and bonds on to the glass. The supernatant liquid is then carefully decanted, after which the inside is dried. A part of the remainder of the internal surface is then coated with graphite by painting with a graphite emulsion. This layer, which conducts electricity, serves to remove disturbing space charges due to stray electrons and forms the high-tension connection between anode contact and anode. It also eliminates internal light reflections.

With most designs of tube a thin layer of aluminium is deposited on the back of the fluorescent screen in order to improve the picture intensity. In order to provide a smooth surface for the aluminium a layer of lacquer a few microns thick is deposited on the sintered fluorescent layer. This is done by covering the layer with water on which a few drops of lacquer are allowed to spread. When most of the solvent has evaporated the water is decanted, and the lacquer skin smoothly deposited on the screen. Aluminium is then deposited in vacuum by means of a sputtering technique.

Following the deposition of graphite or aluminium, the tubes are heated in a tunnel oven 30m long to a temperature of 380 deg. Cent. This removes water and certain impurities, improves the adhesion of the various layers, and burns the collodion film under the aluminium. This heating process also makes certain faults apparent to the ultra violet inspection, which is then carried out. Such faults would otherwise only be detected after final evacuation. Any tubes found to be faulty at this stage have their deposits stripped and are returned to the head of the production line.

After sealing in of the electrode assembly, which is manufactured in the adjoining receiver tube factory, the tubes are evacuated. During this process the tubes, each of which is mounted on its own pumping trolley, pass through a 20m long tunnel oven which heats them to 400 deg. Cent., the metal parts being further degassed by h.f. induction heating. The tubes are then sealed, provided with a socket, and the getter is evaporated by means of a separate h.f. induction coil.

The completed tubes are subjected to electrical and optical tests, as well as to an excess pressure test to eliminate mechanically weak tubes which might implode in use. At this stage also an external graphite coating is applied to a portion of the glass to provide a certain required electric capacity. After several weeks' storage the tubes are finally submitted to a brief check of their insulation, electrical performance, and quality of the vacuum, and are then ready for dispatch.

### Wire Race Ball and Roller Bearings

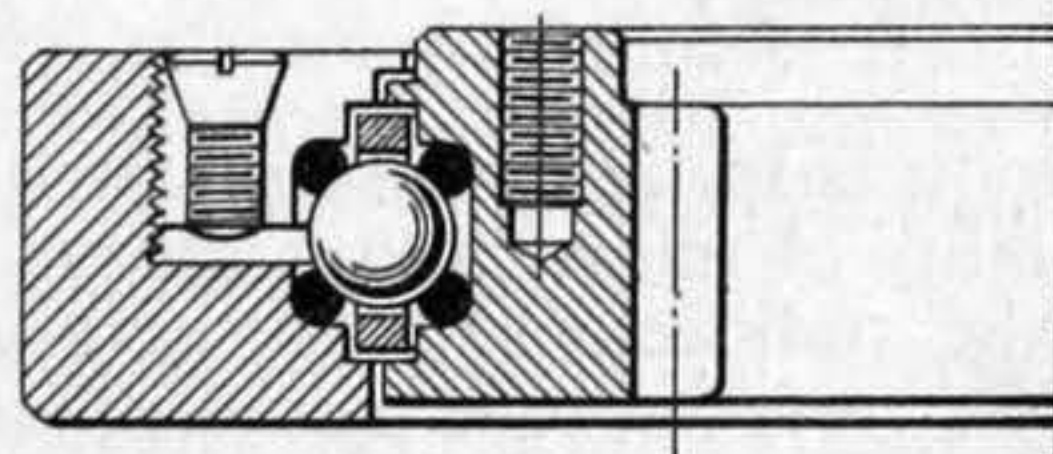
Our illustration shows an example of a "Design Franke" wire race ball bearing, as made by Eisenwerk Rothe Erde G.m.b.H., Dortmund, P.O.B. 311, German Federal Republic. It will be seen that the balls, which are held in a cage in the usual manner, run on four wires placed in the corners of grooves cut into the inner and outer rings. The outer ring consists of two halves, one screwed into the other, which provides the possibility of adjusting the clearance of the bearing.

It is the basic characteristic of this design of bearing that the balls (or rollers, as the case may be) move on round (or flat) wires. For ball bearings, four wires support each row of balls. The wires are made of hardened spring steel; the rings are split so that they spring

into their housing, and can accommodate themselves to expansion due to temperature changes and other distorting factors.

Great accuracy and load capacity is obtained in the case of the ball bearings by pregrinding the part of each ring where the balls make contact, and during assembly rolling the contact surface to the radius of the balls.

For wire roller bearings, rings made of flat

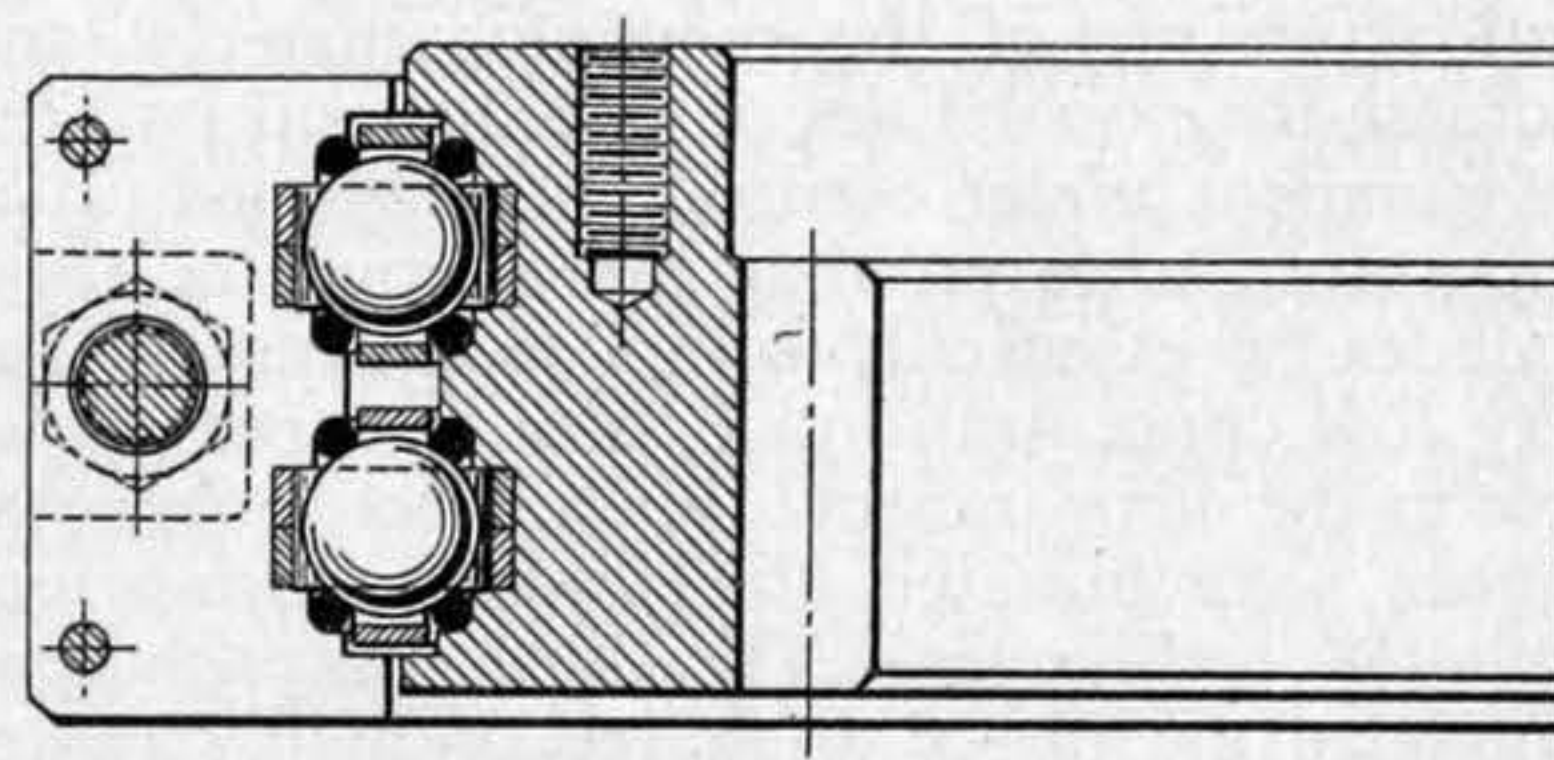


Single row wire race ball bearing for axial, radial or oblique loading. The outer housing is in two parts for adjustment

wire are used. It is even possible to use a combination of ball and roller bearings, as shown below, where the possibility of adjustment by means of a split outer ring is shown.

It is claimed for this kind of ball and roller bearing that it permits the taking up of radial, axial or tilting forces by a single bearing of appropriate design, thereby replacing more complicated arrangements comprising several bearings. The wire bearings take up a minimum of space, they are adjusted to the required degree of accuracy at the time of manufacture, and can be readjusted subsequently. The adjustment also permits the correct distribution of the load between the rows of a multiple bearing.

The rings in which the wire races are housed are normally made of steel, but it is also possible



Double row wire race bearing comprising alternate balls and rollers. The outer ring is split for purposes of adjustment

to employ a light alloy for this purpose, if required. Corrosion-resisting wire ball and roller bearings are also available and are for use with housings made of non-corroding material.

Additional savings in space can be made by machining any internal or external gearing into the rings themselves, bolting adjacent components directly on to the rings, and incorporating seals against dust and water in the bearing.

Wire ball bearings are made in sizes up to 4000mm diameter (13ft) and are suitable for peripheral speeds up to 20m per second (65ft per second). Slewing rims up to the largest size are adjusted to the desired degree of accuracy prior to delivery.

The maker's agent in the United Kingdom is Alexander Marcar and Co., 61, Pall Mall, London, S.W.1.

### Expansion of Civil Aviation

According to information issued by Esso A.G., Hamburg, orders for civil airliners to be delivered before the end of 1960 amount to 1291 units, valued at over 3000 million dollars. About 64 per cent of the total, or 824 aeroplanes, are on order in the U.S.A., 417 machines, chiefly

Present Orders for Civil Aircraft

| Type            | Power plant     | For delivery in : |      |      |      |      | Total |
|-----------------|-----------------|-------------------|------|------|------|------|-------|
|                 |                 | 1956              | 1957 | 1958 | 1959 | 1960 |       |
| Long distance   | Piston engine.. | 140               | 248  | 39   | —    | —    | 427   |
|                 | Turbo-prop ...  | 14                | 25   | 24   | 98   | 28   | 189   |
|                 | Jet ... ..      | 0                 | 0    | 12   | 92   | 122  | 226   |
|                 | Total ... ..    | 154               | 273  | 75   | 190  | 150  | 842   |
| Medium distance | Piston engine.. | 55                | 64   | —    | —    | —    | 119   |
|                 | Turbo-prop ...  | 166               | 95   | 56   | 13   | —    | 330   |
|                 | Jet ... ..      | —                 | —    | —    | —    | —    | —     |
|                 | Total ... ..    | 221               | 159  | 56   | 13   | —    | 449   |

"Viscounts" and "Britannias," are on order in Britain, a further twenty-two in France, and twenty-eight in the Netherlands. The figures do not include Government or non-commercial orders; they are analysed in the accompanying table with regard to power plant and delivery date.

### Bi-Centenary of Voigtlander

On September 28th the oldest optical-mechanical works in the world celebrated the 200th anniversary of its foundation. It was in 1756 that Johann Christoph Voigtlander founded in Vienna the firm which still bears his name, and which in those days was concerned with the manufacture of compasses, sextants and surveyor's instruments. Much of the work was carried out in wood, as the drawing of brass tubes was still unknown. The founder's son, Johann Friedrich, became known for his invention of the binocular telescope originally due to Galilei, and his further development of binoculars and field glasses, for which he obtained an Imperial patent in 1823. When Daguerre invented photography in 1839, the grandson, Peter Wilhelm Friedrich, immediately recognised the great importance of this event. Already a year later he had put on the market the famous objective lens which Petzval had designed and which had the then extraordinary aperture of 1:3.7. Its use reduced Daguerre's daylight exposure times from twenty to two minutes. The principle of this objective is still employed for cinema projection lenses. In the same year was produced the world's first metal camera with rack and pinion focusing.

In 1849, P. W. F. Voigtlander decided to transfer the firm to Brunswick, because of the political unrest in Vienna, and for economic and also personal reasons (Brunswick being his wife's birthplace). His son, Friedrich von Voigtlander, the last male heir, transformed the business into a limited company in 1898. Almost the total share capital was acquired in 1924 by the Schering concern, and in 1935 was founded the Voigtlander-Gevaert G.m.b.H. A few months ago, the Voigtlander shares were sold by Schering to the Carl-Zeiss-Foundation at Heidenheim (Brenz).

### The Late Dr. G. Masing

Professor Dr. Georg Masing, the distinguished German metallographer and teacher, died at his home in Göttingen on Wednesday, October 3rd.

Georg Masing was born on February 2, 1885, in St. Petersburg, Russia, where his father was a chemist. He was educated at the Humanistische Gymnasium there, and then studied chemistry in St. Petersburg before going, in the autumn of 1905, to Göttingen University as a pupil of Professor G. Tammann. He received his Doctorate in 1909 for a thesis "On the Formation of Compounds Under Pressure and the Reactions of Metals in the Solid State."

He then entered industry in Berlin, and in 1922 was made head of the Metallographic Department of the Research Laboratory of the Siemens concern. In that capacity he carried out extensive experiments in many fields. As a result of his work Masing was offered the directorship of the Kaiser-Wilhelm Institut für Metallforschung, Stuttgart, when it was founded in 1933, but he declined the post. In 1937 the Deutsche Gesellschaft für Metallkunde awarded him the Heyn Medal, and in the same year he accepted the appointment of director of the Institut für Allgemeine Metallkunde at Göttingen University. He held that position, in succession to Professor Tammann, until his retirement a few years ago. In December, 1952, the Technical University of West Berlin made him an honorary Doktor-Ingenieur.

Masing's works covered a great range of metallurgical subjects, both theoretical and practical, and he was the author of a large number of scientific and technical papers. In 1926 he developed the alloys of beryllium in co-operation with O. Dahl. In 1953 Professor Dr. Masing received the Platinum Medal of the Institute of Metals, its highest award, in recognition of his outstanding contributions in the field of metallography.

# Work of the U.S. Atomic Energy Commission

BY OUR AMERICAN EDITOR

No. III—(Concluded from page 493, October 5th)

**S**OLID scavenging techniques have also been used by Atomics International on irradiated uranium metal and have resulted in the removal of many fission products by both adsorption and chemical exchange. Refractory salts and graphite have been used in the scavenging phase. Due to the high oxidation potential of thorium, irradiated thorium-uranium melts become seriously contaminated by container materials at elevated temperatures. Finally, the fused salt extraction of plutonium and some fission products from irradiated uranium metal has been demonstrated, using uranium tetrafluoride as the salt phase, at 1300 deg. Cent. The resulting plutonium-rich salt phase subsequently was reduced to yield a uranium-plutonium alloy containing a small fraction of the original fission products.

When a gas stream is passed up through a bed of finely divided solids, the solids can be suspended in the gas by varying the velocity of the stream so that the solids are held in equilibrium within the pipe or container. In this "fluidised" form heat can be transferred to or from the material much more easily than when the same material is in solid form. "Fluidised" material also presents a large area for interaction between solids and gases. Engineers at the Argonne National Laboratory are applying "fluidisation" to radioactive waste treatment. Radioactive waste solutions of aluminium nitrate are sprayed into a heated, air-"fluidised" bed of aluminium oxide, where the water is evaporated and the aluminium nitrate is converted into aluminium oxide. The non-volatile radioactive materials remain in the oxide. The oxide has a much smaller volume than the original solution, and it can be stored without concern about its corroding through a container. These characteristics are expected to reduce the cost of treating wastes. Another promising method has been developed at the Oak Ridge National Laboratory for the inexpensive disposal of radioactive wastes containing aluminium nitrate. Following heat-treatment to convert the aluminium compound to a form that does not adsorb on ion exchange resins, the fission products are removed by ion exchange and concentrated to a small volume. These are the only components of the waste requiring expensive storage facilities.

In the field of safety studies more than 200 "transient" tests have been made at the Special Power Excursion Reactor Test Facility (SPERT-I) of a heterogeneous reactor concept which is operated by the Phillips Petroleum Company at the National Reactor Testing Station in Idaho. During a typical test the reactor power reached 510MW in 0.75 second and then dropped equally rapidly under the self-regulation of temperature rise and void formation. Data on SPERT experiments were released in June, as part of the Commission's programme to provide information to industry for the evaluation of reactor hazards. The design work on SPERT-II and III progressed satisfactorily and the construction of central control facilities and the SPERT-III reactor started this summer.

Many metals will burn or even cause explosions under certain conditions, particularly if they are finely divided as in machining operations. The Argonne National Laboratory has initiated an investigation of such pyrophoric behaviour of metals used in nuclear reactors (e.g. uranium, plutonium, thorium, zirconium) by studying factors affecting the kinetics of ignition in the metals. This investigation is designed to lead to more effective measures for the control and prevention of the serious hazard of metal fires or explosions.

In the field of sanitary engineering research and development in the disposal of highly radioactive wastes followed three major approaches. The first of these was the fixation of the waste

fission products in an inert solid carrier so that the possibility of release and subsequent migration of the radioactivity into environment is eliminated or reduced to acceptable limits. This would allow the carrier containing the radioactive material to be permanently stored or buried in special locations without harmful effect on the environment. Work along these lines was carried out at the Brookhaven National Laboratory on the conversion to the oxide form of the inert salt and fission product constituents of high-level waste. Subsequent leaching and fixation in clays are further steps involved in the complete disposal. A preliminary engineering evaluation of this system is planned. Studies at Johns Hopkins University on the fixation of caesium 137 and strontium 90 in hydrated alumino-silicates showed considerable promise. It appeared that the formation of highly stable feldspars at relatively low temperature (300 deg. Cent.) is the dominant factor in the success of this method. The second approach to the problem of disposal of highly radioactive wastes involves the selective removal of specific nuclides, such as caesium 137 and strontium 90. Because of the severe radiotoxicity and long half-lives of these materials their removal from wastes and fixation would substantially reduce the effective radioactive life of the remaining material and increase the possibilities of safe disposal into the environment under controlled conditions. It is important, however, that the removal of these nuclides be essentially complete because of the very low concentration of these isotopes allowable in the environment. Such selective removal studies were initiated at Oak Ridge using ion-exchange techniques. The third approach contemplates the direct discharge of highly radioactive wastes to specially selected geologic formations. Through the Earth Sciences Division of the National Academy of Sciences, a group of experts in the fields of geophysics and geology is preparing an initial report to indicate existing information pertinent to the problem and in a preliminary way, the technical possibilities, delineate areas where information is lacking, and recommend research and development to obtain pertinent data.

## PHYSICAL RESEARCH

Highlights of the last six months of research in physical, chemical and metallurgical problems related to nuclear energy and to the Atomic Energy Commission's programmes. During this period, the Commission approved the construction of two high-energy particle accelerators at two eastern university sites and authorised a group of mid-western universities and the Argonne National Laboratory to undertake the design and development of high-energy particle accelerators of an advanced nature. The accelerators which were approved for construction are: (1) a joint Harvard University-Massachusetts Institute of Technology machine to be placed on the Harvard campus, and (2) a joint Princeton University-University of Pennsylvania machine to be placed on the Princeton campus. The Mid-western University Research Association, which was authorised to undertake the design and development of an accelerator, comprises the University of Chicago, University of Illinois, University of Indiana, University of Iowa, Iowa State College, University of Michigan, Michigan State University, University of Minnesota, North-western University, Notre Dame University, Ohio State University, Purdue University, Washington University and University of Wisconsin. The Harvard-M.I.T. machine will be a circular alternating gradient electron synchrotron, with a 118ft radius. It will be a 6000MeV machine and is estimated to cost the Government 6,500,000 dollars. Construction will require about forty-two months. The Prince-

ton-University of Pennsylvania accelerator will be a uniform gradient proton synchrotron that will require about forty-four months to construct. This machine will have an energy of 3000MeV and will be built at an estimated cost to the Government of 5,800,000 dollars. The accelerators will be operated by the institutions under contract with the Commission, and will be available to scientists from other institutions.

For the calendar year 1955, the number of isotope shipments from Oak Ridge increased slightly over calendar year 1954, and the total amount of radioactivity supplied rose from 48,879 curies in 1954 to 49,383 curies in 1955. There were also considerable increases in shipments of cobalt 60 and caesium 137 for large irradiation units. Twenty-nine new short half-life products, ranging from antimony 122 to yttrium 90, were offered for sale as a result of increased manipulator cell facilities and faster processing techniques. Most of these products were irradiated in the Low Intensity Testing Reactor (LITR) at Oak Ridge, and users were supplied with higher specific activity material, assayed and in solution form. A remote manipulator cell for handling multi-kilocurie amounts of radioactivity was completed and placed in operation at Oak Ridge during this reporting period. Radiation sources containing more than 15,000 curies of cobalt 60 have been simultaneously handled in this cell. The addition of this facility has made it possible to assemble and fabricate large radiation sources without underwater operations. The largest single source assembled to date, 10,000 curies of cobalt 60, was prepared for the General Electric Company to use in studies of radiation damage.

In physics research, during the first half of 1956, experimental evidence for the existence of a nuclear particle of vanishingly small mass and without electrical charge, the neutrino was collected by a team of research investigators from the Los Alamos Scientific Laboratory, which is operated for the Commission by the University of California. This is the second theoretically predicted nuclear particle, the existence of which has been detected at Commission laboratories within recent months. The Nobel laureates, Enrico Fermi and Wolfgang Pauli, predicted the existence of the free neutrino to account for, among other things, the release of energy, otherwise unaccounted for, in a radioactive process known as beta decay. The neutrino was postulated to carry away part of the energy released in this process. The neutrino is extremely penetrating and would pass through millions of miles of solid matter. Its detection consequently posed an extremely difficult scientific problem.

Frederick Reines and Clyde Cowan, Jr., who headed the research team, believed they first observed the neutrino in 1953 when, with the help of other scientists, they set up equipment near a production reactor at Hanford. They installed a rather novel liquid scintillation system as a sensitive detector. Although evidence obtained at that time indicated the neutrino's existence, the experiment was not entirely conclusive. Cosmic rays and other background radiation made it difficult to make use of the signals of the neutrino. A new and more complex detecting system was built and, last year, was set up deep underground near one of the large production reactors of the Commission's Savannah River plant, which is operated by E. I. du Pont de Nemours and Co. Several months of work enabled the scientists to conclude that they had checked each important characteristic of the neutrinos caught in their equipment. The detector included a target containing more than 100 gallons of water in which cadmium salts had been dissolved. Cadmium is a strong absorber of neutrons. The target was "watched" by a scintillation system containing over 1000 gallons of nuclear radiation-sensitive liquid, and 330 large photo-multiplier valves. Despite the huge size of the detector and the millions of neutrinos produced within the reactor, which passed through the detector each second, only a few neutrino captures were observed in the target each hour.

The discovery is believed to involve the first time that scientists have, knowingly, caused a

direct reversal of the process of beta decay. In the process of beta decay, the nucleus apparently loses this negative charge and becomes a proton. In the present experiment, stable protons in the target water were made to absorb neutrinos, emit positive electrons, and become neutrons. The particle thus detected by simultaneous detection and identification of the positron and neutron shows the expected properties of the neutrino as predicted by the theory of Fermi and Pauli. The importance of the discovery is that it confirms theories which scientists will ultimately evolve into an understanding of the nature of the forces which hold together the atomic nucleus.

A major research programme carried out at the University of California Radiation Laboratory in Berkeley with the bevatron was the investigation of the properties of the antiproton. This research followed the discovery of the antiproton in October, 1955, by electronic techniques. It was expected that if an antiproton came into contact with a proton or neutron a mutual annihilation would result, which would transform the mass of both particles into energy. The technique used to demonstrate the annihilation properties of the antiproton consisted of placing a stack of photographic plates coated with nuclear emulsion in the path of anti protons produced by the bevatron. Any charged nuclear particle passing through nuclear plates produces an image which, after development, consists of a track-life series of small silver grains. This technique permitted the observation of the fate of an antiproton going through the plates. Shortly after the discovery of the antiproton the same bevatron beam which had been shown to contain antiprotons was used to irradiate a stack of photo-emulsion plates. Half of the exposed plates was sent to Italy to be examined by a group of scientists at the University of Rome; the remaining half was studied at Berkeley. While no evidence of interactions was found in the California study, the Italian group reported discovering one "star" in the emulsion, which is believed to be the first antiproton interaction seen by man.

The depicted star was caused by an antiproton entering a nucleus of either a silver or bromine atom in the photo-emulsion. The resulting explosion liberated seven heavy particles, such as protons or alpha particles, and two mesons, probably pions. The antiproton track extended 4 in into the emulsion, and the fact that it produced a large star indicated that it was a negative particle. The energy released was calculated from an analysis of the star. The tracks in the photograph were interpreted as those of pi mesons, and the other tracks as those of protons or alpha particles. Since this star was found thirty antiprotons have been detected in nuclear plates in a large co-operative effort by physicists in Berkeley. In all cases antiprotons have been seen to annihilate with either a proton or a neutron since the energy released in the process has been shown to be greater than that corresponding to the mass of a single proton. Thus the existence of the antiproton, which was predicted in 1930 by P. A. M. Dirac, the English Nobel laureate, has been conclusively proved.

Some interesting facts have been learned about the annihilation phenomenon. In the annihilation most of the energy is carried away in pi mesons, about five pi mesons on the average being emitted. It was also found that antiprotons have a much larger probability than expected of interacting with protons or neutrons when passing through matter. It is now thought that this must mean there are strong mutual forces between the antiproton and proton, or neutron, which cause annihilation to occur at larger relative distances apart than was first predicted.

The use of the cosmotron at the Brookhaven National Laboratory at Upton, Long Island, and the bevatron at the University of California Radiation Laboratory, has made available for laboratory study new and important data on the interaction and the interrelation of fundamental nuclear particles. Many particles previously found only in cosmic radiation now can be produced in sufficient numbers in laboratories for quantitative investigation. The heavy mesons and hyperons are as yet little understood. The

heavy meson has less mass than a neutron or proton; the hyperon has a mass equal to that of a proton or neutron plus that of a meson. In seeking to understand the relationship of the mesons and hyperons to each other, and to the better-known nuclear particles such as the proton and neutron, investigators have studied the simplest interactions, since these should be the easiest to understand. The production of new particles in the elementary collision of an accelerated proton with another free proton, or studies of the interaction of one of the newly produced particles with other protons represent such simple interactions.

The mechanical and electrical restrictions of such accelerators as the Brookhaven cosmotron make it difficult to use free protons as a target inside the machine since hydrogen, which is needed in the liquid state to achieve the necessary target density requires a temperature of  $-252.8$  deg. Cent. to become liquid. Brookhaven has successfully developed an efficient method for extracting from the cosmotron an intense proton beam and directing it on a liquid hydrogen target placed outside the accelerator. This makes it possible to study the important elementary acts of production of heavy mesons and hyperons in hydrogen. Extracting the beam also permits greater freedom in placing apparatus for the detection of the particles. Since the new particles are highly unstable, having lifetimes between one millionth and one millionth of one millionth of a second, freedom of placement is an important advantage in experimentation.

The heavy-meson beam facilities at the University of California bevatron have been greatly improved during the past year. As a result, significant contributions have been made to understanding the production and properties of heavy mesons. The rate of production of positive heavy mesons by 6200 MeV protons is approximately five times the rate at 3000 MeV, and at present a beam of 5000 positive heavy mesons per hour makes counter experiments possible. Photographic emulsions have been exposed to both positive and negative heavy mesons. The emulsion work at Berkeley has yielded much information on the masses and other properties of the various types of mesons. Hyperons and unstable nuclear fragments have also been studied in emulsion, since they are among the products resulting when negative heavy mesons interact with ordinary nuclei. In addition to the large amount of emulsion research on these particles performed at Berkeley, there have been many emulsion exposures made for other scientific groups both in this country and abroad. Mutually corroborative work was done, and a natural expansion of the scope of the studies has resulted from this combined effort. The accelerated research programme and the accompanying increased rate of information exchange have made major contributions to high-energy physics.

Recently Dr. Donald A. Glaser, of the University of Michigan, developed the "bubble chamber," a new instrument for studying the mass, energy and reactions of high-energy nuclear particles. In order to follow the nuclear events of very high-energy particles that have long range, it is necessary to study them as they come to rest in a dense material. Previous to Dr. Glaser's development of a chamber filled with superheated ether, these studies could be made only in cloud chambers operated under very high pressure—of the order of 700 times the normal atmospheric pressure—or in photographic emulsions. Since Glaser's success with this technique, scientists have been experimenting with placing other materials in the bubble chamber, among them liquid hydrogen, propane and other hydrocarbons. During this report period, Dr. Glaser developed a bubble chamber that uses liquid xenon. He found that pure xenon would not work in the bubble chamber, but when diluted with a few per cent of a hydrocarbon it functioned very well. It is now planned to exploit this development by providing for a liquid xenon chamber large enough to stop the highly energetic particles from the large particle accelerators. The chamber will provide, for the first time, a particle detector which will allow the effects of all particles from high-energy reactions, as well as gamma rays

from the decay of neutral particles, to be seen at the same time.

The average number of prompt fission neutrons produced in fission by neutrons of plutonium atoms has been measured at the Argonne National Laboratory for numerous resonances in the region of neutron energy below 100 electron volts. It is found to be constant within a few per cent throughout this region. This constancy agreed with general theoretical expectation, but was contrary to results showing a resonance of about 0.3 electron volt which were reported at the International Conference on the Peaceful Uses of Atomic Energy in Switzerland last year. Similar constancy at low-energy resonances subsequently was found at several other laboratories, but the results have not been extended into higher resonances. The apparatus used in the study which was installed at the Argonne Research Reactor (CP-5), consisted of a newly designed chopper for producing neutron bursts, a new detector for recording triple coincidences between fission events and two of the secondary neutrons produced in them, and a new electronic analyser and recorder that sorts out these triple events into 1024 separate intervals of time measured from the instant the burst of neutrons was produced at the chopper. The events are thus investigated for 1024 different values of the velocity of the neutrons. The detector of the fission events employs a xenon gas scintillator developed at Argonne, and produces pulses that are very short compared with those obtained in early fission chambers which depended upon the collection of ions. Because of the speed scintillator, much more plutonium can be used without excessive piling up of the counts from the alpha particles. Efficiency consequently is increased, and the time of detection of the neutrons can be more accurately determined.

The directions of emissions of alpha particles from non-spherical nuclei have been found to be susceptible to experimental observation in recent experiments at the Oak Ridge National Laboratory. The alpha-emitting nuclei are built into special salts, that in certain crystalline forms have strong molecular electric fields. These fields act upon the nuclei so that, at very low temperatures, the nuclei point along preferred directions in the crystal. The observations then are made by comparing the alpha emission rate from different faces of the crystal at temperatures low enough (about 1 deg. absolute) to make sure that nuclear alignment is present, and at higher temperatures (several degrees absolute) where no alignment is present. Pronounced directional asymmetry of alpha particle emission has been observed in neptunium 237 and in uranium 233. Recent experiments at Oak Ridge on the states of atomic ionisation produced by radioactive decay have shown that the ionisation can be much more extensive than heretofore realised. The experiments are conducted by magnetic analysis of atoms after decay, and the results show how frequently one, two, three or more electrons are thrown from the atom. In xenon, the process of internal conversion of a nuclear gamma ray removes an electron from an inner shell of the atom. As a consequence, the complete outer electron shell containing eight electrons usually is stripped off, and half the total complement of fifty-four electrons may be ejected. The exact atomic mechanisms for these events are as yet imperfectly understood.

The so-called Knudsen cell method has long been used for the study of vapours in equilibrium with solids or liquids. The cell consists of a small furnace, completely closed except for a pinhole from which gases can escape. The amount that escapes is so slight that it does not affect the equilibrium between the solid and vapour present. By condensing and weighing the escaping material, it is possible to determine the vapour pressure at the temperature of the cell, provided the molecular composition of the escaping gas is known. At the Argonne National Laboratory, in experiments with such a cell, the escaping molecules were ionised by a stream of electrons and the resulting positive ions were analysed in the mass spectrometer. A considerable number of metal-metal oxide mixtures has been studied. In many cases, molecules of quite unexpected composition—the molybdenum oxide,

$\text{Mo}_5\text{O}_{15}$ , for example—have been found in the vapour. The experiments necessitate changing the interpretation of much earlier data obtained without such analyses, and throw light on the composition of the metal-oxygen molecules that are stable at high temperatures.

Electromagnetically enriched isotopes of plutonium, as well as isotopes of uranium, are now available in small quantities for nuclear research studies among Commission laboratories and contractors. The enriched products are allocated for use in both basic and applied research programmes. The highly purified isotopes are prepared at Oak Ridge in 24in radius calutrons, which have been modified to meet the exacting requirements for multi-stage separation of relatively small quantities of rare feed materials. The focus in the improved machines is such that the scattering of isotopes into adjacent isotope collectors is only 2 or 3 per cent. Since isotopes of high purity are required for precise nuclear measurements, more than one stage of separation is usually necessary. Gramme quantities of uranium 234 and 236 above 95 per cent purity, and tens of grammes of 99.9 per cent uranium 235 and 99.999 per cent uranium 238 have been obtained from the two-stage separation of special uranium feed materials. The quantity and purity of the separated isotopes are, of course, determined by the availability and composition of suitable feed materials. Single-stage isotope separations of plutonium, obtained from highly irradiated natural uranium, have yielded gramme amounts of plutonium 240 and a few hundred milligrammes of plutonium 241, with maximum purities of 85 per cent and 62 per cent, respectively. A method for recovering the rare isotope protactinium 231 from a uranium production residue was devised at the Mound Laboratory in Ohio. The first gramme produced will be used at the Oak Ridge National Laboratory to extend the knowledge of the chemical and physical properties of the element.

The Commission's programme of research on the controlled release of nuclear energy from fusion continued during the first half of 1956 at three major sites: the Los Alamos Scientific Laboratory, the Livermore Laboratory of the University of California Radiation Laboratory, and at Princeton University. Smaller projects were carried forward at New York University and Oak Ridge. Although it may be possible to use a number of light elements in the fusion process, the controlled thermonuclear programme has as its ultimate goal the controlled release of energy from the fusion of deuterium nuclei, and the use of this energy to provide an economic source of power. Since deuterium occurs in great abundance in sea water, it would constitute a source of energy virtually without limit. As contrasted with the fission process, in which a very heavy nucleus is split into lighter nuclei, the fusion process being studied under the Controlled Thermonuclear Programme involves a merging of two extremely light nuclei to form a heavier nucleus. Both processes are accompanied by a release of energy. In order to bring about fusion, sufficient kinetic energy must be provided to light nuclei so that they can overcome their mutual electrostatic repulsion and approach close enough to each other to allow fusion to occur. Accomplishing this will require creating a system in which light particles move in more or less random directions and are reflected many times from confining barriers before either escaping or undergoing fusion. It is estimated that the energies that would have to be provided to light nuclei so as to overcome their electrostatic repulsion correspond to temperatures of several hundred million degrees Centigrade. Since at these temperatures—equivalent to those in the interior of the sun—a reaction chamber of any material would vaporise instantly, another method of containment has to be devised. The only thing which conceivably is capable of containing this type of reaction is an electric or magnetic field, which might be used to insulate the walls of a reaction chamber from extremely high temperatures at the centre of the container. Thus, in essence, the problem involved in controlling a thermonuclear reaction is that of ionising a suitable material, such as deuterium, heating the resulting plasma to temperatures of 100 million deg. Cent. or higher, and confining it at this temperature long enough

to permit an appreciable fraction of the ions to fuse with a consequent release of energy. The energy thus released would then have to be converted into electrical power either directly or through suitable heat exchangers.

Each laboratory engaged in the programme is pursuing a somewhat different approach to this problem. The research certainly is on a very long-term basis, but it is probable that success will be achieved eventually. It is, however, reasonable to expect that an approach as yet unformulated may yield the greatest promise of success. A number of statements can be made about the probable characteristics of a fusion reactor. Any thermonuclear power unit gives promise of being extremely safe. The amount of fuel within the thermonuclear machine at operating temperatures would be simply that required to sustain a normal power output of the device at any instant, and this amount would be extremely minute. The fuel supply itself would be stored outside the machine chamber and would be wholly incapable of participating in the reaction without first being introduced into the reactor and heated. The possibility of a serious accident due to failure of a component or to human error seems virtually negligible. In addition there probably would be no fission products to escape in the case of an accident. Any thermonuclear reactor that consumed hydrogen isotopes as a fuel would produce intense fluxes of neutrons. As a result of the copious yields and high energies of the neutrons involved, care would have to be taken to provide adequate shielding from this radiation. It is conceivable that a controlled thermonuclear reactor, burning a fuel of helium 3, for example, might eventually be developed which would produce no neutrons at all, and for which no neutron shielding would be required. Such a reactor is purely of academic interest for the foreseeable future, since the temperatures which would have to be achieved in this case to energise the helium atoms would be much greater than even the enormous temperatures required for deuterium.

#### THE EBR-1 FUEL MELT-DOWN INCIDENT

On November 29, 1955, a power surge occurred which resulted in damage to the Experimental Breeder Reactor No. 1 (EBR-1), which has been operated by the Argonne National Laboratory at the National Reactor Testing Station. The incident occurred in the course of experiments intended to determine the cause of certain nuclear instabilities noted during the operation of the reactor at low power. It was known in advance that there existed a real possibility that the experiment could result in a melt-down of the fuel. The results of the experiments were considered sufficiently valuable to the fast breeder reactor programme to warrant the degree of risk involved. The particular experiment that resulted in damage required allowing the reactor temperature to rise without coolant flow until the fuel temperature increased by a large amount. It had been anticipated that the reactor period to be reached in this experiment would be so short that period meters installed in the reactor control system could not be set without rewiring the meter circuits. (The reactor period is that length of time in which a reactor increases its generation of neutrons 2.7 times.) Accordingly, the pile period meter had been disconnected from the "scram" circuit which shuts down the reactor instantaneously in emergency and it was left for the operator, or for automatic power level circuits, to shut the reactor off when this became necessary.

Excess reactivity was introduced into the reactor, so that its initial period was sixty seconds at a power level of a few watts. As the power and temperature increased, the reactor's period shortened. At a power level of about 150kW to 200kW, a period of less than five seconds, much shorter than usual, was reached. At this point the scientist in charge called to the reactor operator to press a button which would have cut off reactivity very rapidly. The operator misunderstood and began to move the control rods at their normal speed, reducing reactivity slowly. When the scientist noticed this, he pressed the "reactor scram" button. At the same time, the automatic power level controls were triggered, and shut down the reactor. They

were set to operate when the power level reached 1500kW. This whole operation took place within two seconds. Shortly after the excursion occurred, radioactivity was detected in the building and personnel were promptly evacuated. There was no over-exposure to radiation or other injury. Monitoring instruments recorded no release of radioactivity to other portions of the testing station, or to the surrounding area.

Information on the incident at first remained incomplete and speculative, as the reactor was too radioactive to permit proper inspection. It was not until May 17th that it became possible to remove the core from the reactor vessel, since then it has been feasible to dismantle and examine limited portions of the reactor core. Further dismantling has been prevented by the consequences of the extreme heat reached in the reactor during the experiment, now known to have exceeded the melting point of uranium, 1130 deg. Cent. It was not known during the experiment that temperatures had reached this level because three thermo-couples which measured core temperatures were not operating properly. The heat caused fusing together of some of the fuel rods and of various other parts of the core, and they cannot be separated by disassembly methods previously in use without danger of ignition and breakage. The balance of the core will therefore be removed as a unit and disassembled under the more controlled conditions of a "hot" laboratory. Significant observations which can already be made as a result of the experiment are that, in this case, substantial melting of the fuel did not produce a violent nuclear reaction, and the radioactive products of the melt-down were readily contained. Dismantling of this highly radioactive system is providing valuable experience in remote handling of large radioactive objects. It is believed that the instability displayed by the EBR-1 is not characteristic of fast breeder reactors in general, and that it can be corrected by modifications of the core and fuel elements. Work to establish this conclusion more firmly is now proceeding.

Following the fuel melt-down incident at the National Reactor Testing Station both the local management of the station and the A.E.C. in general were subjected to considerable criticism in American atomic energy circles, and several American technical journals carried leading articles accusing the Commission of poorly managed public relations in this matter. Some of these criticisms were answered in a statement released by Dr. Walter H. Zinn, the former director of the Argonne National Laboratory, which was responsible for the operation of the EBR-1. Since this entire incident is of considerable interest to nuclear engineers we quote from this statement as follows.

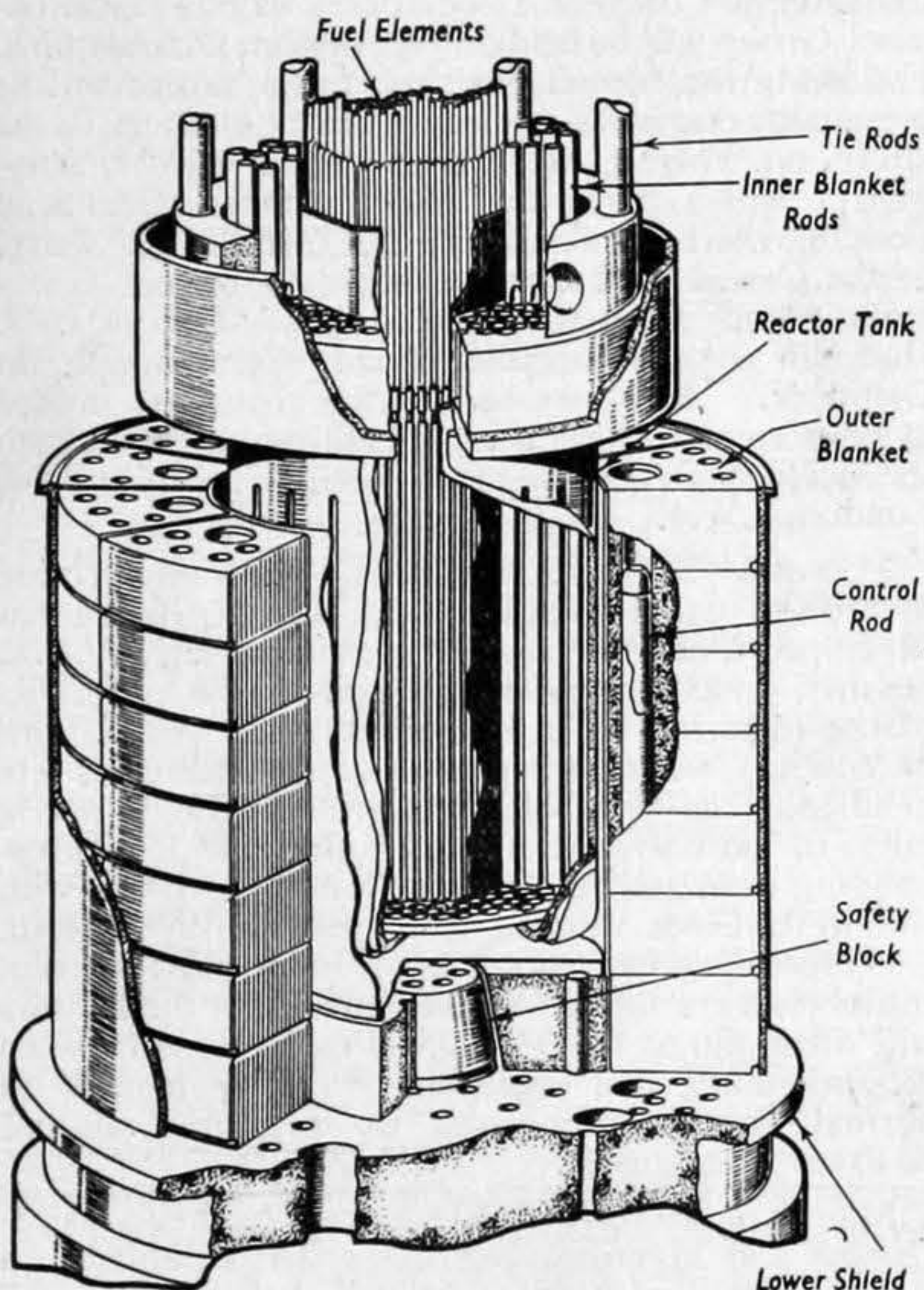
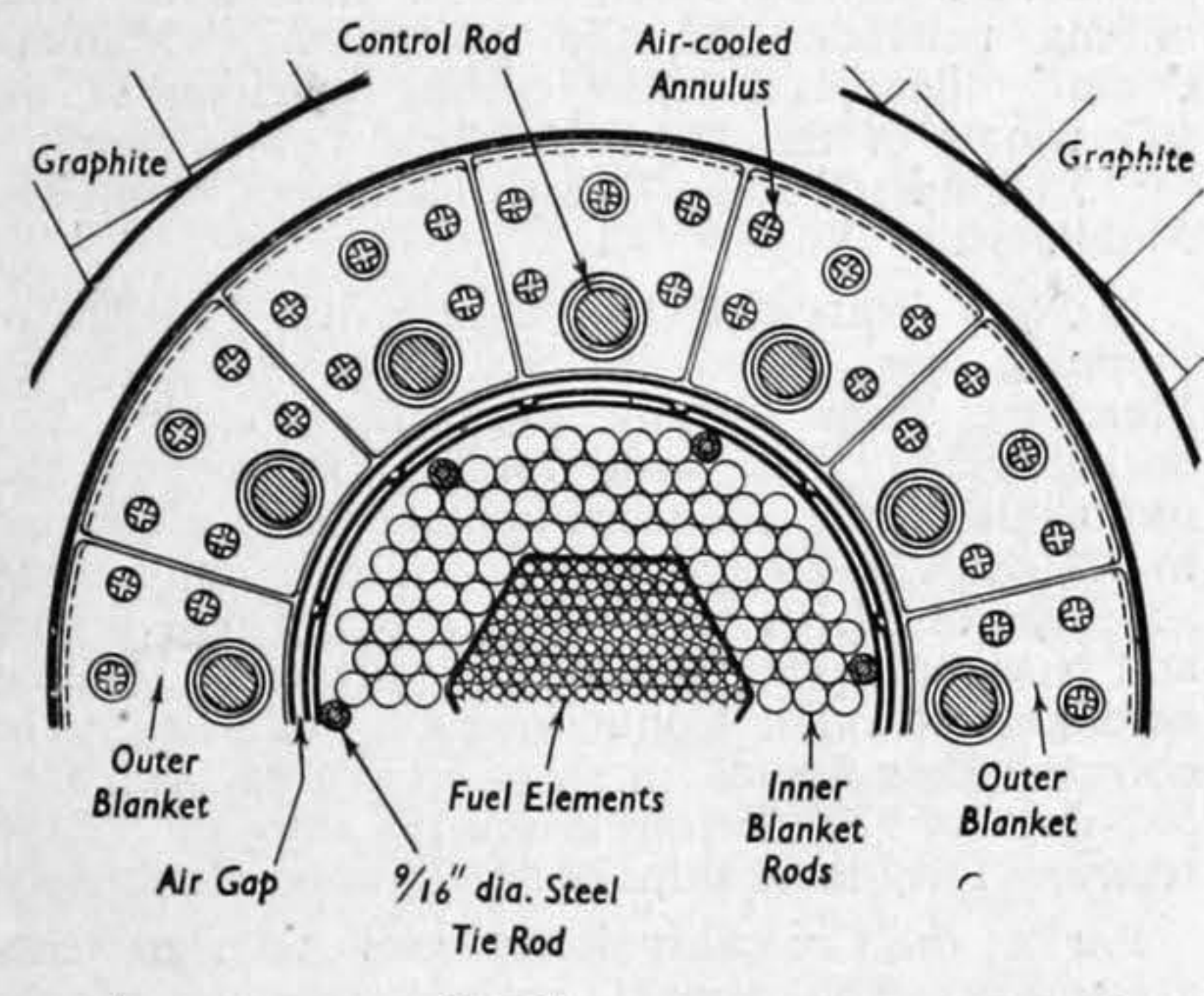
#### STATEMENT BY DR. WALTER H. ZINN

"As far as I know, it never has been claimed by anyone who is knowledgeable in reactor technology, that, under the proper circumstances, fuel elements of metallic construction could not be melted in a reactor. In the EBR-1 case, the experiment in hand was of such a nature that it fully qualified as a proper circumstance. In this letter, some detailed information about the event is given so that its relation to power plant operation can be judged.

"(1) EBR-1 has been used for a number of years in an experimental programme, mostly in the physics of fast reactors. The reactor was scheduled to be placed in standby early in 1956, and the fuel was to be sent to chemical processing and not replaced unless new experimental uses developed. This decision was made because all experiments that were practical to perform and that might be expected to yield useful results had been carried out and because there had been placed into operation at the same site a new zero power reactor of much greater versatility. As a last experiment, however, it was decided to make measurements on transient temperature coefficients. Briefly, the experiments consisted of measuring changes in reactivity of the reactor as the temperature of the fuel elements was increased. By far the most difficult part of these experiments involved placing the reactor on a short positive period and permitting the fuel temperature to rise to 500 deg. or 600 deg. Cent. Because it was

desired to obtain the temperature coefficient of the fuel only, it was necessary to shut off the flow of the liquid-metal coolant. Therefore, it can be said that the experiments were done not on an operating reactor but actually on a critical assembly.

"(2) Two details of the design of EBR-1 should be in mind in considering this experiment. First, the fuel elements of EBR-1 are cylindrical rods of diameter slightly under  $\frac{1}{2}$  in. The uranium fuel cylinder is bonded by liquid metal to the stainless steel cylindrical jacket. Secondly, because EBR-1 is an experimental tool, the design required that the fuel elements should be remov-



Details of core construction of "EBR-1" reactor showing U-235 fuel elements, inner and outer blankets of U-238, control rods and graphite reflector

able individually, although it would have been much simpler to have fastened the fuel elements to each other in a compact core. Because each fuel element has to be removable individually, it passes through a holding plate for which the average clearance between the hole of the holding plate and the fuel element jacket is only six thousandths of an inch. This means that a small amount of distortion of the jacket is sufficient to prevent the removal of the fuel element from the core. Because of the liquid metal bonding, the uranium part of the fuel element can distort without producing distortion in the jacket. This feature of design has been so successful that in the almost five years of use of the reactor no fuel jacket has distorted sufficiently to fail to pass through the holding plates, although there have been a number of difficult-to-remove rods. However, in the original design it had been anticipated that such distortion might occur. In that event, it was expected that the whole core assembly would be lifted out of the reactor tank and dismantled in order to remove the fuel. This, in fact, is the method which is used in other reactors where the fuel element core is of small dimensions. Increasing the temperature of the uranium rapidly involved very considerable

chance of distorting the fuel-element jackets, especially since uranium metal and stainless steel form a eutectic at about 725 deg. Cent. This is very little above the temperature to which it was desired to pulse the fuel elements.

"(3) That there was some risk of melting the fuel elements was well appreciated. In fact, when the experiments began in November, 1955, I, as a matter of course, informed the Atomic Energy Commission that in my opinion there was a real possibility that such results could follow. I also expressed the opinion that the information being sought was highly necessary and that the risk to be taken was not excessive.

"(4) The experiment, to be successful, required sizeable temperature excursions with short time constants. A comparison would be the Borax experiments on water-moderated reactors that were done by Argonne in 1953. The excursion in question was one in which the power doubled about every 0.27 second. The temperature of the uranium was to be permitted to rise to approximately 500 deg. Cent. This meant that the shut-down of the reactor would have to be rapid and would have to be initiated at the proper instant. Because of the rapid temperature rise required by the experiment, an error of one second in initiating the shut-down could be expected to give trouble. From some news reports the impression may have been gained that no instrumentation was used. This is erroneous: the normal multiple-circuit power-level shut-down instrumentation was fully operative and, in fact, acted swiftly and correctly when the normal operating power was reached. The reactor-period meter was disconnected, since it did not have the flexibility that would permit it to be used for excursion experiments.

"(5) In previous experiments of this type, it had been possible to interrupt the excursion and return the reactor to low power by making use of the motor-driven control rods. These subtract reactivity slowly. In this excursion, the technician at the control panel was expected to use the fast-acting shut-off rods upon receipt of a spoken instruction from the scientist in charge, who was observing closely special neutron and temperature recorders. These instruments were special in the sense that they had time constants much shorter than the normal operation instruments. Upon receiving the instruction to shut down the reactor, the technician repeated the use of the slower control rods. The staff scientist, as soon as he realised the situation, reached over and pressed the rapid shut-off button and, simultaneously, the automatic power-level trips responded to activate the shut-off rods. The delay in time, which was at most two seconds, was sufficient to permit the reactor power to overshoot to a point where the alloying of uranium and steel and melting of the uranium took place.

"(6) The reactor, of course, shut down, and there was no way by sound or sight to know that anything untoward occurred. The record of the power level of the reactor as indicated by the neutron flux did show that the power surge might have raised the temperature of the fuel elements too high, but the many thermocouples attached to the fuel did not show an excessive temperature. Past experience has been ample to show that where thermocouples are embedded in uranium metal, rapid changes in temperature may not be recorded.

"(7) How, then, was it known that melting of the fuel had occurred? There was, of course, no unusual noise, explosion, or fire. It is characteristic of this work that the first indication came through radioactivity. After a period of fifteen minutes, detectors for radioactivity installed both in the cooling system, some distance from the reactor, and in the ventilation exhaust ducts of the building began to show readings higher than normal. From the detector installed in the cooling system, it could be inferred that gaseous radioactive fission products had diffused through the gas blanket connections to the point where the detector was installed. (It should be recalled that the coolant was not flowing.) The activity in the building exhaust, while low, also was abnormal. This was due to the fact that the thermocouples for this experiment had been installed with temporary connections that did not seal gas-tight, so that some of the radioactive gas in the reactor vessel diffused into the

room. As a precaution, the room was evacuated promptly. Normal use of the room was resumed just as soon as quantitative measurements of the activity could be made. On later examination, it was found that while some of the fuel rods could be removed, many could not be pulled through the holding plate.

"(8) Fuel from this reactor is sent for processing to the Reactor Testing Station chemical processing plant. An extended period of radioactive decay is desirable before chemical processing begins. Since the procedure of lifting the core holder and the fuel elements as a unit from the reactor is easier if the radioactivity has decayed, this operation has been delayed while the cooling takes place. Inasmuch as there is no programme immediately requiring the use of the reactor, there is no urgency about removing the core. In due course, this will be done. Once the damaged fuel elements have been cut away, it is expected that the coreholder can be reassembled and dropped back into the tank.

"(9) There has been considerable comment concerning the fact that the events of November 29th were not reported publicly. Since it is believed that experiments of this type and the mishaps that can be expected when such experiments are attempted should not be classed as accidents, this event was handled and reported as any other experiment. It would be a disservice to the progress of our atomic energy programme if such occasions are not treated as unfortunate penalties exacted by the necessity of getting on with the job.

"(10) There also has been some comment that information vital to industrial programmes was withheld. This is not true, since the only company that conceivably could have a prime interest in the experiment being performed, the Atomic Power Development Associates, Incorporated, had a representative present as a participant in the experiments.

"(11) It also has been claimed that the A.E.C. was not informed. On the contrary, the A.E.C. was informed by me on November 30th, by telephone and, subsequently, in a number of written statements. At other times, A.E.C. officials have received first-hand accounts at the site from the scientists who were performing the experiment. Also, the Atomic Energy Commission's Advisory Committee on Reactor Safeguards was informed to ensure that no misinterpretation of the matter could affect the deliberations of that committee. It must be pointed out that no one was injured, and that the mechanical damage, it is expected, will be confined to the fuel elements, which were to be dissolved anyway. There is justification, therefore, in the belief that information was not withheld from anyone who could profit by it.

"(12) The unplanned part of this experiment has yielded some information of a useful nature as follows:—(a) the behaviour of the reactor was observed as its power rose into the damaging region, and it was evident that no unforeseen or catastrophic processes occurred. (b) The melting behaviour of fuel elements in liquid sodium was observed for the first time under actual conditions of reactor operation. The metallurgical behaviour of fuel elements and their containers under conditions of rapid melting or softening is one that can be studied in no other way than by the rapid increase of power in an actual reactor. Examination of the fuel elements should yield important data on this behaviour. (c) The relative ease with which the radioactivity released into the reactor coolant was controlled has indicated that the melting of highly radioactive fuel elements in sodium is not very hazardous to the reactor surroundings. Observations on the behaviour of this activity may be of value in the development of methods of detecting individual fuel-element failures in power reactors. (d) The process of removing the core will provide new experience since it is the first highly radioactive sizeable object to be removed from a sodium coolant. If this experience is favourable, it may lead to economies and simplifications of handling methods in cases of a more routine nature.

"It is my hope that this statement will help in correcting whatever misunderstandings exist of this event. Above all, I hope that it will help those interested in atomic energy to understand the problems faced by experimenters.

# Personal and Business

## Appointments

MR. F. W. MARTIN has been appointed a director of Tube Investments, Ltd.

MAJOR-GENERAL C. A. L. DUNPHIE has been appointed managing director of Vickers, Ltd.

MR. P. CLARKE has been appointed chief engineer of Firth-Vickers Stainless Steels, Ltd., Sheffield.

MR. V. W. PRESS and Mr. W. R. Jones have been appointed directors of Lancashire Dynamo Nevelin, Ltd.

de Havilland Propellers, Ltd., states that Mr. A. S. Wheate, secretary, has been appointed a director.

MR. J. U. COOKE has been appointed export director of A.C.V. Sales, Ltd., Berkeley Square, London, W.1.

MR. K. COLLINSON, A.M.I.E.E., has been appointed manager of the Leeds branch of British Insulated Callender's Cables, Ltd.

W. H. DORMAN AND Co., Ltd., Stafford, states that Mr. J. W. Whimpenny, general manager, has been appointed a director.

GENERAL SIR WILLIAM D. MORGAN, chairman of Siemens Brothers and Co., Ltd., has been appointed chairman of Submarine Cables, Ltd.

MR. G. A. MARRIOTT, a director of the Marconi-Osram Valve Company, Ltd., has been nominated president for 1956-57 of the British Institution of Radio Engineers.

THE CENTRAL ELECTRICITY AUTHORITY has announced the appointment of Mr. H. E. Vickers, M.I.E.E., as chief generation engineer (operation) of the South Western Division.

MR. ANDRE L'HERMINIER, managing director of La Mont Steam Generator, Ltd., has been appointed executive chairman of the La Mont International Association, 42, Leicester Square, London, W.C.2.

THE MINISTRY OF WORKS has announced the appointment of Mr. W. T. Lewis as regional director, S.W. region, in succession to Mr. E. Hughes-Jones, who has retired. Mr. D. F. Mann succeeds Mr. Lewis as regional director, N.W. region.

LANCASHIRE DYNAMO AND CRYPTO, Ltd., has announced the appointment of Mr. J. Taylor as commercial manager at the Trafford Park works, Manchester, in succession to Mr. H. H. Eaton. Mr. Eaton is retiring after fifty-three years in the company's service.

SHEEPBRIDGE ENGINEERING, Ltd., states that Mr. B. C. Goodwin has been appointed sales manager of Harold Andrews Sheepbridge, Ltd. Mr. C. J. Calori has been appointed sales director of Hardinge Machine Tools, Ltd., which is a member of the Sheepbridge group.

MISS MARY GEORGE has been appointed director and secretary of the Electrical Association for Women, 25, Foubert's Place, London, W.1. She succeeds Dame Caroline Haslett, who has retired from office but who continues to serve as the Association's honorary adviser.

THE BRITISH TRANSPORT COMMISSION has appointed Mr. Arnold G. Kentridge to be principal of the work study training centre which is to be established at The Grove, Watford. At present, Mr. Kentridge is acting head of the School of Commerce (Management Studies), Leicester College of Technology.

RUSTON AND HORNSBY, Ltd., Lincoln, announces the retirement of Mr. J. H. Trickey, M.I.Mar.E., from his position as engineer-in-charge (marine), after twenty-five years in the company's service. Mr. P. H. Hylton has been appointed manager, marine department, Mr. P. F. Dilnot, marine installation manager, and Mr. R. L. Rawlings, engineer-in-charge, marine installations department.

ROLLS-ROYCE, Ltd., has stated that Lord Hives, C.H., has decided to retire from the chairmanship and from the board in January. Lord Kindersley is to succeed Lord Hives as chairman, and Mr. J. D. Pearson and Mr. Whitney Straight will become deputy chairmen. Mr. Pearson is to be the chief executive of the company and will continue as managing director of the aero engine division. Mr. F. Llewellyn Smith is to continue as managing director of the motor-car division, and Mr. W. A. Robotham has been appointed managing director of the oil engine division.

## Business Announcements

THE RUBEROID COMPANY, Ltd., is building a new paper mill at its factory at Brimsdown, Middlesex.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has acquired a new factory at Huyton, near Liverpool.

W. J. FRASER AND Co., Ltd., has opened a new pilot-scale process laboratory at Harold Hill, Romford, Essex.

STERN AND BELL, Ltd. (a member of the Triplex group), is erecting a new factory at Stour Street, Birmingham.

CHLORIDE BATTERIES, Ltd., has opened a new supply and service depot at Colliery Road, West Bromwich, Staffs.

MR. F. T. HEARLE has retired from the board of de Havilland Holdings, Ltd. He is one of the founder members of The de Havilland Aircraft Company, Ltd.

THE MARCONI INTERNATIONAL MARINE COMMUNICATION COMPANY, Ltd., has moved its Belfast office to Marconi House, 2, Corporation Square, Belfast (telephone, Belfast 22250).

THE COUNCIL OF THE BRITISH ELECTRICAL DEVELOPMENT ASSOCIATION states that, on account of his health, Mr. V. W. Dale will shortly retire from his position of director and secretary.

KEITH BLACKMAN, Ltd., has acquired control of the Blackman Export Company, Ltd. Mr. D. S. Woodley has been appointed chairman of the latter company, which will continue its business at 23, Queen Square, Southampton Row, London, W.C.1.

LANSING BAGNALL, Ltd., Basingstoke, has formed a subsidiary in Canada under the title of Lansing Bagnall of Canada, Ltd. Its headquarters are in Toronto. Mr. P. A. Berry, formerly the export sales manager in this country, will manage the business in Canada.

## Contracts

W. J. FRASER AND Co., Ltd., Harold Hill, Romford, Essex, has received a contract valued at over £1,000,000 for the erection and equipment of a fertiliser factory at Woodend, South Island, New Zealand.

LONDON TRANSPORT has ordered 850 A.E.C. "Routemaster" double-deck buses for delivery, commencing 1958. Early in 1959 these will replace some of the 1500 trolley-buses which have completed about twenty years' service. Announcing the order for diesel vehicles, London Transport drew attention to the report, published in the *British Medical Journal*, of experiments showing that the concentration of benzpyrene was no higher inside than outside one of its bus garages.

THE GENERAL ELECTRIC COMPANY, Ltd., has received an order from the U.K. Atomic Energy Authority to build the turbo-alternator to be installed in Britain's first fast breeder-reactor nuclear power station, now under construction at Dounreay, Scotland. The contract is for one 15MW steam turbo-alternator, to operate initially under steam conditions of 150 lb per square inch gauge, and 518 deg. Fah. temperature, and to generate at 11kV, three-phase, 50 c/s. The turbine will be built at the Fraser and Chalmers Engineering Works (at Erith, Kent), which is also the research and design centre of the G.E.C.-Simon Carves Atomic Energy Group. The Motherwell Bridge and Engineering Company, which is in association with this group, is building the sphere which will contain the breeder-reactor at Dounreay.

THE award of a 92,000,000 dollar contract to an American construction firm—believed to be the biggest "turnkey" contract of its kind ever signed in the U.S.A.—has brought the English Electric Company sub-contracts for hydro-electric machinery and associated equipment worth approximately 24,000,000 dollars. The 12,000,000 dollars order recently announced by the Grant County Commissioners covering water turbines formed part of this contract. The main contract is for the construction of a new dam and power house at Priest Rapids on the Columbia River. It has been given by Grant County Public Utility District No. 2, of Ephrata, Washington State, in the Pacific Northwest, to the Merritt-Chapman and Scott Corporation. A sub-contract for water turbines, generators and transformers, valued at approximately 24,000,000 dollars, has accordingly been awarded to The English Electric Export and Trading Company. The Priest Rapids site is downstream from Grand Coulee, Chief Joseph and Rock Island dams, but upstream of McNary dam and immediately above the confluence of the Snake River with the Columbia River. The plant to be installed by English Electric will comprise eight 114,000 h.p. water turbines and eight generators, each having an output of 83MVA at 85.7 r.p.m. The output from each pair of generators will feed into a step-up transformer; five 13.2/230kV transformers (one being a spare) will be supplied, each having an output of 183MVA.

## Miscellanea

ANTI-SKID BRAKING.—The electro-mechanical anti-skid detector mentioned on page 365 of our issue of September 14, 1956, is an entirely new product of the Goodyear Tyre and Rubber Company, Ltd., and not a modification of the all-electric component.

MACHINE TOOL DEMONSTRATION.—During the week beginning October 15th a series of demonstrations will be given of the Heckler and Koch automatic production milling machine, the Rambaudi VR2, milling machine and the Mannaioni "Man-au-Cycle" high-speed screw cutting machine at the showrooms of the Elgar Machine Tool Company, Ltd., Hampton Road West, Hanworth, Feltham, Middlesex.

LOYD'S WRECK RETURNS.—Lloyd's Register of Shipping has issued its Statistical Summary of Merchant Ships Totally Lost, Broken Up, &c., during 1955. The world total of steamships and motorships lost consequent upon casualty amounted to 178 ships of 254,658 tons gross, including twenty-six ships of 37,704 tons belonging to Great Britain and Northern Ireland and thirty ships of 26,244 tons belonging to other Commonwealth countries. The corresponding figures for ships broken up, &c., are: 503 ships of 920,426 tons gross, 189 ships of 212,196 tons and forty-three ships of 56,035 tons, respectively.

PAPERS ON CONCRETE ROAD AND AIRFIELD CONSTRUCTION.—The annual general meeting of the Cement and Concrete Association's Pavings Development Group will be held on Wednesday, October 17th. Following the formal business, three papers will be presented, one in the morning and the others in the afternoon. Mr. F. R. Martin, of the Air Ministry, will present a paper on "Recent Developments in Concrete Airfield Construction," Mr. D. R. Sharp, of the Cement and Concrete Association on "Concrete Road Construction To-day," and Mr. J. Hoffman on "Concrete Road Construction in Denmark." Non-members of the group are invited to be present to hear the papers, but should inform the secretary at Terminal House, Grosvenor Gardens, London, S.W.1.

FLEXIBLE P.T.F.E. BELLOWES.—The engineering division of Crane Packing, Ltd., Slough, Bucks, has developed a new process for manufacturing P.T.F.E. bellows, which, because of the particular properties of the material, have many specialised applications particularly where corrosive liquids and gases are handled. The bellows are at present available in a range of bore sizes from ½in to 6in, and in corresponding nominal free lengths from 1½in to 3in with wall thicknesses ranging from 0.020in to 0.040in. Corresponding extensions are from 0.6in to 1.6in. Initial tests are stated to have shown that the bellows will withstand at least 1,000,000 oscillations between the minimum and maximum working lengths at normal temperatures, and at pressures around 30 lb per square inch.

MASTIC ASPHALT.—The Natural Asphalte Mine-Owners and Manufacturers Council has published a booklet entitled "Specifications and Safeguards," which sets forth the policy now adopted by the member firms. The booklet is intended for the guidance of architects and engineers in preparing specifications for mastic asphalt and recommends that they should be those of the British Standards Institution. It recommends that the material should bear the B.S.I. "Kite" mark and appropriate specification number, together with the manufacturer's mark. With regard to "safeguards" the booklet suggests insistence that the contractors furnish: a certificate of origin, a certificate concerning the appropriate marking of blocks, and particulars of the place of manufacture of the mastic asphalt. Copies of the booklet may be obtained free from the Council's offices, 94/98, Petty France, London, S.W.1.

FRIAR'S WASH WATER SCHEME.—Opening of the Friar's Wash pumping station was referred to recently in our "Seven Day Journal." More than 3,000,000 additional gallons of water a day will be available to consumers in Luton and Dunstable following the opening of the station, which cost £320,000 and has been constructed jointly by the Luton Water Company and the Eastern Gas Board, who are the water undertakers for Dunstable. A borehole 36in diameter at ground level, reducing to 27in diameter at the bottom, 342ft deep (11ft A.O.D.) serves the station. Water is delivered to the Chaul End covered service reservoir by a 24in diameter spun-iron, bolted-gland-jointed pipeline, 8000 yards long, the maximum static pressure being 267ft. From the reservoir water is delivered to the distribution mains system by a 24in diameter spun-iron main 730 yards long. The reservoir has a capacity of 5,000,000 gallons.

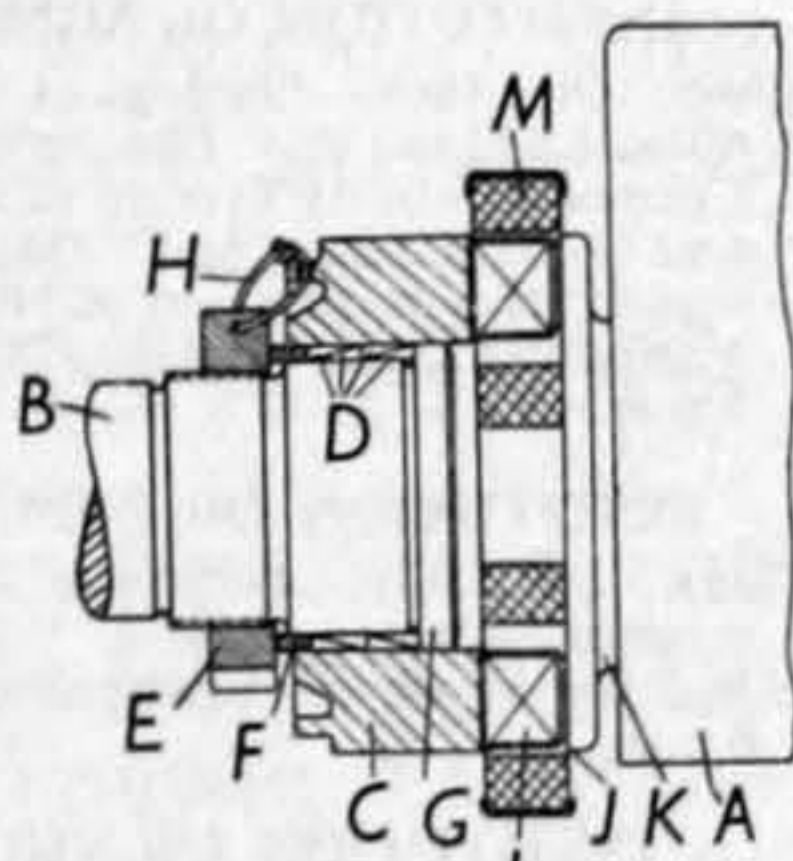
**British Patent Specifications**

*When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. 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. each.*

**INTERNAL COMBUSTION ENGINES**

**756,836.** December 22, 1954.—**COUPLING FOR INJECTION PUMP,** Fried. Krupp Motoren- und Kraftwagenfabriken G.m.b.H. (formerly known as Sudwerke Motoren- und Kraftwagenfabriken G.m.b.H.) of Essen, Germany.

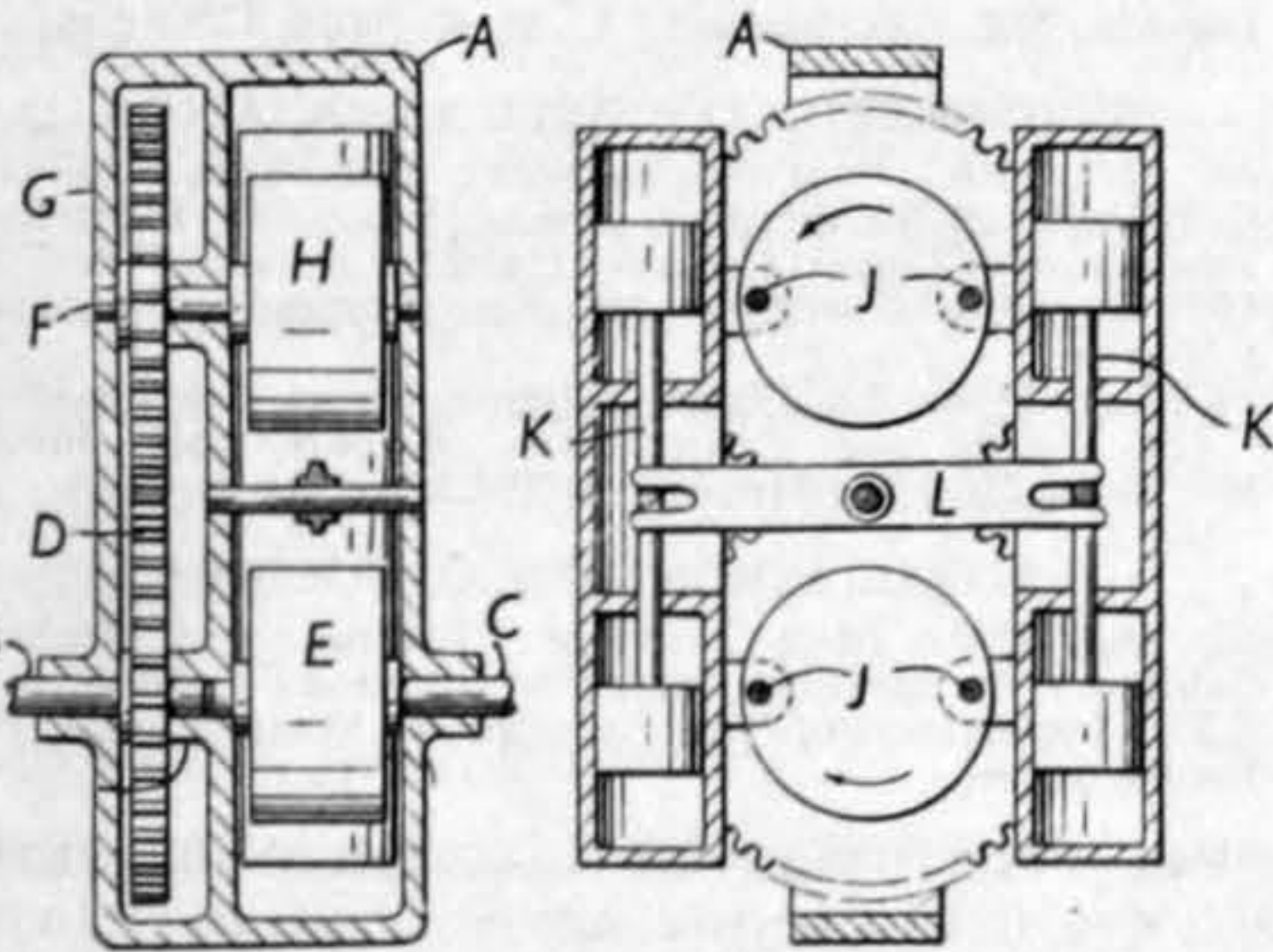
The invention relates to couplings for fuel injection pumps for internal combustion engines which provide a simple and convenient way of adjusting the coupling. As will be seen from the drawing, the injection pump *A* is driven by a shaft *B* connected to the engine shaft by gearing not shown. One flange *C* of the coupling is locked to the driving shaft *B* by means of annular tightening elements *D*. The elements consist of endless rings, arranged in pairs and having conical contacting surfaces, which produce a radial locking pressure when they are pressed together axially. After setting the injection timing, the rings are pressed by tightening a nut *E* and through the agency of a distance piece *F* against a collar *G* on the driving shaft, thus producing a radial pressure sufficient to ensure transmission of the drive by friction. The nut *E* is prevented from coming loose by a safety wire *H*. The flange *C* and the flange *J* on the pump shaft *K* engage by means of claws *L*. An elastic disc *M* provided between the flanges *C* and *J* constitutes a shock absorber.—September 12, 1956.



No. 756,836

**756,865.** August 14, 1953.—**A NOVEL RECIPROCATING ENGINE,** Frederick Arthur Summerlin, 20, Brantwood Avenue, Isleworth, Middlesex.

The invention relates to reciprocating internal combustion engines and its object is to provide an engine which is not liable to stall and which will not require a gearbox merely because of the inability of the engine to develop the necessary torque at a desired speed. As shown in the drawing, the invention comprises essentially two piston-cylinder units, arranged to drive a pair of coaxial shafts through free wheels. The two output shafts may be used to drive the wheels of a road vehicle. As the two shafts are not directly connected, their angular speeds can be different if necessary, e.g., when the vehicle is cornering. The engine is mounted in a frame *A* which is formed with bearings for the two output shafts *B* and *C*. Carried on the output shaft *B* is a gear wheel *D* and carried on the shaft *C* is a free wheel *E*, the shaft being rigid with the driven part of the free wheel. Mounted in bearings in the frame *A* is a shaft *F* on which are carried a gear wheel *G* which meshes with, and is the same size as, the gear wheel *D*, and a free wheel *H*, the driven part of which is rigid with the shaft. The cylinder units of the two oscillating piston engines are mounted



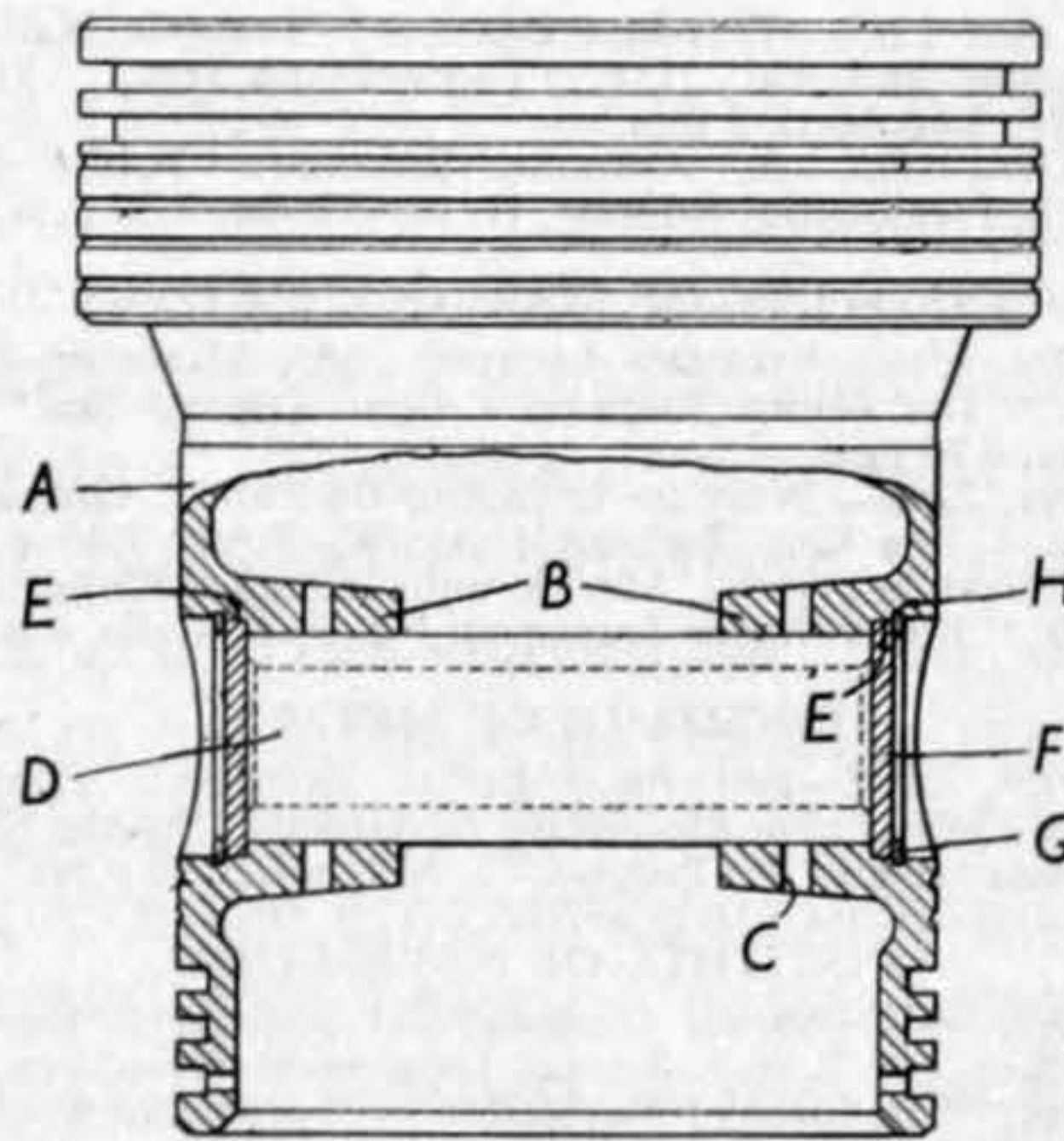
No. 756,865

on the driving parts of the two free wheels by means of pins *J*. The pins are rigidly secured to the driving parts of the free wheels *H* and *E*. The piston-rods *K* of the two engines are coupled by means of a link *L* which is pivoted at its centre on a pin fixed in the engine frame. U-shaped slots are provided in the ends of the link and the pins fixed to the piston-rods are arranged to rotate and slide in these slots. Thus, the piston-rods are constrained to move in anti-phase relative to the engine frame. In view of the difficulty of designing robust and

reliable free wheels of the ratchet and pawl type, the free wheels can conveniently consist of conventional gear pumps modified as explained in the specification, which also shows modified arrangements.—September 12, 1956.

**757,226.** November 17, 1953.—**MOUNTING A GUDGEON PIN IN A PISTON,** Bristol Pneumatic Tools, Ltd., Causeway Works, Fishponds, Bristol; and Hugh Carlisle Wescombe, "Oakdene," Oakdale Road, Downend, Bristol.

The invention relates to means for mounting gudgeon pins in pistons and in particular to an arrangement for the mounting of the gudgeon pin in the piston of a two-stage air compressor. Referring to the drawing, the piston *A* has a pair of inwardly projecting bored bosses *B*, preferably provided with one or more transverse bores *C* for the lubrication of the ends of a gudgeon pin *D* mounted with a free fit in the bosses. At the outer end of each of the bored bosses is a counter bore *E*, which forms a seating for a disc *F* of bronze, aluminium or other suitable material. This metallic disc is of greater diameter than the diameter of the gudgeon pin *D* and under non-

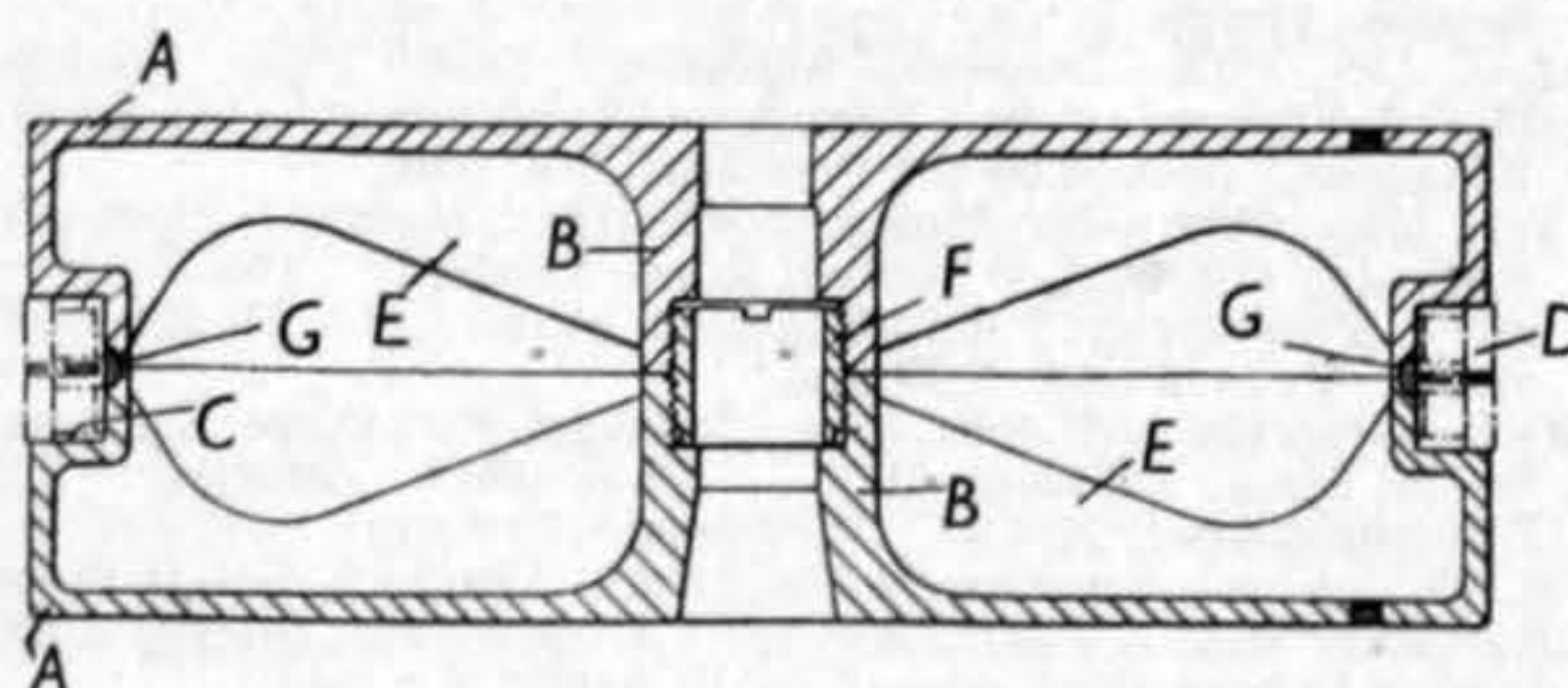


No. 757,226

working conditions is retained in its seating by means of a ring clip *G*, adapted to snap into an annular groove *H* in the counter bore *E*. When the gudgeon pin mounting is applied to the piston of a two-stage air compressor the air in the high-pressure chamber of the compressor will tend to force the discs *F* against their seats in the counterbores. Thus the discs will function as sealing means for preventing leakage of air from the high-pressure chamber through the gudgeon pin mounting under working conditions and the discs also serve to retain the pin in its mounting. As the gudgeon pin is a free fit it is liable to a degree of rotary movement during operation and for this reason the bored bosses are preferably provided with transverse lubricating bores *C*.—September 19, 1956.

**757,425.** April 6, 1954.—**PISTONS,** Belliss and Morcom, Ltd., Ledsam Street Works, Birmingham, 16. (Inventor: Henry Edward Muckley.)

The invention relates to pistons for air or other gas compressors, pumps, engines, and like reciprocating machines, the object of the invention being to provide a hollow piston of improved construction. Referring to the drawing, each half *A* is made as a hollow steel casting having a flat end face and a peripheral flange. At its centre each half has formed on it a hollow and inwardly extending boss *B* for attachment to a piston-rod. The periphery of each half is shaped to form an annular step *C* such that when the two halves are placed together the two steps form a circumferential groove for piston rings *D*. Each half may also be stiffened by internal radial



No. 757,425

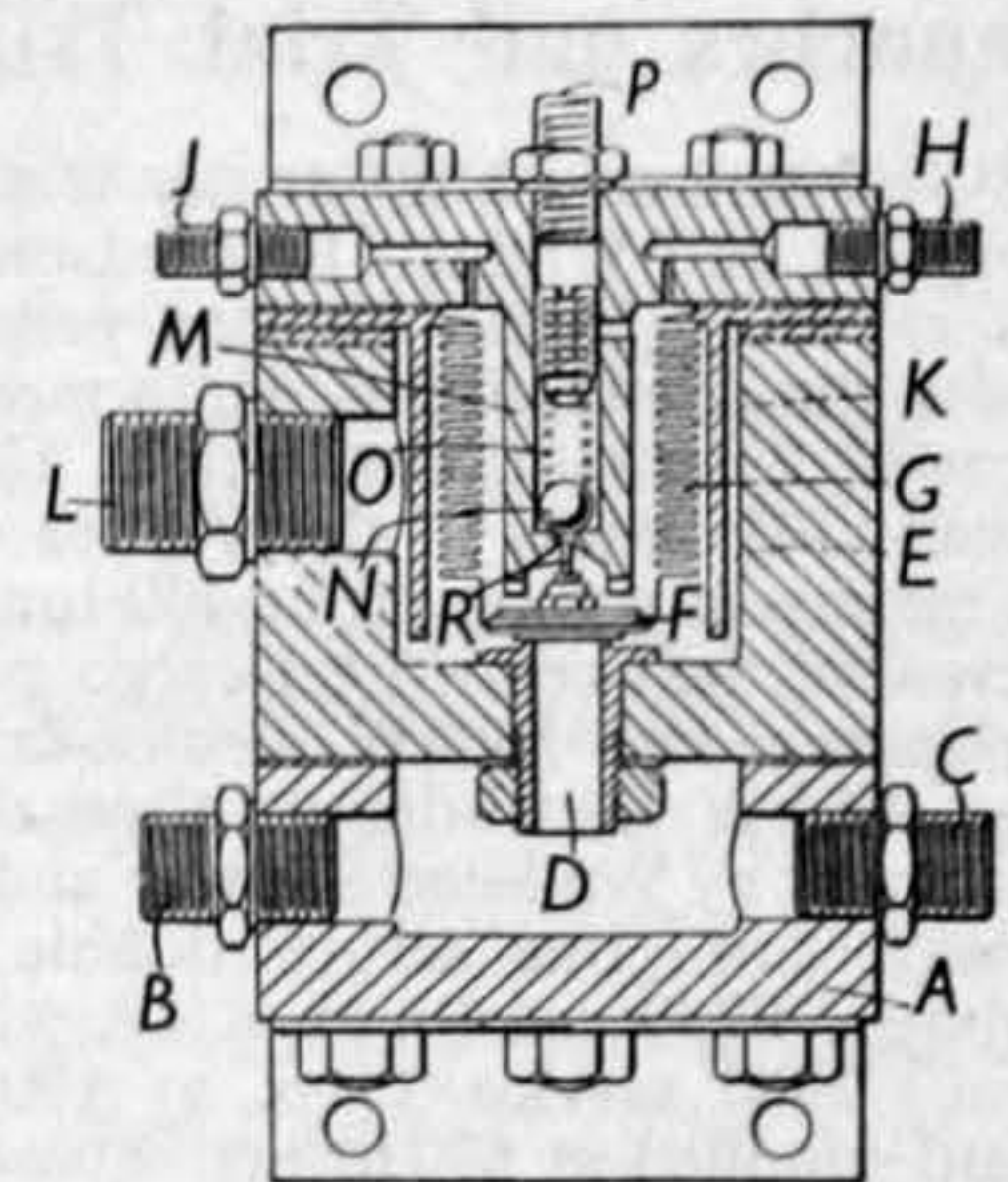
ribs *E*. Further, the inner end of the bore of the boss is enlarged and threaded for engagement by a bush *F*. The interconnection of the halves is effected in part by the bush, which, when assembled, is wholly enclosed. Preferably a slight clearance is left between the peripheral edges of the stepped parts of the halves so as to ensure tight contact between the contiguous faces of the bosses. The peripheral edges are then united by welding or brazing as indicated at *G*.

By this invention a light and strong piston can be constructed in a simple and satisfactory manner.—September 19, 1956.

**GAS TURBINES**

**757,346.** October 14, 1953.—**PRESSURE RESPONSIVE VALVE DEVICES,** The English Electric Company, Ltd., Queens House, 28, Kingsway, London, W.C.2. (Inventor: Roy Starmer.)

The invention relates to a pressure responsive valve device for cutting off the fuel supply to a gas turbine engine upon failure of lubricating oil pressure. As will be seen from the drawing, the lower compartment *A* of the valve casing is connected at *B* to the fuel pump and at *C* to the burners of a gas turbine. A valve seat *D* leads to the upper compartment *E* and is normally closed by a valve disc *F* pressed against the seat *D* by a bellows *G* in the upper compartment. The bellows *G* acts as a compression spring in the sense of closing the valve, and its interior is connected through a narrow bore and an adaptor *H* to the lubricating oil supplied under

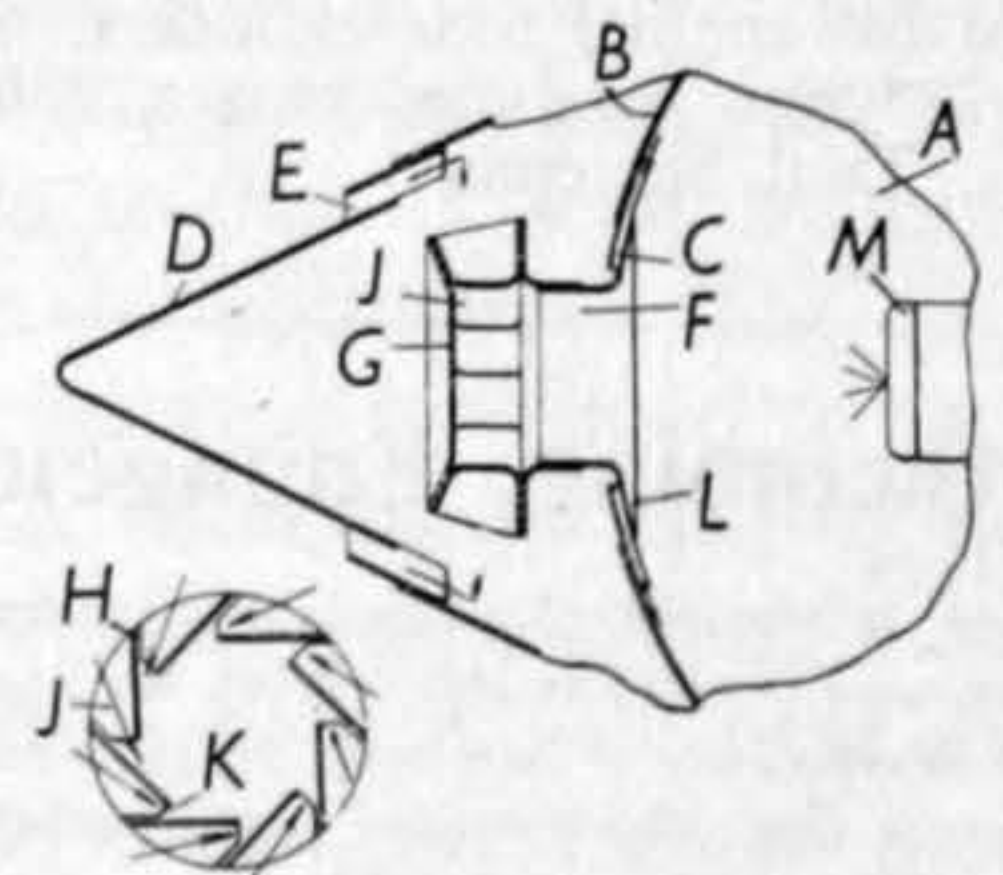


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pressure to the bearings of a gas turbine. Another adaptor *J* is available for the connection of a pressure gauge. The bellows is surrounded by a cylindrical shroud *K*, which screens it against the outlet *L* connected to the intake of the fuel pump. A hollow boss *M* extends into the interior of the bellows *G* and houses a ball valve *N* and a spring *O* biasing it against a seat in the boss; the interior of the latter is connected by an adaptor *P* to the sump of the lubricating oil pump. A pin *R* is attached at the inside of the disc *F* of the fuel pressure relief valve, which, with some clearance is in juxtaposition to the ball valve *N*. When the fuel pressure relief valve *F* is lifted off its seat a certain distance it opens the ball valve *N*. This valve device is particularly suitable for gas turbine bearings which are exposed both to lubricating oil pressure and to air pressure.—September 19, 1956.

**757,332.** June 11, 1953.—**FUEL COMBUSTION CHAMBERS FOR JET PROPULSION ENGINES AND GAS TURBINES,** Joseph Lucas (Industries), Ltd., Great King Street, Birmingham, 19. (Inventor: Squire Ronald Jackson.)

The invention relates to combustion chambers for jet propulsion engines, gas turbines, or other purposes, its object being to minimise or prevent formation of a carbon deposit on the central region of the end of the combustion chamber, and/or to ensure rapid and intimate mixture of the air with the fuel. Referring to the drawing, the combustion chamber *A* may be of any convenient construction having an



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entrance end of hemispherical or other curved or conical form. The end *B* may be constructed from two or more overlapping metal parts forming narrow air inlet passages *C*, through which air can flow from a surrounding air jacket over the inner surface of the end, the air being supplied under pressure from a blower. In the drawing the outer side of the end of the combustion chamber has secured to it a hollow nose piece *D* constructed from overlapping sheet metal parts forming between them a narrow air passage *E*, through which air can flow into the nose piece from the air jacket. On the axis of the entrance end of the combustion chamber is secured a short cylindrical air duct *F*. The upstream

end of the duct is closed by a plate *G*. Around the end of the duct are formed air entrances *H*, which receive air under pressure from the interior of the nose piece. These entrances are formed by flat blades *J* so disposed as to form between them a number of tapering air passages, each of which terminates in a narrow exit *K* at the periphery of the duct, the passages *H* being adapted to direct the air into the duct tangentially, and so form a rapidly swirling air stream in the duct. At the exit end of the duct is formed an outwardly flared flange *L*, which forms with the adjacent part of the combustion chamber the air passage which receives air from the region around the duct. By the provision of an air-swirling means on the axis of the entrance end of the combustion chamber the deposition of carbon on the end, and particularly its central part, from the fuel spray directed by the fuel supply nozzle *M* towards the end, can be effectively prevented or minimised in a simple and reliable manner.—September 19, 1956.

## Launches and Trial Trips

**HELISOMA**, oil tanker; built at the Wallsend yard of Swan, Hunter and Wigham Richardson, Ltd., for Shell Tankers, Ltd.; length between perpendiculars 530ft, breadth moulded 69ft 3in, depth moulded 39ft, draught loaded 29ft 9½in, deadweight 18,000 tons, service speed 14½ knots; thirty-three cargo oil tanks, one main pump room, four 400 tons per hour turbine-driven vertical centrifugal cargo pumps, two stripping pumps; two 550kW turbine-driven alternators, one 200kW diesel-driven alternator; propelling machinery by Wallsend Slipway and Engineering Company, Ltd., one set of double reduction geared turbines, 8250 maximum s.h.p. at 103 propeller r.p.m., 7560 service s.h.p. at 100 propeller r.p.m., steam supplied at 500 lb per square inch and 800 deg. Fah., by two Babcock and Wilcox integral furnace water-tube boilers. Launch, September 6th.

**CENTURY**, cargo ship; built by Hall, Russell and Co., Ltd., for Australian Steamships, Pty.; length between perpendiculars 335ft, breadth moulded 50ft 3in, depth moulded 26ft 6in, deadweight 5500 tons, four holds, electric deck machinery; four 100kW diesel-driven generators; Ailsa-Doxford three cylinder oil engine, 2300 b.h.p. at 120 r.p.m. Trial, September 13th.

**RISELEY**, cargo ship; built at the Neptune Works of Swan, Hunter and Wigham Richardson, Ltd., for the Thomasson Shipping Company, Ltd.; length between perpendiculars 440ft, breadth moulded 61ft, depth moulded to shelter deck 39ft 1in, deadweight 11,000 tons on 26ft 3in mean draught; five cargo holds, ten 10-ton derricks, steam winches; two 45kW and one 30kW generators; Swan Hunter-Doxford diaphragm oil engine, four cylinders, 600mm diameter by 2320mm combined stroke, 3300 b.h.p. at 108 r.p.m.—Launch, September 20th.

**CRYSTAL CROWN**, sister ship to Crystal Jewel; built by Smith's Dock Company, Ltd., for the Sugar Line, Ltd.—Launch, September 21st.

**CRYSTAL JEWEL**, cargo ship; built by Smith's Dock Company, Ltd., for the Sugar Line, Ltd.; length overall 460ft 9in, length between perpendiculars 430ft, breadth moulded 61ft, depth moulded to upper deck 37ft 3in; deadweight 9815 tons on draught of 24ft 6½in, service speed 12½ knots; five cargo holds, one 25-ton and ten 10-ton derricks, steam winches; two 75kW diesel-driven generators, one 20kW steam-driven generator; Hawthorn-Doxford diaphragm, two stroke oil engine, four cylinders, 600mm diameter by 2320mm combined stroke, 3300 b.h.p. at 108 r.p.m.—Trial, September.

## 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.

### ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

**To-day, Oct. 12th.**—STOKE AND CREWE BRANCH: Royal Hotel, Crewe, "Space Heating by Electricity," K. G. Stephenson, 7.30 p.m.  
**Mon., Oct. 15th.**—SOUTHAMPTON BRANCH: Court Royal Hotel, Southampton, "Mineral Insulated Cables and Accessories," R. B. Thom, 8 p.m.  
**Tues., Oct. 16th.**—LONDON NATIONAL LECTURE: Institution of Electrical Engineers, Savoy Place, London, W.C.2, Presidential Address, "Engineering Developments in Sound Broadcasting and Television," 6.30 p.m.  
**Wed., Oct. 17th.**—NOTTINGHAM BRANCH: E. Midlands Electricity Board's Showroom Theatre, Smithy Row, Nottingham, "Rewinding a 10,000kVA Turbo Rotor," A. D. Campbell, 7.30 p.m.  
**Thurs., Oct. 18th.**—KENT BRANCH: Rose and Crown Hotel, Tonbridge, "Electrical Safety," S. J. Emerson, 8 p.m.  
**Sat., Oct. 20th.**—OXFORD, READING AND DISTRICTS BRANCH:

Collier Lecture Room, Regents Park College, Pusey Street Oxford, "Nuclear Reactors and Instrumentation," D. D. Bowen, 6.30 p.m.

### HULL CHEMICAL AND ENGINEERING SOCIETY

**Tues., Oct. 23rd.**—Church Institute, Hull, Film Show, "Air Compressors, their Manufacture and Use," C. A. F. Mackintosh, 7.30 p.m.

### ILLUMINATING ENGINEERING SOCIETY

**Tues., Oct. 16th.**—GLOUCESTER AND CHELTENHAM CENTRE: Fleece Hotel, Westgate Street, Gloucester, "Recent Developments in Plastic Materials," P. H. Collins, 6.30 p.m.  
**Wed., Oct. 17th.**—N. LANCASHIRE GROUP: N. Western Electricity Board, 19, Friargate, Preston, Presidential Address, W. E. Harper, 7.15 p.m.  
**Thurs., Oct. 18th.**—MANCHESTER CENTRE: N.W. Electricity Board, Town Hall, Manchester, "School Lighting," G. S. Pester and J. Blackie, 6 p.m.

### INCORPORATED PLANT ENGINEERS

**To-day to Sun., Oct. 12th to 14th.**—SOUTHERN REGIONAL CONFERENCE: Grand Hotel, Bournemouth. Theme: "Future Developments in Plant Engineering."  
**Wed., Oct. 17th.**—KENT BRANCH: King's Head Hotel, High Street, Rochester, "Free-Piston Gas Generators," P. Watson, 7 p.m.  
**Thurs., Oct. 18th.**—BLACKBURN BRANCH: Golden Lion Hotel, Blackburn, "Steam for Process," L. G. Northcroft, 7.30 p.m.  
**Fri., Oct. 19th.**—BIRMINGHAM BRANCH: Imperial Hotel, Birmingham, "Electrical Safety Concerning Building Sites and Civil Engineering Projects," G. L. Leighton, 7.30 p.m.

### INSTITUTE OF BRITISH FOUNDRYMEN

**To-day, Oct. 12th.**—TEES-SIDE BRANCH: Teesdale Hall, Head, Wrayton and Co., Ltd., Thornaby-on-Tees, "Foremanship," F. Shepherd, 7 p.m.  
**Tues., Oct. 16th.**—E. ANGLIAN SECTION: Public Library, Ipswich, Presidential Address, H. A. Wincer, 7.30 p.m.

### INSTITUTE OF MARINE ENGINEERS

**Mon., Oct. 15th.**—STUDENT LECTURE: 85, Minories, London, E.C.3, "The Junior Engineer's First Trip to Sea," H. C. Gibson, 6.30 p.m.  
**Mon., Oct. 22nd.**—WEST OF ENGLAND SECTION: Grand Hotel, Bristol, "The Gas Turbine," A. W. Pope, 7.30 p.m.—N.E. COAST SECTION: Marine and Technical College, South Shields, "Boiler Water Treatment," J. F. Colville, 4 p.m.

### INSTITUTE OF METALS

**Mon., Oct. 22nd.**—SHEFFIELD LOCAL SECTION: Engineering Lecture Theatre, The University, St. George's Square, Sheffield, 1, "Bessemer and His Process," J. Mitchell, 7.30 p.m.

### INSTITUTE OF NAVIGATION

**Tues., Oct. 16th.**—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, Annual General Meeting, Presidential Address, "The Place of Navigation in Modern Air Transport," A. M. A. Majendie, 3 p.m.

### INSTITUTE OF ROAD TRANSPORT ENGINEERS

**Mon., Oct. 15th.**—SCOTTISH CENTRE: North British Hotel, Edinburgh, "Wear and Tear," J. Johnson, 7.30 p.m.  
**Tues., Oct. 16th.**—N. REGIONAL CENTRE: Victoria and Station Hotel, Preston, "The Design and Construction of a Modern Goods Carrying Vehicle," A. S. C. Marks, 7.30 p.m.—N.E. CENTRE: Three Tuns Hotel, Durham City, "Petroleum in Transport," P. H. G. Crick, 7 p.m.  
**Thurs., Oct. 18th.**—YORKSHIRE CENTRE: Great Northern Hotel, Wellington Street, Leeds, 1, "Congestion of Traffic in Large Cities," J. B. Buchanan, 7.30 p.m.

### INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

**Tues., Oct. 16th.**—Royal Society of Arts, 6, John Adam Street, Strand, London, W.C.2, John Fowler Memorial Lecture, D. R. Bomford, 4 p.m.

### INSTITUTION OF CHEMICAL ENGINEERS

**Tues., Oct. 16th.**—Geological Society, Burlington House, London, W.1, "Liquid-Liquid Extraction," R. Gayler and H. R. C. Pratt, 5.30 p.m.—N.W. BRANCH: Reynolds Hall, College of Technology, Manchester, "A Method of Design of Continuous Through-Circulated Dryers," H. C. Glover and A. A. H. Moss, 7 p.m.  
**Sat., Oct. 20th.**—MIDLANDS BRANCH: College of Technology, Loughborough, "The Manufacture and Industrial Uses of Hydrazine," W. S. Stevens and J. West, 3 p.m.

### INSTITUTION OF CIVIL ENGINEERS

**Tues., Oct. 16th.**—RAILWAY MEETING: Great George Street, Westminster, London, S.W.1, "Some Methods of Extending the Life of Bridges by Repair or Strengthening," J. D. West, 5.30 p.m.  
**Thurs., Oct. 18th.**—LECTURE ON THE CONSERVATION OF NATURAL RESOURCES: Great George Street, Westminster, London, S.W.1, "The Control, Storage and Use of Water," G. M. Binnie, 5.30 p.m.  
**Fri., Oct. 19th.**—ASSOCIATION OF LONDON GRADUATES AND STUDENTS: Great George Street, Westminster, London, S.W.1, Graduates' and Students' Conversation, 7.30–11.30 p.m.

### INSTITUTION OF ELECTRICAL ENGINEERS

**Sat., Oct. 13th.**—N.E. GRADUATE AND STUDENT SECTION: Visit to the Central Electricity Authority's Stella South Generating Station, 11 a.m.  
**Mon., Oct. 15th.**—INFORMAL MEETING: Savoy Place, London, W.C.2, Discussion on "Telephone Development in the United Kingdom," opened by the President, 5.30 p.m.  
**Tues., Oct. 16th.**—N. MIDLAND CENTRE: Central Electricity Authority Offices, 1, Whitehall Road, Leeds, 1, "The Development of a New 3:1 Pole-Charging Motor," G. H. Rawcliffe and B. V. Jaywant, 6.30 p.m.  
**Wed., Oct. 17th.**—RADIO AND TELECOMMUNICATION SECTION: Savoy Place, London, W.C.2, Chairman's Address, "The Electronic Age," R. C. G. Williams, 5.30 p.m.  
**Fri., Oct. 19th.**—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "Experiments for the Electronics Laboratory," opened by V. Attree, 6 p.m.

### INSTITUTION OF HEATING AND VENTILATING ENGINEERS

**Wed., Oct. 17th.**—YORKSHIRE BRANCH: Royal Victoria Station Hotel, Sheffield, "Process Steam," L. G. Northcroft, 7.30 p.m.

### INSTITUTION OF LOCOMOTIVE ENGINEERS

**Wed., Oct. 24th.**—GENERAL MEETING: Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, "Experiences with Diesel Railcars," M. J. Devereux, 5.30 p.m.

### INSTITUTION OF MECHANICAL ENGINEERS

**Mon., Oct. 15th.**—DERBY A.D. CENTRE: Midland Hotel, Derby, "An Experimental Turbo-Diesel Locomotive," F. L. Picard, 7 p.m.—SCOTTISH A.D. CENTRE: Institution of Engineers

and Shipbuilders, 39, Elmbank Crescent, Glasgow. Address by the A.D. Chairman, 7.30 p.m.—MIDLAND GRADUATES' SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Some Aspects of Nuclear Reactor Design," B. E. Eltham, 6.30 p.m.

**Tues., Oct. 16th.**—WESTERN BRANCH: Large Lecture Theatre, University Engineering Laboratories, University Walk, Bristol, "The Wider Aspects of Management," Sir F. Ewart Smith, 7 p.m.—COVENTRY AND MIDLAND GRADUATES' SECTIONS: Craven Arms Hotel, High Street, Coventry, "Engineering in a Coal Mine," D. W. Smith, 7.30 p.m.

**Wed., Oct. 17th.**—E. MIDLANDS BRANCH: Conference Room, Central Electricity Authority, Generating Station, Peterborough, "Fuel Requirements of the Small Automotive High-Speed Diesel Engine," G. M. Barrett, 7.45 p.m.—SOUTHERN BRANCH: Sevenoaks School, Sevenoaks, "An Approach to the Techniques of Graduate Training," D. L. Marples, J. F. A. Radford and J. L. Reddaway, 7.15 p.m.—YORKSHIRE BRANCH: Royal Station Hotel, Hull, "The Design and Construction of Aden Oil Harbour," J. E. G. Palmer, 7.30 p.m.

**Thurs., Oct. 18th.**—N.W. INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP: Engineers' Club, Albert Square, Manchester, "The Basic Principles Involved in the Production of Welding Electrodes," J. H. Paterson, 6.45 p.m.

**Fri., Oct. 19th.**—GENERAL MEETING: 1, Birdcage Walk, Westminster, London, S.W.1, Presidential Address, "Motive Power on Sea and Land," T. A. Crowe, 6 p.m.—SCOTTISH A.D. CENTRE: Robert Gordon Technical College, Aberdeen, "Sales and Service in the Transport Industry," J. M. Forbes, 7.30 p.m.

### INSTITUTION OF MINING AND METALLURGY

**Thurs., Oct. 18th.**—Geological Society, Burlington House, Piccadilly, London, W.1, Discussion of two papers: "Changes in Copper Solubility During Flotation of Malachite," E. J. Pryor and G. M. Lowe; and "Outline of a Solvent Extraction Process for the Purification of Niobium from Ores or from Ferromanganese," J. M. Fletcher, D. F. C. Morris and A. G. Wain, 5 p.m.

### INSTITUTION OF PUBLIC HEALTH ENGINEERS

**Thurs., Oct. 18th.**—SESSIONAL MEETING: Caxton Hall, Westminster, London, S.W.1, "The World Health Organisation and its Work in Environmental Sanitation," F. E. Bruce, 6 p.m.

### INSTITUTION OF STRUCTURAL ENGINEERS

**Tues., Oct. 16th.**—NORTHERN COUNTIES BRANCH: Cleveland Scientific and Technical Institution, Middlesbrough, Chairman's Address, T. Johnson. Film, "Oil Harbour at Aden," 6.30 p.m.

**Wed., Oct. 17th.**—YORKSHIRE BRANCH: Central Electricity Authority Offices, Whitehall Road, Leeds, Chairman's Address, A. L. Percy, 6.30 p.m.

**Thurs., Oct. 18th.**—LANCASHIRE AND CHESHIRE BRANCH: College of Technology, Manchester, Chairman's Address, J. B. G. Martin, 7.15 p.m.

### IRON AND STEEL INSTITUTE

**To-day, Oct. 12th.**—CORROSION MEETING: 4, Grosvenor Gardens, London, S.W.1 10 to 11 a.m., "The Corrosion Resistance of Low-Alloy Steels," J. C. Hudson and J. F. Stanners; 11 a.m. to 12 noon, "The Corrosion Resistance of Wrought Iron," J. P. Chilton and U. R. Evans; 12 noon to 12.15 p.m., interval; 12.15 to 1.15 p.m., "Corrosion Resistance of Some Austenitic Cr-Ni Steels of 18/8Ti Composition: The Effect of Variation in Chemical Composition and Thermal Treatments," E. J. Heeley and A. T. Little; 1.15 to 2.30 p.m., Buffet Lunch; 2.30 to 3.30 p.m., "Effects of Sulphate-Chloride Mixtures in Fuel Ash Corrosion of Steels and High-Nickel Alloys," H. T. Shirley; 3.30 to 4.45 p.m., "The Stress Corrosion Cracking of Austenitic Stainless Steels," Part I, "Mechanism of the Process in Hot Magnesium-Chloride Solutions," T. P. Hoar and J. G. Hines; Part II, "Fully Softened, Strain-Hardened, and Refrigerated Material," J. G. Hines and T. P. Hoar.

### JUNIOR INSTITUTION OF ENGINEERS

**To-day, Oct. 12th.**—ORDINARY MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "The Problem of O and M Study," W. J. Kease, 7 p.m.  
**Fri., Oct. 19th.**—INFORMAL MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Oil Additives," S. E. Holmes, 7 p.m.

### MANCHESTER ASSOCIATION OF ENGINEERS

**To-day, Oct. 12th.**—Visit to Joseph Adamson and Co., Ltd., Hyde, 2.30 p.m.—STUDENTS' SECTION: Engineers' Club, Albert Square, Manchester, "The History and Future Development of Education for Engineering," H. Wright Baker, 7.30 p.m.

### NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

**To-day, Oct. 12th.**—GENERAL MEETING: Mining Institute, Newcastle upon Tyne, Presidential Address, R. C. Thompson, 6.15 p.m.

### OLD CENTRALIANS

**Mon., Oct. 15th.**—The Mapleton Restaurant, Coventry Street, London, W.1, "Population," C. M. R. Balbi, 12.45 p.m.

### REINFORCED CONCRETE ASSOCIATION

**Mon., Oct. 15th.**—SCOTTISH BRANCH: Edinburgh Film Guild, 6, Hill Street, Edinburgh, 2, Films, "U.S.S.R. Plant for the Production of Precast Concrete Units for Housing," and "The 1954 Moscow Exhibition of New Building Techniques," 6.30 p.m.  
**Wed., Oct. 17th.**—11, Upper Belgrave Street, London, S.W.1, "The Design and Construction of Two Dock Sheds at Huskisson Dock, Liverpool," A. T. Clarke, 6 p.m.

### ROYAL AERONAUTICAL SOCIETY

**Wed., Oct. 17th.**—MAIN LECTURE: Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "The Importance of Time in Aircraft Manufacture," F. R. Banks, 6 p.m.

### ROYAL INSTITUTION OF CHARTERED SURVEYORS

**Wed., Oct. 17th.**—QUANTITY SURVEYORS' GENERAL MEETING: 12, Great George Street, Westminster, London, S.W.1, "Organisation and Planning for Large Building Contracts," L. J. Holloway, 6 p.m.

### ROYAL INSTITUTION OF GREAT BRITAIN

**Tues., Oct. 16th.**—21, Albemarle Street, London, W.1, "Optics in Industry," No. 1, "Size and Shape," A. G. Menzies, 6 p.m.

### SOCIETY OF INSTRUMENT TECHNOLOGY

**Thurs., Oct. 18th.**—INFORMAL MEETING: Junior Institution of Engineers, Pepys House, 14, Rochester Row, London, S.W.1, "The Importance of Minimising Hysteresis in a Process Temperature Controller," Dave M. Boyd, 7 p.m.

### WEST OF SCOTLAND IRON AND STEEL INSTITUTE

**Fri., Oct. 19th.**—39, Elmbank Crescent, Glasgow, Symposium on the Application of Low-Alloy Steels for Welded Pressure Vessels, 10 a.m.