THE ENGINEER

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BATHING BEACHES AND SEWAGE

The filthy practice of discharging untreated sewage into the sea has been vociferously—and quite justifiably—condemned in the daily and technical press on several occasions in the past year or two. One aspect of this problem has now been extensively reported upon by a research committee set up by the Medical Research Council, and responsible to the Ministry of Health. This committee has been carrying out investigations since 1953, with the aim of determining " whether sea-bathing can play a part in the causation of disease through contact with or ingestion of disease-producing micro-organisms liberated into the sea through the discharge of sewage." The investigations were thus largely confined to the possibility of catching poliomyelitis and enteric fever, but a study of the relevant literature of what are termed " minor gastro-intestinal illnesses " was also made. Broadly speaking, the report gives a negative answer to this question, and says " studies suggest that with the possible exception of a few æsthetically revolting beaches round the coast of England and Wales, the risk to health of bathing in sewage-contaminated sea-water can, for all practical purposes, be ignored."

In all its investigations, the committee could cite only four cases which strongly suggested a connection between sea-bathing and paratyphoid. The beaches concerned were filthy, and it is stated that " it is far more likely that the four patients just referred to were infected by direct contact with undisintegrated fæcal matter rather than by swallowing contaminated sea-water." The report stresses the technical difficulties of the work it has carried out, and points out that for various reasons a bacteriological standard for bathing water similar to that applied to drinking water and foodstuffs is impracticable. Nevertheless, it would be difficult to contest the committee's main findings, which appear to have been arrived at after sound and thorough investigations. If criticism is to be made, it must be aimed at the generalisations made from these findings, for the report was, by intent, strictly limited in scope, and generalisation to cover the entire problem of sewage pollution in coastal waters is not necessarily valid. The committee's view is as follows : " The committee has not yet been able to make a careful study of the effect of comminution or of other modifications in sewage disposal on the bacterial quality of sea-water, and in particular on the distribution of pathogens. On some of the beaches studied, comminution—i.e. the mechanical disintegration of the sewage before discharge—is practised during the bathing season. Analysis of the bacteriological results obtained before and after the start of comminution has not, however, shown any obvious effect on the topographical distribution of pollution on the beaches concerned. " Clearly, comminution may be desirable in situations where gross visible contamination of bathing beaches is occurring. Under these conditions, the disintegration of fæcal masses might be desirable on health grounds as well as æsthetically, because this would reduce the chances of contact with a heavy concentration of infective excreta from carriers, and would, moreover, expose the disease-producing organisms to the disinfectant action of the sea-water. " Where no gross pollution of beaches is occurring, the need for extensive improvements in the quality of sewage effluents discharged into the sea does not, in our opinion, arise. Even full treatment of sewage does not produce a pathogen-free, sterile effluent, and the committee's findings do not offer any valid grounds for attempts to render bathing waters virtually free from excretal organisms."

These conclusions arise, and are valid only within the limits of a purely medical viewpoint. For the same reasons which prompted the committee to reject a bacteriological standard of purity (i.e. the great complexity of patterns of pollution, difficulties of comparison, and deliberate up- or down-grading) can be quoted to refute the conclusion that " the need for extensive improvements in effluents . . . . . does not arise." A deterioration from the standards of cleanliness and beauty found in nature is not a necessary nor an inevitable accompaniment of a crowded community. Engineers, whose work is especially important in modifying the environment in which we all live, will be sensitive about this point ; squalor and filth accompany the misuse of engineering development and should be principal targets for elimination in the drive towards higher living standards, about which we hear so much. The concentration of the report on " bathing beaches " also gives a misleading impression. Many coastal regions are automatically excluded because they are so filthy. This applies particularly to river estuaries, where the committee's conclusion is clearly untenable. In such cases it is possible to meet conditions where sewage is simply oscillated to and fro by the tide, and where polluted river water may add to the problem. But on the " bathing beach " pure (*sic*) and simple, it is impossible not to be nauseated at the thought of bathing in water containing macerated sewage ; the committee does not mention one consequence of "comminution "—that it effectively conceals filth which would otherwise be readily visible. Even allowing for all the factors set out in this report, primary sedimentation at coastal outfalls should be the minimum acceptable treatment before discharging sewage into the sea.

EDUCATION FOR ELECTRICITY SUPPLY

Elsewhere in this issue we print the summary and conclusions from a " Statement on Technical Staff Education and Training in the Electrical Supply Industry" prepared by the Electrical Power Engineers' Association. It is quite a stimulating document. On a number of subjects, it is true, its compilers merely re-echo views that have been just as well expressed elsewhere ; but they do not see eye to eye with the Institution of Electrical Engineers upon one subject and they certainly take a more advanced view of adult education for engineers

than the central authority and the separate area boards appear to take. For our part we applaud the Association's criticism of the " means test " applied to parents to determine whether financial assistance shall be made available to their children to enter universities. It seems to us a nonsensical test because it is the children, not the parents, who have earned by hard work, and by giving proof of quality, the right to go to a university ; and it is of obvious benefit to the nation that nothing should stand in the way of their going. We also applaud some of the Association's remarks about specialisation in education and the tendency towards the creation of a sharper division between the organisations of the generation and distribution parts of the industry. Specialisation, it agrees, is inevitable for a considerable proportion of the staff. But " the industry needs not only engineers of high technical quality but in addition engineers of good general technical knowledge with leadership and managerial qualities predominating." There is also much to be said for the adult training which the Association recommends. It is very noticeable in the Services that officers and other ranks upon promotion or upon change of job are often required to attend courses, days or weeks or months in length, to give them an insight into the new work. Something of this kind appears to be in the minds of the compilers of the Statement.

A more controversial part of the Statement relates to technical staff training. The fact that only about 26 per cent of engineers recruited to the electricity supply industry are trained within it, is not regarded as grounds for criticism ; the remainder, beneficially in the Association's view, come as to 35 per cent from promotion of manual grades and, as to 39 per cent from outside the industry. It is, however, pointed out how very few university graduates are joining the industry—only five in 1957–58 as compared with twenty-five in 1953–54—and how holders of the Higher National Diploma are also falling off in numbers. There was a drop between the same two years from 143 to only forty-two. The figures need to be related to a total technical staff of 16,000 approximately. The explanation offered is " the generally small numbers of young qualified technologists available in relation to the total demands of British industry." Yet it is to be noted that a recent report of the Advisory Council on Scientific Policy revealed that in many other industries engineers and scientists finding employment between 1956 and 1959 actually exceeded estimates whereas in electrical engineering the increase was only 9·7 per cent as against a forecast of 43·2 per cent. There is, therefore, a strong suggestion that the Association is right in saying " the rewards and opportunities of electrical supply have . . . seemed relatively unattractive." Is any other explanation possible ?

The Association proves strongly critical of the Institution of Electrical Engineers because it has made it very much more difficult than in the past for a student to follow a route to corporate membership through Higher National Certificate courses. What are to be the requirements for entry into corporate membership are, of course, matters solely for the Institution itself to decide, so that we think it unlikely that the Electricity Council will make the approaches to the " Electricals " recommended by the Association. Yet it is good that criticism should be uttered by outside (though interested) bodies like the Association. Moreover, there is certainly some point in the Association's contention that, while, no doubt, the technologist " analyses and solves " and the technician " applies techniques " both " share the common clay of engineers which fact often makes the division academic in practice." In the unlikely event of the distinction being pressed too far the Institution might find itself admitting to membership only teachers and men with the habit of mind of research workers !

MACHINE TOOLS UNDER FIRE

It was particularly noticeable last year how an increasing degree of criticism was directed towards the machine tool industry of this country, and, indeed, a confidential report was prepared on an investigation made into the industry (at the industry's request) by the D.S.I.R. No information on the findings of the D.S.I.R. has yet been released but there is little doubt that dissatisfaction is expressed about the amount of research and high level training being carried out. We think the industry would be wise to publish the Report, since failure to do so gives rumour free rein. But we can certainly be sympathetic with any desire there may be within the industry to show proof that it is taking action upon the D.S.I.R. findings before it does publish them.

No doubt the industry is open to criticism for many things but the fact must be borne in mind that, taking into account its importance to the national economy, it has not always had the full backing it should have had either from user firms or the Government. No doubt, also, the machine tool manufacturers should have increased their productive capacity and embarked upon more intensive research to make available machines incorporating the latest developments. But to do such things makers naturally wish to have at least some assurance that sales in the home market will cover the capital investment within a reasonable time. We doubt if they have had much assurance. For many industrial firms and Government establishments in this country seem to go on quite happily using a deal of old out-of-date plant. Nor do many people make much attempt to prepare replacement programmes by which machine tool makers could be assured their efforts would not be wasted. Indicative of the difficulties a machine tool firm experiences when it does develop an improved design is the fact that relatively few high precision machines equipped with automatic control have, we understand, been sold to British firms. We would have thought that these machines, developed at considerable cost and capable of saving much time, would have been welcomed by many firms ; but, in fact, we are told, only by really intensive salesmanship have even a few large firms been persuaded to purchase them. Each potential user appears to hold back in the hope that some other firm will try out the first of the machines and prove it completely successful in production. This inertia may at first sight seem to amount to good business ; but it shows a lack of confidence in the machine tool industry which is not easy to understand and is surely short-sighted. For a reluctance to purchase machines of new design does not encourage development —the lack of which is then criticised by potential users, who, it appears, themselves make development virtually impossible economically !

Frequently we have heard British production engineers praising machines of advanced design after a visit to a Continental factory or exhibition, and expressing dissatisfaction that similar machines had not been developed by manufacturers in this country. But we wonder ! How many of these engineers would have been prepared to purchase the prototypes of the same machines for use in their works and to take advantage of initial developments before they have been fully tried out ? This practice is quite often followed in the United States and on the Continent and does much to make further development economically possible. By not giving the machine tool

industry the assurance of a receptive and expanding market for improved products, by failing to work out programmes for replacement, and by showing reluctance to purchase other than tried and proved machines user firms and Government departments in this country can surely be claimed to deserve a substantial share of the criticism levelled at the industry. As usual, in fact, not all the blame lies on one side.

ELECTRICAL ACCIDENTS

The report, *Electrical Accidents and Their Causes*, 1958, recently published by H.M. Stationery Office, price 5s., recalls that it is just over fifty years since the Electricity Regulations came into force. As pointed out in a foreword to the report, these regulations have remained unchanged, except in one minor particular, and are still regarded as a fully adequate legal basis for preventing electrical accidents. Why is it that these regulations, substantially unchanged during half a century of rapid development in the science and practice of electrical engineering, should have remained effective as a code of safety ? No doubt, as the report suggests, it is because many of the individual regulations were " framed in general terms, defining the risk to be prevented, rather than stating in detail the precautions to be taken."

Statistics can, of course, be misleading, but the overall effectiveness of the code is confirmed by the fact that, in 1907, the year before the Electricity Regulations were drafted, there were 264 electrical accidents, eight of which were fatal, whereas in 1958 the number of accidents had risen only to 714, including thirty-eight fatalities, despite the enormous increase (more than thirty-fold) in the supply and industrial use of electricity over the half-century. However, although the overall trend is not unsatisfactory, the detailed accident analysis given in the 1958 report is disquieting. For the total number of electrical accidents fell from 797 (forty fatal) in 1956 to 687 (thirty-two fatal) in 1957 but, unfortunately, rose to 717 (thirty-eight fatal) in 1958. Such figures should quickly dispel complacency. Constant vigilance backed by well-informed application of the best that is in modern electrical practice and education of the user, are the only means of lowering the accident rate. The task of education is complicated by the fact that, while the majority of victims of electrical accidents are unskilled, an unexpectedly high proportion (45 per cent in 1958) are skilled men, including supervisory staff, switchboard attendants and others with a knowledge of electricity and of the hazards to which their work may expose them. Here, we feel, the 1958 report, like its immediate predecessors, has much to offer all industrial users of electricity. The chapters on fire risks and safety are worth close study. The latter is specially instructive, for it is essentially practical and well illustrated, with many examples of good and bad practice, including the design and functioning of protective devices such as limit switches and interlocks. We suggest that the self-evident maxims " Don't take it for granted " and " If you don't know, don't do it yourself," should encourage industrial users of electricity to make a careful study of the report.

RECEPTION FOR OVERSEAS STUDENTS

A very large number of overseas students come to this country for varying lengths of time to further their engineering education. We doubt whether statistically there is any exact information about their numbers. Prominent among them because of the special methods of selection employed are Canadian engineering graduates who spend two years in this country under the Athlone Fellowships Scheme and are engaged on post-graduate courses in the universities, or in engineering works, or upon research ; and graduates from a number of countries, especially in the Commonwealth, in the Middle East, and in South America, who come here for a year or two under various schemes devised by the Federation of British Industries. Other schemes are sponsored under the Colombo Plan, and some students come here under their own volition to study in our universities, or colleges, or to acquire practical experience in British works.

Last Friday a reception was held at the Institution of Mechanical Engineers for such students within the mechanical engineering field. Such a reception held within the Christmas/New Year period is becoming a regular and a praiseworthy feature of the " Mechanicals' " annual programme. Representatives of the " Civils " and of the " Electricals " were there and so were people from the Board of Trade and the Federation of British Industries and the British Council. The guests were received by Professor Saunders, a vice-president of the Institution. There was a formal discussion on " Mechanical Engineering Education and Training," introduced by Mr. Norman Allen, and a film was screened. But the real value of the reception lies less in these things than in the way it brings students from all over the world together and gets them mixed up in intimate discussion with older engineers in this country and with members of the Institution's education committee.

The Engineer—100 Years Ago (JANUARY 6, 1860)

" THE PAST AND THE FUTURE."

" Although the past year has been marked by no unusual engineering progress, the details of what has been accomplished possess considerable interest. Great and signal strides can only occur at long intervals, and even then, however brilliant may be their fruits, they may be surpassed in real value by that silent and constantly accumulative progress which is so surely changing the face of the world and the fortunes of its inhabitants. Considerable advances have been made in railway, marine, and telegraphic communication . . . .

" The main drainage works of the metropolis have been commenced, and considerable progress has already been made. In the north, the opening by Her Majesty of the Loch Katrine Waterworks has been an important event for the people of Glasgow. The works, when fully completed, are likely to cost nearly £1,300,000 . . . In the iron manufacture, the introduction of Mr. Bessemer's steel into the metal market is an event of great importance and one from which great results may be expected . . . Steam fire engines have made their appearance during the year in the streets of London, and it is to be hoped that their use may become general, and that the miserably inefficient hand apparatus now relied upon may be altogether displaced.

" In the future, the general condition of affairs is hopeful. Trade is, in most respects, better than a year ago, and the circulars of the leading commercial houses have an encouraging tone of confidence."

Naval Construction in 1959

By RAYMOND V. B. BLACKMAN

Great Britain

THE highlight of naval construction in 1959 in Britain was the completion of the aircraft carrier "Hermes" (Fig. 1). During her full power steaming trials in the English Channel on November 17 and 18, when she was handed over by her builders, Vickers-Armstrongs (Shipbuilders), Ltd., Barrow-in-Furness, and accepted by the Royal Navy, the present writer had the privilege of being on board, and it was most noticeable how much she differs from the aircraft carriers "Albion," "Bulwark" and "Centaur," of which she was originally a sister ship. The "Hermes" was laid down on June 21, 1944, but her construction was not pressed and she was not launched until February 16, 1953. Work on her was then delayed so as to incorporate all the latest aids to naval flying which were then being developed, and it was not until towards the end of 1955 that construction was resumed in earnest, the labour input from then until November 1, 1959, representing 83 per cent of the total labour input to build the vessel. H.M.S. "Hermes" was commissioned for trials and service at Portsmouth on November 25 and sailed for Gibraltar the following day. She shares with the aircraft carrier "Victorious," reconstructed and modernised in 1950–58, the distinction of having the finest operational equipment of any aircraft carrier in any navy. Not only has she a wide angled flight deck (7 deg. off the centre line), two steam catapults, two mirror landing sight mountings, and the "3-D" radar antenna carried forward on her island superstructure, to make her first-rate operationally, but the accommodation for her 189 officers and 1643 ratings (the total complement will be 2100 with aircraft squadrons embarked) compares favourably with any other warship. Air conditioning has been installed to enable the ship to operate at peak efficiency in any part of the world. The "Hermes" has a displacement of 22,500 tons standard and 27,800 tons full load, with a length of 650ft between perpendiculars and 744ft 3in overall, a beam of 90ft on the hull and 144ft 6in overall, and a draught of 28ft. She is armed with ten 40mm Bofors anti-aircraft guns in twin mountings, all radar controlled. The propelling machinery comprises four Admiralty three-drum type boilers and a two-shaft arrangement of Parsons geared turbines developing 78,000 s.h.p. and equal to a speed of 28 knots. The ship has a deck edge lift on the port side forward as well as a central lift aft. The cost of H.M.S. "Hermes" is variously estimated at between £18,000,000 and £20,000,000.



Fig. 1—H.M.S. "Hermes," a new Centaur class aircraft carrier, entered service in 1959. She probably has the finest operational equipment of any carrier in any navy

Another large ship completed for the Royal Navy during the year was the new cruiser "Tiger" (Fig. 2). Built by John Brown and Co., Ltd., Clydebank, this vessel was laid down on October 1, 1941, and launched on October 25, 1945, but her construction was suspended in July, 1946. The decision to proceed with her completion was officially announced on October 15, 1954, and she was actually dismantled ready for the resumption of construction to a new design in 1955. The Royal Navy's first cruiser to be built with quick-firing fully-automatic 6in guns, H.M.S. "Tiger" was commissioned on March 18, 1959. With a displacement of 9550 tons standard and 11,700 tons full load, she has a length of 538ft between perpendiculars and 555ft 6in overall, a beam of 64ft and a draught of 21ft. Her armament comprises four 6in guns in two twin turrets, one forward in "A" position and one aft in "Y" position, and six 3in anti-aircraft guns in three twin gunhouses, one before the bridge in "B" position and two on the beam abaft the mainmast in "Q" position. There appears to be space for "Seacat" close-range anti-aircraft guided missiles to be mounted eventually, as in destroyers and frigates now being built. The main machinery consists of four sets of Parsons geared turbines aggregating 75,500 s.h.p., turning four shafts and developing a speed of 31·5 knots, taking steam from four Admiralty boilers of the three-drum type. Two sister ships of the "Tiger," namely the "Blake" and "Lion," are fitting out and will be completed in 1960.

Fig. 2—H.M.S. "Tiger" is the first cruiser to be built for the Royal Navy with fully-automatic quick-firing 6in guns

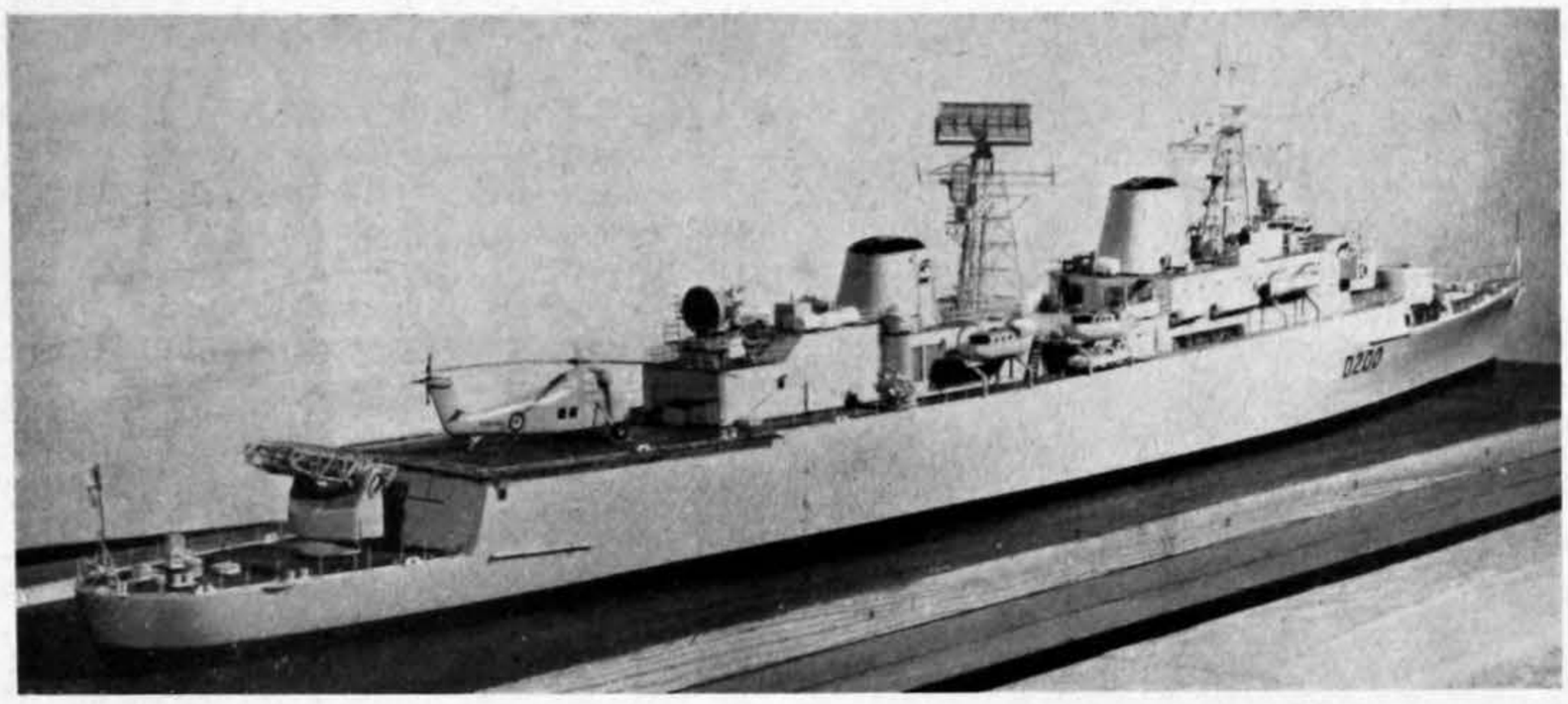


Fig. 3—Model of one of the Royal Navy's guided missile ships, two of which have already been laid down, while the building of a third will be started later this year. These ships will be the first to join the Fleet fitted with the "Seaslug" surface-to-air missile : the launching ramp is fitted on the quarterdeck. Launchers for the "Seacat" missile, designed for close air defence, are located abreast the after funnel. The landing space for the helicopter carried by this class of ship is at the after end of the upper deck

The four new guided missile destroyers of the "County" class, to be named "Devonshire," "Hampshire," "Kent" and "London," were laid down or commenced prefabrication during the year. A photograph of a model is reproduced in Fig. 3. It is officially stated that these ships will be the first to join the Fleet fitted with the new "Seaslug" surface-to-air missiles and the launching ramp is fitted on the quarter deck. The two launchers for the "Seacat" ship-to-air missiles designed for close air defence are located abreast the after funnel, while the flight deck for the helicopter to be carried by this class of ship is provided at the after end of the upper deck. The four ships will also be armed with four 4·5in guns disposed in two twin turrets, both forward, and six 21in torpedo tubes, firing a new type of homing torpedo to combat submarines, in two triple mountings, one on each side amidships. The "County" class will be propelled by combined steam and gas turbine machinery of exceptionally compact and light design enabling the amount of fighting equipment carried to be increased: they will have long endurance and are designed to be able to operate in "fall out" areas after an atomic attack.

The first ship of the new "Tribal" class of general purpose frigates was launched at the yard of Yarrow and Co., Ltd., Scotstoun, Glasgow, on March 9, 1959, and named "Ashanti." An indication of the development of the so-called "little ships" of the modern Navy is that these new "Tribal" class frigates are larger than the big fleet destroyers of the same class name which served with such distinction in all theatres during the second world war. They have an overall length of 360ft and a broad beam of 42ft 6in, and are the first frigates designed to carry a helicopter for anti-submarine reconnaissance. They will have an armament including two 4·5in dual-purpose guns in single mountings, one forward and one aft, four 40mm anti-aircraft guns in two twin mountings abreast the after funnel, a "Limbo" three-barrelled anti-submarine depth bomb mortar just before the helicopter platform aft, six 21in torpedo tubes in single mountings, three on each side abreast the funnels, and two "Seacat" close-range ship-to-air guided missile launchers, one on each side abreast the very sturdy lattice mast surmounted by a large radar aerial. The ships will have a totally enclosed bridge and are to be equipped with warning radar of the most modern design. The propulsion machinery of the "Tribal" class is of a novel kind. A steam turbine provides the power for normal cruising and manœuvring. A gas turbine driving on to the same propeller shaft provides the additional power for high-speed steaming. This gas turbine also enables ships lying in harbour without steam up to get under way instantly in emergency. The design of this machinery was evolved by close co-operation between the Admiralty, the Yarrow-Admiralty Research Department of Yarrow and Co., Ltd., Glasgow, and Associated Electrical Industries. The machinery is remotely controlled at all powers. Ships of this class are of all-welded prefabricated construction and the structural arrangements have been designed to provide a robust hull with special emphasis on the prevention of corrosion. Denny-Brown stabilisers are being fitted to reduce rolling, while good sea-keeping qualities will enable them to maintain a high speed in rough seas. A high standard of living accommodation has been achieved for the complement of ten officers and 220 ratings, and in particular all manned compartments will be air conditioned.

Six more of the fast anti-submarine frigates of the "Whitby" class were launched during the year, and the fourth anti-aircraft frigate of the "Leopard" class, the "Jaguar,"



Fig. 5—H.M.S. "Brave Borderer" is powered by three Bristol "Marine Proteus" gas turbines, each of 3500 maximum brake horsepower. Her speed exceeds 50 knots

was completed on December 12. H.M.S. "Lincoln," the fourth of the aircraft direction frigates of the "Salisbury" class, was launched on April 6, 1959.

The keel of "Dreadnought," the Royal Navy's first nuclear powered submarine, was laid on June 12, 1959 (see Plate 8 *ante*), by Admiral of the Fleet H.R.H. the Duke of Edinburgh at the Barrow-in-Furness shipyard of Vickers-Armstrongs (Shipbuilders), Ltd. The propulsion machinery is being supplied by the Westinghouse Electric Corporation of the United States, and will be similar to that installed in the latest nuclear powered submarines of the "Skipjack" class in the U.S. Navy. It is officially stated that "Dreadnought" will be twice the size of present British submarines.

The first two of eight new attack submarines of the "Oberon" class, namely the "Oberon" and "Orpheus," were launched on July 18 and November 17, 1959, respectively. According to the Admiralty the superstructure of "Orpheus" is of aluminium, while before and abaft the bridge of "Oberon" the superstructure is of glass fibre laminate. The "Oberon" class are generally similar in design to the "Porpoise" class. They will be equipped to fire homing torpedoes.

Of the eight conventional submarines of the "Porpoise" class, "Narwhal" (Fig. 4)

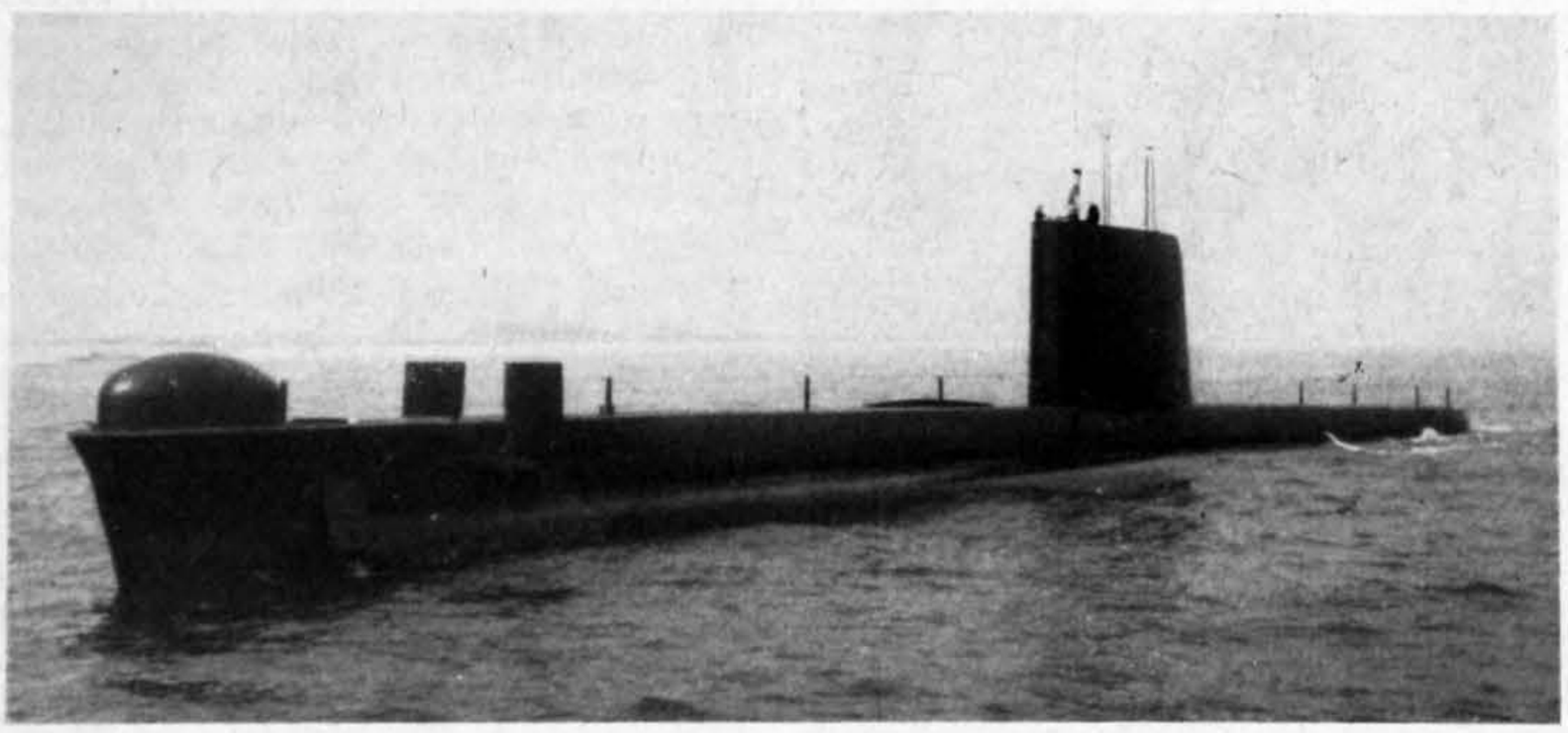


Fig. 4—H.M.S. "Narwhal" is a conventionally-powered submarine of 1700 tons standard and 2500 tons submerged



Fig. 6—U.S.S. " Richard S. Edwards " is a new " Sherman " class destroyer. This class of ship has conventional engines of 70,000 h.p. and is armed with guns, torpedoes and depth-charges

was completed during the year while "Finwhale," "Sealion" and "Walrus" were launched. With a displacement of approximately 1700 tons standard and about 2500 tons submerged, they have an overall length of 295ft 3in, and a beam of 26ft 6in. The diesel-electric main propulsion machinery is powered by Admiralty standard range diesel engines.

The present writer was on board H.M.S. " Brave Borderer " (Fig. 5), the first of a new " Brave " class, at present limited to two, of very fast patrol craft designed as convertible torpedo/gun boats, when on trials in September she achieved a speed of 50 knots. With an average displacement of 95 to 100 tons, an overall length of 98ft 10in and a beam of 25ft 6in, she and her sister ship " Brave Swordsman " can carry four side-launching torpedoes and one 40mm Bofors in the torpedo boat role or two 21in torpedoes and two 40mm guns in the gunboat role. Built by Vosper, Ltd., Portsmouth, they are propelled by three Bristol " Marine Proteus " gas turbines aggregating 10,500 b.h.p. driving fixed pitch propellers through a reverse/reduction gearbox.

United States

The world's first nuclear powered aircraft carrier and the largest aircraft carrier ever to be constructed, the U.S.S. " Enterprise," being built by the Newport News Shipbuilding and Dry Dock Company, Virginia, and engined by Westinghouse Electric Corporation, Pittsburgh, is approaching the launching stage. With a displacement of 75,700 tons standard and 86,000 tons full load she has an overall length of 1100ft, a hull beam of 133ft and an extreme width of 252ft. Her propelling machinery comprises eight pressurised water cooled nuclear reactors generating steam for a four-shaft arrangement of geared turbines aggregating 300,000 s.h.p. and developing a speed of 33 knots. The ship has an exceptionally broad flight deck, a block island superstructure, no funnels, a fully angled deck, four deck edge lifts, and four catapults. Her armament consists of a battery of " Terrier " surface-to-air guided missiles in each quadrant.

The U.S.S. " Independence," the world's largest conventionally powered aircraft carrier, was completed on April 3, 1959. Particulars accompany an illustration on page 75.

The U.S.S. " Long Beach " is the first nuclear powered surface fighting ship in the world, and was launched from the Fore River Shipyard of the Bethelehem Steel Company, Quincy, Massachusetts, on July 14, 1959. She is illustrated on page 75, where particulars will be found.

The world's first nuclear powered frigate, the " Bainbridge " was laid down on May 15, 1959, by the Bethlehem Steel Company, Quincy. With a length of 550ft and a beam of 56ft she will have a displacement of 6500 tons standard and 7900 tons full load. She will be armed with two " Advanced Terrier " surface-to-air guided missiles in twin launchers mounted fore and aft in addition to conventional guns, torpedo tubes and anti-submarine weapons. Her nuclear power plant, manufactured by the General Electric Company, West Milton, N.Y., comprises two pressurised water cooled reactors and a two-shaft arrangement of geared turbines.

The U.S.S. " Dewey," the first of the new guided missile frigates or destroyer leaders of the " Coontz " class, was completed on December 4, 1959, and three sister ships were launched during the year. These have a displacement of 4770 tons standard and 6140 tons full load with a length of 520ft overall and a beam of 52ft 4in. Mounted forward they have a conventional battery of two single 5in dual-purpose guns, but aft they carry a twin launcher for forty " Advanced Terrier " guided missiles, and they are also armed with four 21in fixed torpedo launchers, two anti-submarine warfare rocket launchers, weapon " Able " and a hedgehog. Four boilers and geared turbines of 85,000 s.h.p. encompass 34 knots.

Several of the guided missile destroyers of the " Adams " class were launched during the year. Unlike the larger so-called " frigates " they carry the " Tartar " guided missile installation, launching smaller surface-to-air weapons but with greater range, mounted on the after shelter deck. They are also armed with two single 5in guns, one forward and one aft, anti-submarine rocket launchers, and four torpedo racks. With a displacement of 3370 tons standard and 4500 tons full load they have an overall length of 438ft and a beam of 47ft. Their propulsion plant is similar to that in the

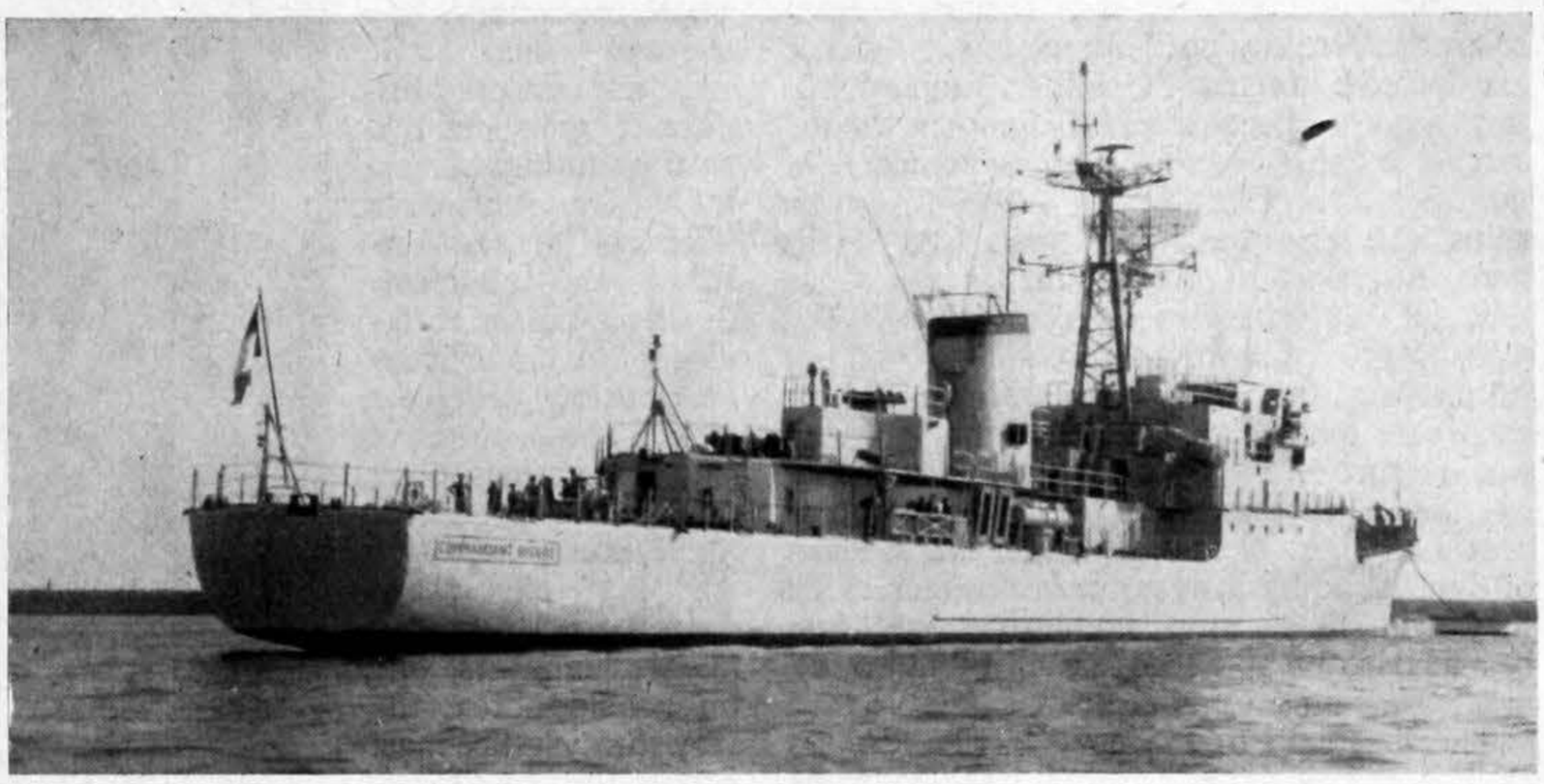


Fig. 8—" Commandant Riviere " has a full load displacement of 2700 tons. She is the first ship of a new class

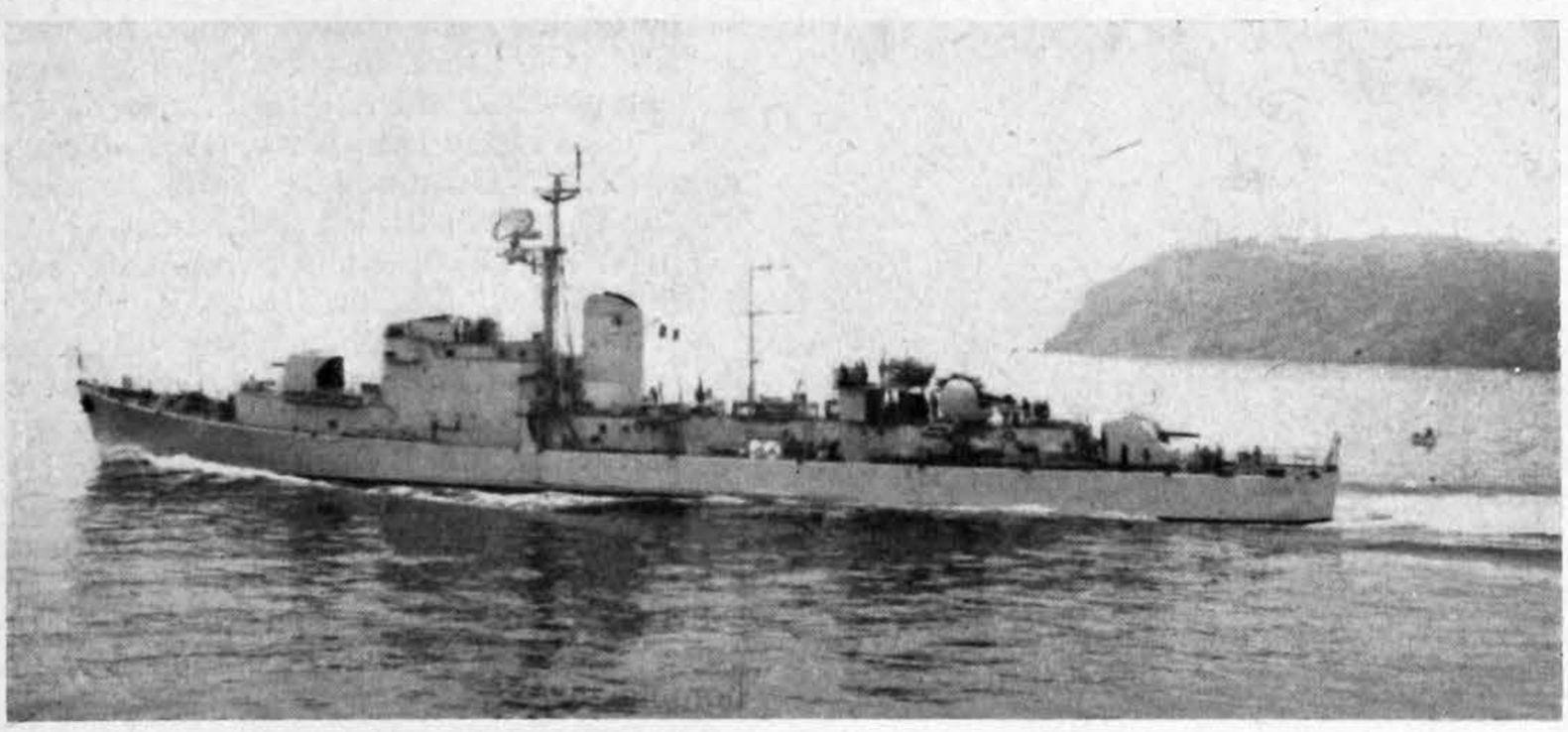


Fig. 7—New French fast frigate " L'Alsacien " has a 1700-ton full load displacement

guided missile frigates of the "Coontz" class.

Five large destroyers of the "Sherman" class (Fig. 6) were completed in 1959. Conventionally armed and powered, these displace 2850 tons standard and 4200 tons full load with a length of 418ft 6in and a beam of 45ft. The entire structure above the main deck, including gun foundations, is of aluminium to obtain maximum stability while maintaining minimum ship displacement. They carry three 5in dual-purpose guns, four 3in anti-aircraft guns, four fixed racks for anti-submarine torpedoes, two hedgehogs and depth charge tracks at a speed of over 33 knots obtained from four boilers and geared turbines of 70,000 s.h.p.

The four new destroyer escorts of the "Jones" class differ from all the other post-war built vessels of the type in that they are diesel instead of steam powered. An illustration and description appear on page 75.

The highlight of United States submarine construction in 1959 was the launching of the nuclear powered fleet ballistic missile submarines "George Washington," "Patrick Henry" and "Theodore Roosevelt" on June 9, September 22 and October 2, respectively. Such is the speed of construction of these underwater cruisers that the "George Washington" was undergoing her trials well before the end of the year. They are the first submarines to be named after men famous in American history instead of after fishes and marine creatures as hitherto. Details will be found recorded on page 77, together with facts about certain other American submarines.

The U.S. Navy's first guided missile nuclear powered submarine, the "Halibut," was completed by the Mare Island Naval Shipyard at the end of the year. The first submarine ever designed from the keel up as a guided weapons carrier, her hull was designed primarily to provide a stable launching platform rather than for speed or manœuvrability. With a displacement of 3555 tons standard and 5000 tons submerged she has a length of 350ft and a beam of 29ft, and is equipped to fire "Regulus" missiles from the surface. Engined by Westinghouse, she is powered by a water cooled reactor and geared turbines.

These latest submarines mark another big step in the U.S. Navy's quite phenomenal build-up of an atomic powered submarine fleet, which is already very formidable. In addition to the prototypes "Nautilus" and "Seawolf," the line-up comprises the "Skate," "Sargo," "Swordfish" "Seadragon," "Skipjack," "Triton" and "Halibut," all completed recently, and the "Scamp," "Scorpion," "Sculpin," "Shark," "Snook," "Thresher," "Permit," "Plunger," "Barb," "Tullibee," "George Washington," "Patrick Henry," "Theodore Roosevelt," "Robert E. Lee," "Abraham Lincoln," "Pollack," "Haddo," "Jack," "Tinosa," "Dace," "Ethan Allen," "Sam Houston," "Thomas A. Edison" and "John Marshall" in various stages of completion, to mention only the thirty-three so far named, and six others are being built.

France

The new aircraft carrier "Clemenceau," built at the Brest Navy Yard, ran her preliminary sea trials towards the end of the year, although she was without her armament of eight 3·9in automatic anti-aircaft guns and her complement of sixty aircraft. She has a displacement of 22,000 tons standard and 30,000 tons full load with an overall length of 845ft, a hull beam of 96ft 6in and a maximum breadth of 151ft. Her propelling machinery comprises six boilers and two Penhoët-built Parsons geared turbines of 120,000 s.h.p., equal to a speed of 32 knots. She is the first aircraft carrier built from the keel up as such in France.

The fast frigates "L'Alsacien," "Le Provençal" and "Le Vendéen" of 1295 tons standard and 1700 tons full load and the dual-purpose frigate "Commandant Rivière" of 1750 tons standard and 2700 tons full load, first of a new class of colonial sloops, were completed.

Japan

The new anti-aircraft destroyers "Harusame," "Murasame" and "Yudachi" of 1840 tons standard displacement were completed, and two larger destroyers, the "Akizuki" and "Teruzuki," of 2890 tons normal displacement were launched. All have a main armament of three 5in guns and a speed of 32 knots. The submarine "Oyashio" was launched, the first to be built in a Japanese shipyard since the second world war.

Aeronautics in 1959

WHILE 1959, like 1958, saw aeronautical achievement continue apace with, for instance, attacks on speed and heavier-than-air altitude records by numerous aircraft, attention in Great Britain was occupied very largely by the virtual collapse of the fifty-year-old aircraft industry, which succeeded in securing orders for no new aircraft of importance and lost an export order which had been regarded as a most significant testimony to one of the tiny handful of aircraft which stood ahead of foreign achievement. Since, historically, the most important achievement of the aircraft industry in this country has been to shape the world politically by the dint of equipping the Royal Navy and Royal Air Force with effective and, where necessary, superior weapons, the question naturally arises whether the country can continue to exist without native sources of airborne or air-breathing weapons, or even, of course, with. To allow fruitful consideration of this matter it is useful to examine what has in fact been produced by the industry in comparison with the requirements of the fighting services, and to discuss what weapons the procurement agency should be seeking at the moment. It is important to bear in mind that there is now less than ever before a direct relationship between the requirements of the services to secure survival of the community and the material products of the industry in this country, since the agency separating user and supplier now has a special interest in strictly civil aviation, so that if, as appears more than probable, the resources available prove inadequate, the system in being may be expected to sacrifice national security to commercial considerations.

A study of military aircraft developments in the United States, of public pronouncements in Britain (such as recent Defence White Papers and the R.A.F. Conference "Prospect II"), and of such details of new Russian military aircraft as have reached the West, make it possible to outline with some confidence the likely trends in air weapon development during the next few years.

It is obvious that weapons planning and development is being based on a closer agreement between military planners about technical possibilities than the general public has been led to believe by the statements of politicians. Military air research and development is in fact going forward to-day, as in the past, on the basis of broad agreement—even between the potentially hostile nations—as to the future roles of alternative weapons systems and their possible lines of development in relation to the two basic requirements of :

(1) Total war, which must be prepared for at the highest priority, if it is to be prevented, but which is no longer, in fact, a practical possibility as a national policy.

(2) Limited war, which remains as the final arbiter of international disagreement when the United Nations machinery breaks down.

Total War

Total war would undoubtedly start with the full-scale use by both belligerents of their strategic nuclear weapons. Full-scale use from the start would be the only possible policy because the side which first delivered the initial wave of heavy blows would gain a probably decisive advantage over its opponent.

At present, the nuclear striking force on both sides of the Iron Curtain is almost entirely composed of long-range manned bombers which have radii of action of up to perhaps 4000 miles, for the heavy types, and 2000 miles for the mediums. These ranges can, however, be extended by flight refuelling. The B-52 heavy and B-47 and "V" medium bombers are ranged against the "Bear" and "Bison" heavy bombers and "Badger" medium bomber. All are jet aircraft, with cruising speeds in the M=0·8 to 0·9 class, except the "Bear" which is a turbo-prop machine of rather lower speed but longer range. These aircraft are likely to remain the main method of delivering the deterrent until well into the 1960s but they are now supplemented by the first intermediate range ballistic missiles, which have effective ranges of up to about 2000 miles. The Russians are believed to have deployed their first weapons of this type in 1957, and they probably now have a fair number in the field in Europe. The first "Thor" I.R.B.M. units became operational during 1959.

The early 1960s should see the appearance in service of the first manned bombers with maximum operating speeds in the M=2 class. The Americans will have the B-58, the Russians the "Bounder," and possibly another as yet undisclosed type. Approximately contemporary with the supersonic bombers will be the first operational intercontinental ballistic missiles, which will have effective ranges of about 5000 miles. The first full-range firing of the American "Atlas" I.C.B.M. took place in the latter part of 1958, which compares with the reported first firing of the equivalent Russian weapon in 1957. This suggests that the West may succeed in more nearly matching in time the operational availability of Russia's I.C.B.M. than it did with the I.R.B.M.

These revolutionary new weapons will not, however, become the backbone of the deterrent forces overnight. They are likely to supplement for a considerable period, rather than replace, large forces of later versions of current subsonic bombers. The effectiveness of these aircraft will be greatly increased by the introduction of supersonic air-to-ground guided weapons (stand-off bombs) to replace free-falling bombs.

Defence in total war has become a far more difficult problem than attack. The last piston-engined bombers and the first subsonic jet bombers, when carrying nuclear bombs, first created the situation in which an effective overall strategic defence is impossible because of the small proportion of an attacking force required to penetrate that defence to achieve a decisive blow. This advantage of the manned bomber over the defences—which will certainly be increased by the introduction of stand-off bombs and supersonic operating speeds—is not expected to be fundamentally changed by the increasing use of aerodynamic ground-to-air guided weapons until some time after the ballistic missile has taken over the main strategic striking role, when the I.R.B.M. and I.C.B.M. will fully maintain the ascendancy of the offensive. An effective anti-missile defence is not expected for about ten years, so that planning will have to assume a continuation of the current strategic situation for at least that period.

In defence, as in attack, the manned aeroplane is still, at the moment, the most important weapon, although ground-to-air aerodynamic guided weapons are now in limited service in the West and their numbers are steadily increasing. The American "Century" series supersonic fighters carrying air-to-air guided weapons—with a substantial backing of lower performance aircraft operated by all the Western powers—are to-day the backbone of the West's air defence system. Their period of utility will be extended by the later "Century" series design and by aircraft like the "Lightni..g," with speed potentials of more than M=2 and increased emphasis on all-weather capability.

The Russians, similarly, are now depending on supersonic manned fighters such as the "Farmer" and their new M=2 types, reinforced by large numbers of older, lower performance fighters. They also have ground-to-air guided weapons in service, although the indications are that they do not have the same time advantage over the West with these weapons as they have with their offensive systems.

It is, perhaps, not altogether surprising that the future shape of defence in total war is likely to be closely similar to that of the organisation for attack. There is likely to be a continuing requirement for manned aircraft integrated with ground-to-air guided weapons. These will be essential if only for the interrogation of unidentified aircraft as long as either side has any manned equipment in service. Indeed, it is difficult to foresee a situation in which all aircraft in all circumstances will always be infallibly identified at a distance. When in doubt, interception by guided weapon would be rather drastic!

The vulnerability and immobility of the runways required by current deterrent delivery systems are the basic reason for the need to concentrate everything on the defence of the strategic base. Relatively little can be done by dispersal of bomber stations to reduce their vulnerability. This situation will, however, gradually change as ballistic missiles take an increasing part in the offensive role. The operational bases of ballistic missile units will, at first, be almost as vulnerable as bomber stations. However, such bases will later become more mobile on land (or less vulnerable when missiles are fired from underground), or more difficult to pin down when surface warships or submarines are used as launching platforms. The development of vertical take-off and landing manned strategic bombers is also a possibility which may maintain manned delivery systems in use alongside ballistic missiles.

Reference to the use of ships as missile launching platforms raises the question of the continuing requirement for manned aircraft for oversea patrol and for early warning. This is a role for which the long-range manned aircraft is likely to be required for a long time. Indeed, it is an obvious application for nuclear-powered aircraft which may become operational in the late 1960s. Much later, a system of manned or unmanned satellites might conceivably take over this work, together with that of strategic reconnaissance—the only other continuing total war requirement for manned operational aircraft. Transport aircraft will also remain as essential in total as in limited war or in peace, although the importance of their part in the deterrent organisation immediately prior to the outbreak of total war will depend largely on the extent to which it proves feasible to stock-pile guided weapons away from their main source of supply and maintenance.

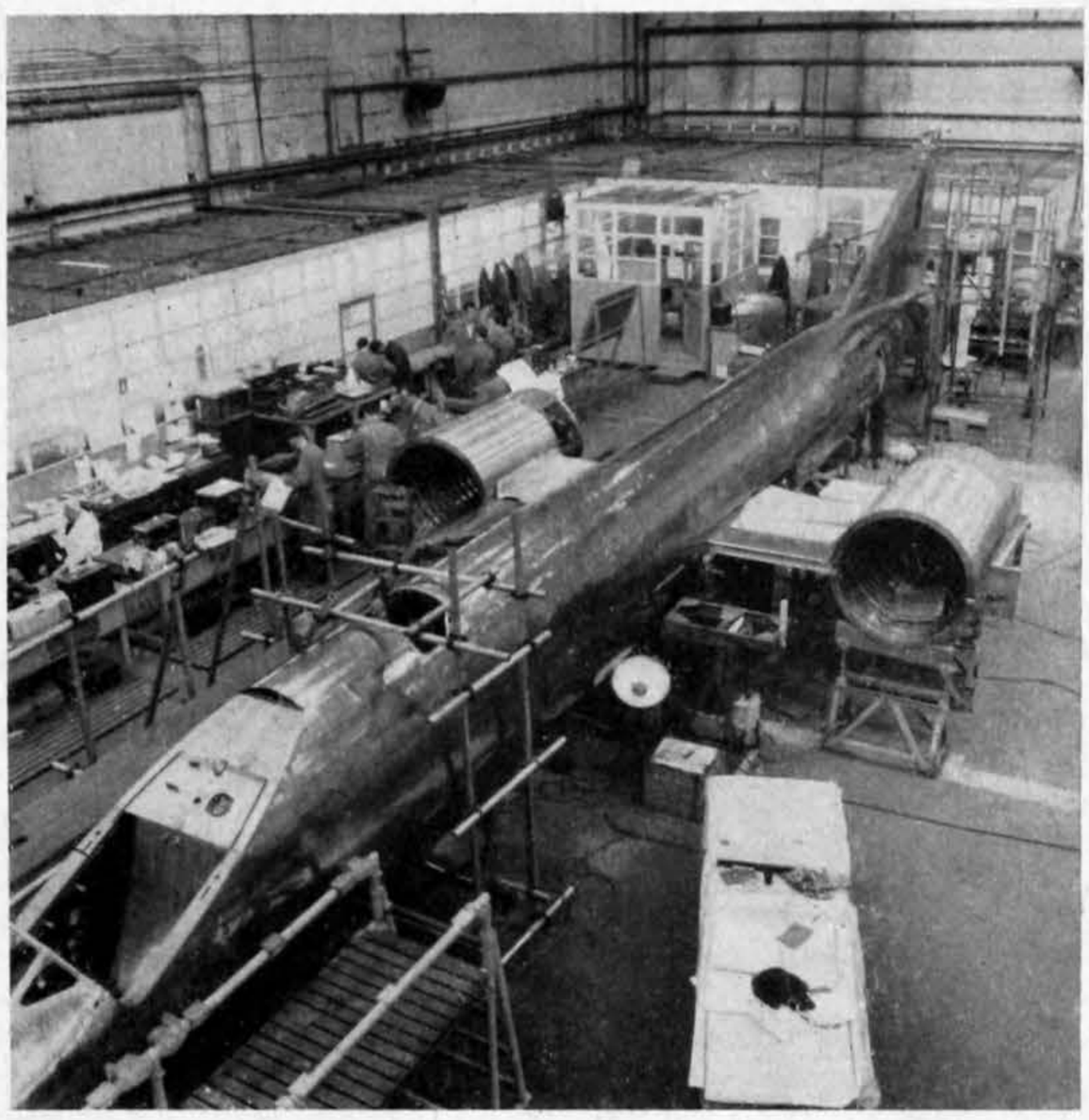


Fig. 1—The partly-completed Bristol 188 is strongly evocative of the supersonic "Trident," in which the straight wing was a great slab of honeycomb. As the British machine has not three but two engines, the turbo-jets have moved inboard, and the swept outer panels pick up on the shells of the nacelles: the engines fit forward and the after-burners aft of the wing. The 188 is the first manned aeroplane built in this country with a supersonic aerofoil since the Miles M.52

Limited War

For limited, as for total, war, there appears to be a large measure of agreement between the military planners as to the kinds of equipment which are required. At present, the emphasis is still on manned aircraft of intermediate performance for both tactical strike and tactical reconnaissance. The light bomber—with the capability (possibly not usable in practice) of carrying tactical nuclear weapons—has become an essential element of the forces deployed for limited wars. Its importance is not likely to diminish in the future because of the advantages of its great operational flexibility. It will, however, be supplemented by guided weapons as these take over increasingly from ground artillery.

In the past, the traditional defensive single-seat fighter, often in modified versions, has played a major part in tactical strike and reconnaissance. More recent maximum performance fighters are less adaptable in this respect and a new category of aircraft, the light fighter and the specialised short or vertical take-off strike aeroplane, is emerging to meet the requirement. This is an altogether easier weapon to operate from the relatively primitive bases likely to be available during peripheral wars in undeveloped parts of the world. Such aircraft will also be useful as anti-aircraft weapons, although, in any large-scale limited war, the larger maximum-performance fighters are also likely to be deployed to win command of the air.

Strategic transport aircraft have assumed a controlling position in limited war operations. Their importance is likely to continue to increase in the future as the tempo of world affairs accelerates in sympathy with improvements in methods of communication and transport. The tactical and assault transport will also be an important machine for related reasons. Helicopters and S.T.O.L. transports have already proved their value in anti-guerilla operations and their usefulness for limited wars will follow the same pattern.

Guided weapons have contributed much to existing preparations for limited wars in certain critical areas, such as Europe and Formosa. They will do so increasingly in the future. Used first for short-range tactical strike, as an extension of ground artillery and as a back-up to manned strike aircraft, guided weapons will also come into use for air defence of the local base and to help establish air superiority over the fighting area. Use of tactical nuclear weapons in a local "strategic" role may, however, force combatants in limited wars towards a concept of concentration on defence of their local base similar to that which now applies to the strategic bases of deterrent forces. If this does happen, the deployment of defensive guided weapons systems during limited wars will have to follow a similar pattern to that already adopted in preparation for total war, although no doubt on a smaller scale.

British Equipment

We propose to discuss first a weapon which has no fundamental relationship to aeronautics, the ballistic missile, since ballistic missiles capable of strategic employment are handled by the Royal Air Force. This may prove to be a well-founded decision, for it is already clear that the ballistic missile is a highly unsatisfactory weapon, particularly for a country of limited resources, and the most likely developments are to employ aerodynamics to improve its effectiveness. An elementary example of such an improvement, reported to have been demonstrated by the Soviets, is to render the re-entry

body asymmetrical in order that the re-entry path shall not be predictable to the defender : the fact that the attacker can do this (and structures of extraordinary resistance to heat are obviously required) renders it very difficult to postulate a successful interception, since even a missile with an acceleration of 10 *g* needs to be launched long before the incoming vehicle is in the denser layers of the atmosphere. It can be taken for granted that any attempt to manœuvre will impair the already marginal accuracy of the delivery system, and will, therefore, be employed very sparingly, but the capability is extremely valuable in deterring the opponent from attempting to build up a defensive system, or in defeating it if it becomes effective in protecting any targets.

The ballistic missile is obviously a throwback in the present phase of evolution in which guided weapons are becoming more and more important, but the mere attainment of some control over flight path will not allow the ballistic missile to be brought into harmony with current trends. The environment of the warhead during re-entry is so severe that even fusing, let alone navigation, strains the state of the art, while command guidance, even if technically feasible over the shorter ranges, will have the same disadvantages in the descent as it has at launch, namely restricting the rate of launching and exposing the system to counter-measures. It thus becomes clear that the ballistic vehicle has little attractiveness compared to the boosted glider or dynamic soaring aircraft, which can be controlled rather powerfully, is fairly unpredictable as to its target, and will have relatively little difficulty in comparing its actual and desired flight paths.

It can therefore readily be understood why a minimum of engineering effort is being devoted to the construction of the ballistic missile in this country, with the paradoxical result that there is appearing a medium-range missile as large as the intercontinental missile already operational. What is not explicable is the intention that the " Blue Streak " shall be emplaced in hardened sites. The theory of the underground storage of missiles is that if the site is hard and the opponent has only a low-grade offensive weapon, such as the ballistic missile, disproportionately more of the opponent's effort is needed to attain a given probability of rendering the site ineffective. This reasoning justifies hardening only if a significant proportion of the enemy resources are allotted to destroying one's missile sites, and therefore is inapplicable to this country. It may be speculated that, as the Royal Air Force has always emphasised tactical mobility and never possessed strategic mobility, the potentialities of the weapon have been lost to sight amid the problems of keeping the vehicle and its large quota of supporting equipment in a state of serviceability. The significance of this to the engineer as distinct from his fellow citizens is that had the British weapon been of contemporary performance—of rapid response or conveniently air-portable, and able to hold a state of readiness for long periods—the strategic dispositions of the country might well have been more ambitious and more intimidating.

At present this country escapes the problem posed by the absence of recall capability inherent in a ballistic missile by using a force of manned bombers, and to avoid the extreme cost of building a manned aircraft capable of penetrating hostile air space an air-to-surface missile or stand-off bomb is proposed. It should be borne in mind that this weapon, the " Blue Steel," is as yet of experimental status, and there is still no sign of an engine to equip the operational version. This may be because " cruise " weapons are regarded as having a limited application in the future, due to the emergence of the air-to-surface " ballistic " missile —not a free-falling bomb, but a weapon similar to the surface-to-surface missile except that it is launched from an aircraft. Since such a weapon does not suffer from the disadvantage that the defender can anticipate its path of re-entry, the ballistic trajectory is no great disadvantage to it, and it does not therefore pay heavily for its increased chance of penetrating the defences On the other hand, the ballistic vehicle demands a far superior navigation system on the launching platform compared to the cruise vehicle, which has time to detect errors in heading or elevation at launch, and as British work on missiles has avoided the applications in which guidance problems are most severe, it does not seem likely that obsolescence is the cause rather than the effect of the delayed introduction of the " Blue Steel."

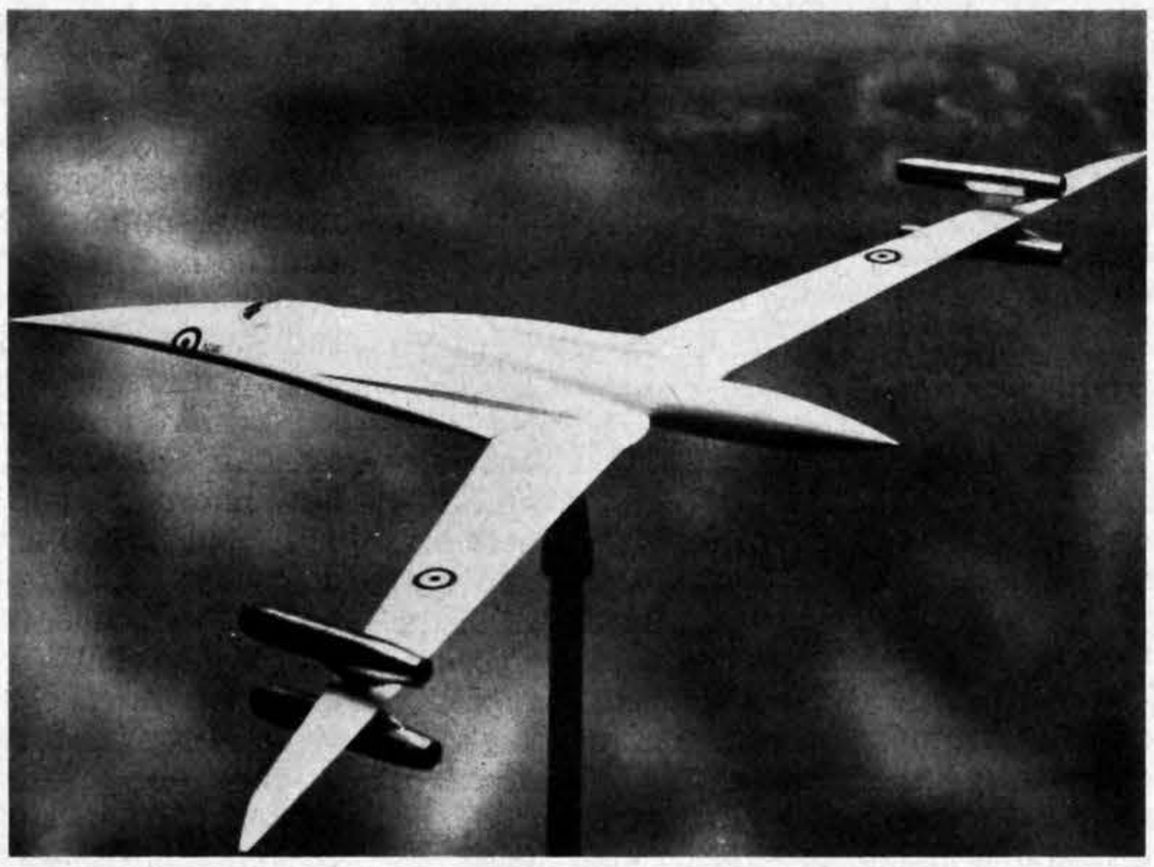


Fig. 2—Another illustration of the difficulties liable to be presented to the structural designer by supersonic flight is afforded by the proposals of Dr. Barnes Wallis. In order to secure communications within the Commonwealth, very long range is necessary, and the low drag implied can only be achieved with subsonic leading edges. Thus, a supersonic design tends to have absurd landing characteristics, and in particular an extreme angle of attack in the approach. The " Swallow " therefore has wings of variable sweep : the aerofoil-shaped forward fuselage is expected to provide sufficient stability for the wings to be almost straight in the low-speed configuration. The engines are carried on the wings to obtain adequate centre of gravity travel as the wings move : since the nacelles are perforce free to yaw, they are also employed to generate control in roll and pitch, thus reducing the difficulty of providing adequate torsional strength. The change in control effectiveness in pitch with sweep, and the need for a sophisticated fuel management system, are among the special problems posed by this concept. A 100,000 lb version to carry sixty passengers would have a maximum length of 130ft and a maximum span of 130ft

The equipment policies for offence discussed above have led, it will be clear, to an extremely difficult problem in respect of reconnaissance. Now that ballistic missiles are in being, reconnaissance appears to be the one mission belonging inescapably to an air force in a total war, but it is not apparent how the Royal Air Force propose to perform it. The fact that a Soviet attempt on the world heavier-than-air altitude record during 1959 involved a sustained flight at over 90,000ft suggests that military objectives in the Soviet bloc at least are not open to overflying by subsonic turbo-jet aircraft. Recent paper studies have encouraged the belief that aircraft with adequate range could be built if a cruising speed of about Mach 3 were adopted. However, the engineering difficulties would entail such vast expenditure that such an aircraft is unlikely to be built unless it has a large field of application, and in fact a somewhat similar aircraft, the F-108 interceptor, has been abandoned by the United States Air Force on the grounds of budget limitations. It must be assumed therefore that the Royal Air Force will rely upon the " Hustler," or any " Mirage IV " squadrons formed in France, for intelligence of hostile dispositions or the results of its own strikes.

The question of the defence of Great Britain in a total war cannot be dismissed, since the Royal Air Force is procuring aircraft and missiles for this purpose. Both are, of course, intended to intercept aerodynes only ; it is already certain that a defence against even the first generation ballistic missiles would represent an extraordinarily large investment, and Great Britain has never yet been able to afford an adequately strong defence against even the manned aeroplane. The defensive strength of the Royal Air Force at home is intended to secure its missile bases from attack or surveillance by aerodynes ; since neither the Douglas " Thor," which was intended to be launched from an air-portable base, nor the D.H. " Blue Streak " is expected to have a reaction time less than the flight time of a missile it is not to be thought that the sites are thereby rendered secure.

It may not be objectionable to discuss the weapons of air combat at this stage, since at the present time the Royal Air Force is equipped to defend this country rather than other parts of the Commonwealth or any bridgeheads overseas. It need hardly be recalled that the twin problems of developing enough muzzle horsepower to make a kill in a fleeting engagement and of laying the gun accurately enough have caused the cannon-fighter to be passed over, although not before some extraordinarily large recoilless guns, which would have posed extreme installation problems, had been evolved. (It should be interpolated that for tactical employment the gun-carrier has much to commend it, so that cannon of extreme rates of fire have been evolved in, for instance, the United States, but even the high-performance aircraft built to carry such guns use homing missiles for classical interceptions.) In the early post-war years procurement was based on the now-discredited policy of evolution, not revolution, as evidenced by the "Meteor" —"Sabre"—"Hunter" succession. Accordingly, the first missile to be procured was one compatible with fighters designed for cannon combat, the Fairey " Fireflash " which rode a boresight beam laid on the target by the pilot, the gyro gunsight solving the navigation problem, so that the fighter gained the advantage of a proximity fuse but at the price of having to fly towards the target until the missile was seen to hit or



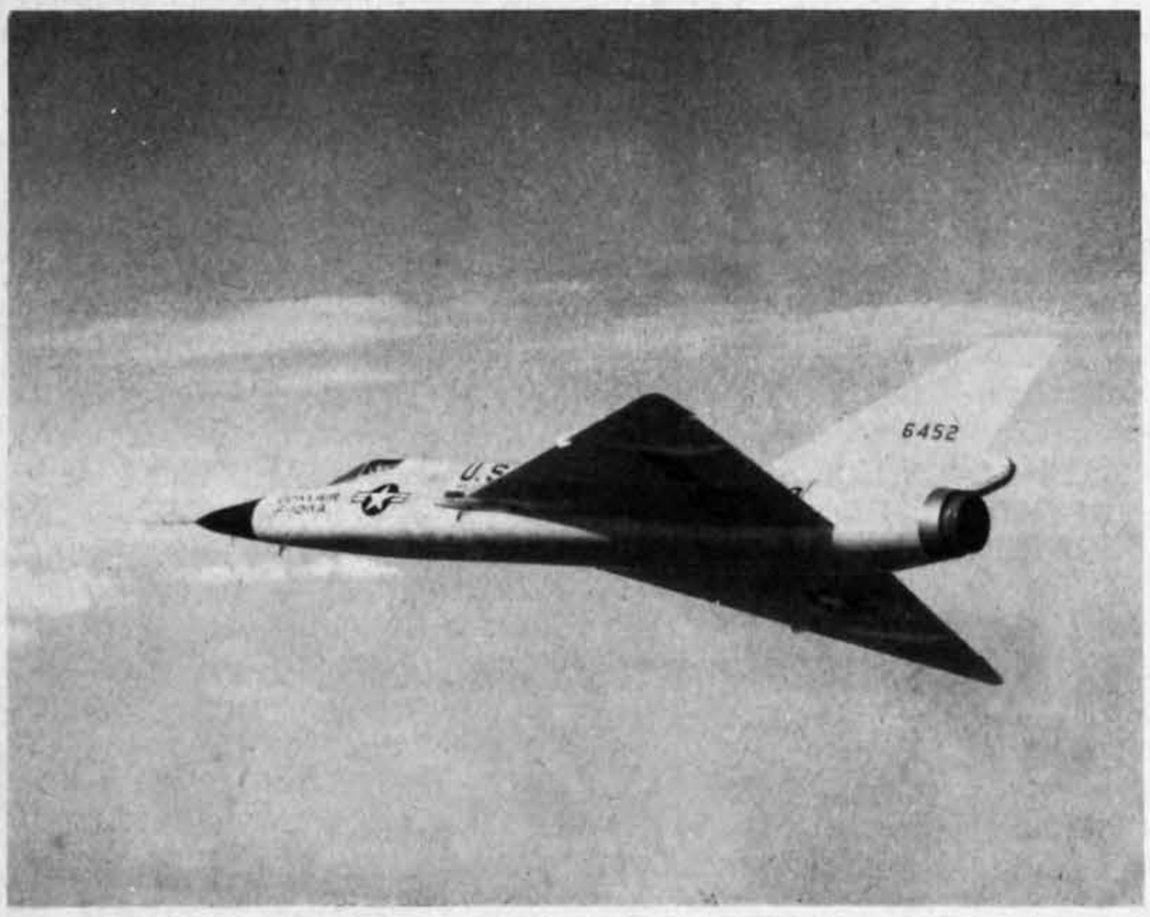
Fig. 3—During 1959 the Lockheed Aircraft Corporation lost its " Triple Crown " of world records, only the distance-without-refuelling achievement of the " Neptune " remaining unsurpassed. The absolute speed record was broken by a Soviet aircraft of which little is known, and then raised to 1521 m.p.h. by a Convair F-106A " Delta Dart." Aircraft such as this are now operational in defence of New York, carrying radar-guided and passive homing missiles and automatically controlled for all-weather interceptions. Powered by a Pratt and Whitney J-75, it bears a strong resemblance to the J-57 equipped F-102A " Delta Dagger," but the intakes are larger and of variable geometry

miss. The potential attackers were of too high performance to be tackled with this weapon by the time it was fully developed, and the only British air-to-air missile yet to become operational is the D.H. " Firestreak." This weapon appears in almost every respect to be an enigma, and at this stage—it has not yet been fully evaluated—one can only speculate how it reached the squadrons. A distinctive feature of the weapon is its use of passive guidance : this can be attributed to its originally being envisaged as an interim device for which ease of development and expendability were requisite —it will be recalled that a radar-guided missile was undertaken to equip the " Javelin," but this was discontinued at the same time as the " Olympus "-powered version; since the Royal Navy missile-carrier has no more ability to dictate the tactics of an interception than the " Javelin," it is probably true that the Vickers-Armstrongs 888 (" Red Dean ") had become too large for use by a " fighter " as the term is understood. Less explicable is the configuration, with the wings and combustion chamber in front of the control surfaces (the control actuators are remote, even as on a conventional aeroplane with an auto-pilot) : it is probable that as de Havilland work on liquid-fuelled rockets had been concentrated on low-energy systems, none but solid propellants were considered, and since the builders had had no experience with supersonic aerofoils, the airframe design was based on that of the " Fireflash," which as a coasting beam-rider was well served by aft controls. (Perhaps the most significant comment on this configuration is that, despite the magnitude of the engineering effort invested in it, no attempt appears to have been made to evolve storable liquid-fuelled engines which could exploit it.) The fact that the infra-red missile is essentially a pursuit weapon had, however, enforced a great increase in the performance of the E.-E. " Lightning " that was to be armed with the missile, and the maximum speed of the carrier is now in excess by hundreds of knots of that at which the " Firestreak " can be launched. Thus, even if the missile proves able to destroy a supersonic target, the defender is left with the problem of getting behind the target, at a close enough range for individual aircraft to be easily distinguished, and manœuvring to lay the seeker on the target for long enough for acquisition to be confirmed and the missile discharged. The problem thus posed to a defence devoid of forward airfields is obvious : pending possible integration of the air defences of N.A.T.O., and to present at least a diminished threat in rain and cloud, the fighters carry numerous unguided rockets which can be fired on a collision course emanating from the aircraft's radar-directed attack computer.

It is, apparently, tempting to believe that, as the limitations of the " Firestreak " were to a significant extent engineered into it, a redesigned version, endowed with the facility possessed by the more expensive infra-red missiles of acquiring a target on a bearing decided before launching, would be an acceptable replacement. This is, however, not a view lightly to be entertained : it appears to be universally accepted overseas that the infra-red homer is compatible only with carriers of very high performance, and while it may be reasonable for, say, Sweden, with a strategically dangerous geography and no commitments beyond her frontiers, to confine herself to the use of Mach 2 interceptors, the same cannot conceivably be thought of Great Britain. It would appear to go without saying that the cost of developing a useful missile is so high by British standards that the finished product should have more than a limited usefulness.

The surface-to-air missile intended for the defence of fixed targets is the Bristol " Bloodhound," which is well suited to the defence of the British Isles in combining high speed and long range : the use of air-breathing engines implies that there is a larger degree of choice of thrust programme than with a rocket, so that a long development life can be anticipated. A more advanced version is reputed to be in hand ; it would appear that the most pressing need is for a change from the semi-active guidance, since each target might occupy the illuminating radar for two minutes, so that a concerted attack by numerous aircraft maintaining bearings such that a missile homing on one is not gaining " ground " on another may conceivably saturate the defence. While the exacting task of building an active homer has not yet been successfully consummated in this country, the relatively large disposable load and tolerance of departures from optimum solutions of the navigation problem should commend the " Bloodhound " for the initial installation.

At present obscure is the Royal Air Force response to the low-flying intruder. The " Lightning " might have sufficient





Figs. 4 and 5—(Left) The " Delta Dart " in flight, showing the conical camber influencing the wing near the leading edge. Above the nozzle are the air brakes and brake parachute stowage. (Right) The U.S. Navy deck-landing interceptor, the McDonnell F4H-1 " Phantom," is a twin-engined two-seater. A plan view shows the ailerons inboard of the fold in the wings, the flaps and air brakes, and the drooping leading edge

performance to intercept such aircraft, even though it is temperature limited and would probably not exceed Mach 1·6 low down, its acceleration capabilities being great. However, gun-laying is at its worst in high-speed low-altitude flight, and the only missile available for the fighter is the D.H. " Fire-streak," avowedly restricted by its infra-red homing to the altitudes where rain and clouds are infrequent. The unmanned system is hindered in dealing with low-flying aircraft by ground clutter, moving target discrimination by, say, Doppler effect being necessary. It seems probable that the threat of the low-flying aircraft is being ignored until production of the Homing-All-the-Way Killer is commenced in N.A.T.O.

Discussions of the weapons of total war cannot, however, seem anything but academic to the aeronautical engineer in Great Britain, since it became apparent during 1959 that such weapons will not be manufactured in this country, at least by the aircraft industry. Effectiveness is at a premium for, say, a deterrent, particularly in the case of a nation with a defence budget small compared to possible enemies, and hence only systems of extreme performance are of interest. Weapon systems in which the aircraft industry might be interested would be such things as the continuously air-borne missile platform, the highly supersonic bombing - reconnaissance - communications aircraft, the boost-glide missile and the supersonic low-flying nuclear-ramjet-powered missile. Assuming that it is not worth while building the actual machines in this country unless the design work is done here—the basic research work, it must be taken for granted, would be wholly or partly done by allied powers—the projects become fantastic compared to the industry that has appeared in the last twelve months.

In limited warfare, however, where a single strike is unlikely to conclude a campaign, and highly trained, experienced and dedicated crews influence the outcome of a clash, the effectiveness of a weapon is no more important than its mobility, vulnerability, and adaptability, and a study of the equipment is of highly practical interest. For convenience, weapons used by or against warships are considered with the weapons of limited warfare, although it is in total war, in which mobility is a condition of survival, that sea-borne forces are uniquely important. However, for the most important naval weapons, those used by and against submarines, it has now become customary for this country to depend on United States sources of supply, and certainly the immense efforts and achievements of the United States Navy in respect of anti-submarine warfare and the fleet ballistic missile system would appear to endorse this policy.

It appears as if the emergence of the guided missile—excluding homing torpedoes—has had as little influence as it conceivably could have on the offensive armament of warships. Ballistic missiles seem to be the sole Soviet and principal United States strategic bombardment weapons, and strike aircraft continue to be armed mainly with free-falling bombs, even though the aircraft performance needed to accomplish the mission may entail ejecting the store backwards through the tail, as on the " Vigilante." The warship is probably adequately equipped for strategic bombardment with a ballistic missile, since there is a relatively small possibility of its being under surveillance and hence it can launch its missiles with deliberation, although a weapon with some navigation capability would reduce the critical dependence on the ship's position- and direction-finding equipment. (It may be interpolated here that, conceptually, the large, simple weapons at present operational can be given the same freedom from neutralisation and interception by launching from vessels that can reliably be run aground.) It is, however, less easy to be satisfied with the use of free-falling or spin-stabilised missiles for limited war purposes and engagements between ships. A ship-to-ship weapon is simplified by the fact that it needs to manœuvre in two dimensions only, and thus there is no essential objection to an air-breathing engine, with which it should be easy to achieve long range, a virtue of value particularly to a force not enjoying numerical superiority. The main problem undoubtedly would prove to be guidance, radar being handicapped by flying close to the surface and passive homers being easily decoyed, as is the practice for protection from the acoustic torpedo—a further objection to an infra-red homer is that a nuclear-powered vessel might dispose of the vast majority of its heat release to the wake. Since contemporary vessels are well equipped to fix the positions of targets for gun armament, consideration of a radio rather than radar system based on two vessels and reminiscent of the "OBOE" bombing aid suggests that this problem should not prove insoluble : such a weapon would be usable against any target moving slowly enough to be followed by the ship's fire control apparatus, and would appear to be attractive for a navy with a largely defensive role that cannot be discharged by task forces of aircraft carriers.

The dominant offensive weapon of the Royal Navy at present is the strike aircraft of transonic performance, the Vickers-Supermarine " Scimitar " to-day and the Blackburn N.A.39 in the future, both intended and probably able to avoid interception by flying relatively fast and absolutely low. Their disadvantages are lack of flexibility, i.e. having solely a mode of attack which simplifies defence by use of natural obstacles, smoke screens, balloon barrages and so forth, and dependence on a carrier. While the carrier is at present the weak link in this weapons system, both because of its need for a defensive screen and because of its limitations in respect of complement, rate of launching, and choice of speeds and headings when using the flight deck, it seems reasonable to hope to eliminate all these restrictions and stride towards all-weather operation by taking advantage of the promise now held out of vertical or at least short take-off for highly loaded jet aircraft. The propulsion engineers propose to provide very large thrusts controllable in direction, albeit highly costly in fuel, by bleeding and burning large quantities of air compressed by the conventional turbo-jet used for normal flight. This opens up an extremely attractive prospect of compact, high-performance aircraft somewhat like the " Cutlass " and the " Skyray," and able to be stowed quickly in large numbers below decks, but when on " deck " needing only to be turned to face the relative wind before they blast off under their own power, although possibly needing an umbilical connection to a fuel main up to the last moment. The deck at present known would hardly allow these machines to use their zero-length ability, since they would tend to blow each other and the ship's crew about, so that a " deck " resembling a grid might be desirable : on the other hand, such machines could bring back the practice of carrying aircraft on all warships of cruiser size. An incidental difficulty would be that thick armour would suffer from having a vast blowpipe turned upon one face of it, and the plating below the " deck " might have to be kept awash, in which case some relative wind would be necessary to keep the deck clear of steam : it seems, therefore, that true vertical take-off and landing may not be compatible with using large numbers of aircraft from the same ship. Aircraft such as these should vastly improve the rate of and weather minima for landing-on, it being conceivable that in high seas the aircraft could be set down in a net clear of the heaving deck, thus reaping all of, if not more than, the advantages of the " rubber deck."

If, however, it is reasonable to look forward to the enhanced use of aircraft and guided missiles against ships, it is indisputable that the problem of defending the ship will increase in difficulty. It is, of course, toward the solution of this problem that most use has been made of guided weapons technology, the results to date in respect of the Royal Navy being the D.H. " Firestreak," the A.W. " Seaslug," and the awaited Short " Seacat " for close-quarter use. The ship-to-air missile is an adequately effective weapon, but when beam riding guidance is used has a limit to its rate of fire that can be a tactical disadvantage, while it is doubtful whether either the delay before launching or the error in following a near-horizontal beam is low enough for it to intercept the low-flying manned or unmanned vehicle. The " Firestreak " is

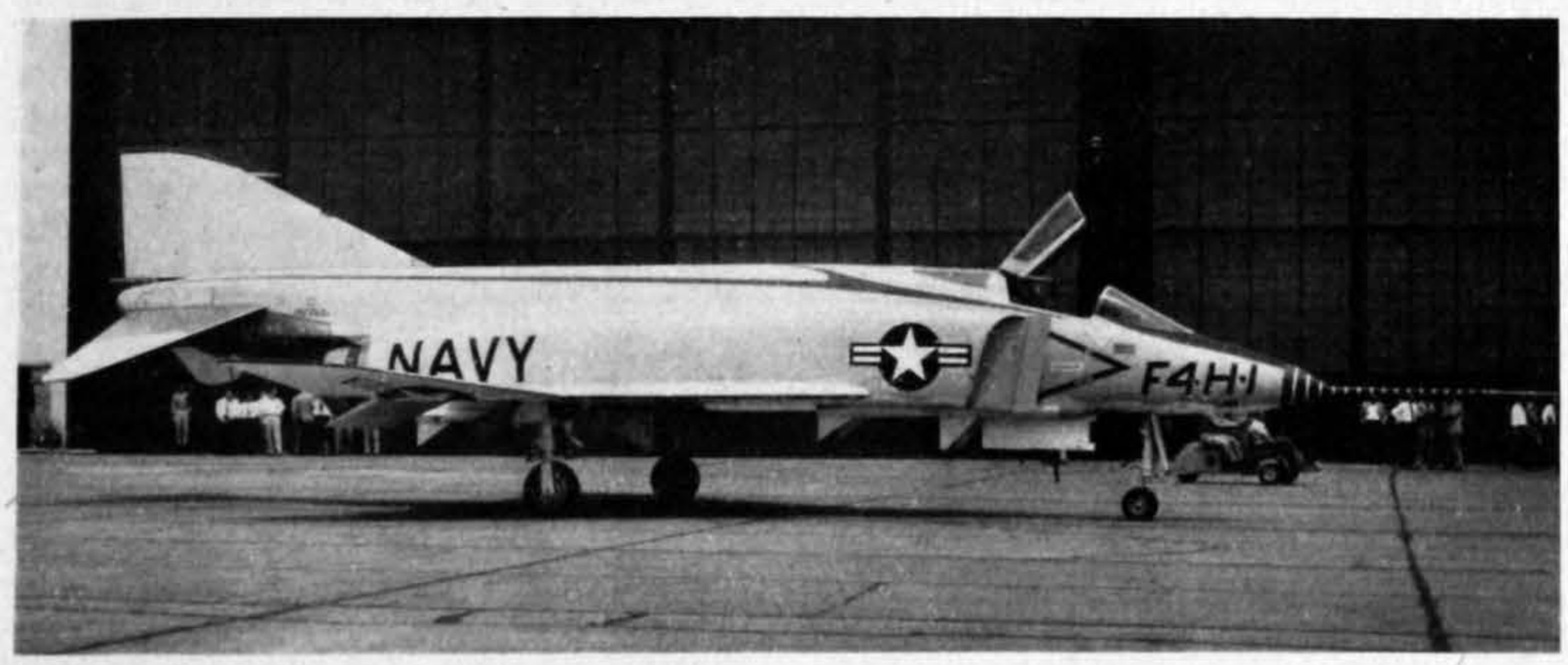


Fig. 6—The " Phantom " is seen here with its complement of four semi-active homing " Sparrow III " missiles stowed against the underside of the fuselage. The vertical tail is heavily swept and fixed, the movable surfaces being inclined downwards 23 deg. The F4H-1 is powered by a pair of General Electric J-79 turbo-jets with variable-angle stator blading, and is among the machines powered with this engine that have exceeded heavier-than-air altitude records. However, the record belongs, as far as is known, to a " Starfighter " at 103,395ft : this achievement was observed by optical triangulation, a feat of, it would seem, extreme difficulty



Fig. 7—A Lockheed C-130B " Hercules " executing a pivot turn at a gross weight of 116,000 lb, during acceptance tests of the assault transport. During the trials the undercarriage wheels were sometimes 2ft deep in the sandy loam at Eglin Air Force Base. The C-130B can carry ninety-two troops or 50,000 lb of freight, and its maximum cruising speed is 370 m.p.h. The Royal Australian Air Force uses the rather less powerful C-130A, with a maximum all-up weight of 124,200 lb (equal to the maximum landing weight) instead of 135,000 lb. The machine illustrated is atypical in not having a bulged dielectric nose

severely limited in its performance, being not expected to home in precipitation, and being rendered almost an embarrassment to the Royal Navy by the fact that the D.H. " Sea Vixen " used as a launcher lacks the performance to carry out the needed pursuit interception, even assuming that weather and operational commitments have allowed it to be flown off. Bearing in mind that it is unlikely that even a more expensive and elaborate infra-red missile with the ability to acquire a target in flight, like the "Falcon," could destroy a powered air-to-surface missile before it reached its target, it is not difficult to accept the reasoning that has led the United States Navy to propose the " slow 'plane " armed with a high-performance active-homing missile. There is reason to believe that the throughput of the fire control centre is already limiting in numerous Royal Navy ships, and decentralising the secondary task of defence therefore appears particularly attractive ; it is a move towards an area defence, and away from leaving isolated ships dependent on their own weapons and vulnerable to a concerted attack. There being a very obvious advantage in having a highly integrated defence over a fleet drawn from more than one navy, it is more reasonable to expect the " Eagle " to be acquired by the Royal Navy than some new weapons system widely different from and vastly more complex than any British product initiated, especially as the " Sea Vixen " defence is even now outclassed.

A completely different approach to the interception problem which is, however, under investigation, is the variable geometry aircraft with the ability to both attain high Mach numbers and " loiter " at altitude. This is philosophically possible with the improved fuel consumption of the ducted fan engines now appearing—it will be recalled that even jet aircraft which were not expected to reach Mach 1 proved very limited in endurance : it is, however, likely to involve substantial practical difficulties, as is illustrated by the best known example of an attempt upon this problem, the " Swallow " inspired by Dr. Barnes Wallis. It is understood that this particular project is being studied as a prospective standing patrol aircraft with supersonic dash performance : it is, however, difficult to believe that this application will prove successful, since even when there exists a fairly free choice of configuration, British aircraft usually appear with a tail, however objectionable the empennage may be operationally—*vide* the H.P. 111 and the D.H. " Sea Vixen." In the case of the " Swallow " the control power in pitch would be least where the need for it was greatest, during the approach, and, moreover, there would be a noteworthy problem in obtaining consistent control response through the rapid changes in thrust commanded by the pilot. Such machines would, clearly, suffer from all the normal disadvantages of carrier operation in that they would restrict the carrier's choice of course and would be able to take off and land at only a restricted rate. This is, it seems, a far more difficult application than that for which the machine was proposed, since in a long-range transport the economy in the low-speed configuration would be of secondary importance, effecting only the magnitude of the reserve supplies of fuel.

The low-flying aeroplane is, of course, particularly well-adapted to use against warships because of the absence of obstacles which would render flying at constant pressure height dangerous. The need for defence against such attack is therefore great and, apparently, lasting. The Royal Navy choice of the " Seacat " appears likely to be no more than an interim solution because even if the performance comes up to expectation, the kill would be made only very close to the ship, and because of the tactical disadvantage that the guidance is susceptible to saturation. This suggests that an air-to-air weapon is a potentially superior solution : considering the two such systems discussed hitherto, the " Eagle " system appears inherently more attractive than the " Swallow," since the " Missileer " would be able to patrol at lower altitudes than the high-performance aircraft and because the unmanned vehicle would be able to accept higher accelerations and risks of hitting the water in a dive on to the target ; moreover, the threat of an attack by a formation would tend to unbalance the " Swallow " defence.

Turning now to campaigns decided on land, it appears that aeronautical engineering techniques have given the attack virtually uncompromised ability to strike with weapons systems such as the " Sergeant " missile and the " Thunderchief " single-seater any target that can be pinpointed ; British substitutes for these weapons are in at least the design stages. There remains, however, the difficulty of finding and fixing the target ; this is surmounted with such a device as the air-launched " Bullpup " which is command guided down to its target, but such systems are open to the counter measure of destroying the carrier while it is monitoring the attack. Machines such as the T.S.R.-2 are going to be too expensive to build and support for a high proportion of fruitless missions to be tolerated, and some solution or avoidance of the problem of accurate " bombing " from a machine flying low and fast appears to be necessary. (Targets such as a dump or headquarters cannot be relied on to be susceptible to homing devices.) The classical answer is, of course, to separate the functions of observing and destroying the target, e.g. air observation of howitzer fire. This concept directs attention to a notable omission from the British armoury, a missile capable of use beyond the line of sight. The line of sight limitation of such weapons as the anti-tank " Malkara " is severe, as positions affording a commanding field of view are not necessarily or probably suitable for collecting numbers of bulky missiles.

The " Lacrosse " of the United States and Canadian armies and the ramjet Sud 4200 have ranges much beyond artillery of readily mobile weight and can strike either a chosen map reference or an observed target under radio guidance ; the discontinuance of the Fairey missile which was to have engaged at least the latter class of targets renders it doubtful whether any replacement for the 25-pounder gun-how is contemplated.

Closely allied with the problem of engaging targets on the surface is that of defence from aircraft bent upon attack or, particularly, reconnaissance. The anti-aircraft mission, because of the difficult and fleeting targets presented, was one of the first for which guided missiles were built, and for the British army radar-controlled guns are now being replaced by a semi-active homing missile, the E.-E. " Thunderbird." Leaving aside the question of whether the required reliability has been demonstrated by this missile in an environment appropriate to an air-portable weapon system, it should be noted that the guidance adopted renders it suitable only for point defence against aircraft flying rather high—say, within line of sight for one minute before arrival. Proposals for an advanced version of the " Thunderbird " have been disclosed, and it may be assumed that the English Electric Company would not allow the performance to remain limited by the electronic equipment : however, the fundamental incompatibility of the wing-before-tail configuration and solid propellants will perpetuate the need to attach separate boost motors before the missile is ready for use. The great bulk of the vehicle, presumably entailed by the high effective ceiling, has resulted in a launcher which is mobile only unloaded and after some preparation and in a very low rate of fire from each launcher, while the crew needed for the relatively unskilled work of manhandling vehicles and equipment is large. The entire system would seem, therefore, far better adapted to its role of providing point defence of Royal Air Force bases than to the protection of ground forces in any campaign in which movement over the ground is not inhibited.

While such a weapon should prevent troops or supplies being parachuted down near to

its location, it does not deter the strike and reconnaissance aircraft : this task, which is of conspicuous difficulty, can be tackled in two ways. The first, which is particularly suited to forward areas where forces are dispersed, is to have large numbers of weapons deployed so that some are bound to be favourably placed to engage the aircraft ; an example of this approach is afforded by the Convair " Red Eye," an infra-red homing rocket for firing from the shoulder—apart from the extreme refinement necessary to keep a complete supersonic missile down to a weight acceptable to an infantryman (18 lb?) the main problem lies in the fusing and arming device necessary to protect own troops from the missile. The second, which alone can protect " nerve centres," is the high performance radar-guided weapon such as the " Hawk " discussed above ; since the " Hawk " can kill not only the low-flying aircraft but anything within the troposphere, the choice made by the continental N.A.T.O. powers appears soundly based. Farther in the future one can see advantages in an area defence system which might well range beyond territory on which own troops were dominant ; the " Eagle " intended to defend battle fleets with aircraft of low performance would appear potentially applicable, if the requirement were raised early enough.

Since no defence is likely to suppress enemy reconnaissance sufficiently to render bombardment impossible, an army engaged in a campaign in which nuclear weapons are being used needs extremely high mobility, to attain, and maintain in battlefield conditions, which there are being evolved numerous flying machines ranging from reasonably conventional rotorcraft through powered lift aerodynes to ground effect machines. However, while to liberate an army from dependence on tyres and feet increases its effectiveness manifold, it also multiplies greatly the investment per soldier and demands a level of education and training unfamiliar in Britain during, at least, the recent past. It is therefore more probable that only campaigns fought without weapons of mass destruction will be considered in procuring tactical transport. This is an application in which the aeroplane, as the embodiment of tactical mobility, enjoys almost universal acclaim ; even the Indonesian army is acquiring a number of Lockheed "Hercules" machines. These aircraft, as our illustration shows, are intended to operate on unimproved surfaces, and such airfields as they need can be expected to be made available in any other than a war of movement or in mountainous terrain. (" Pantobase " operation on a yielding surface is possible, but, of course, the machine must be protected from sinking while at rest.) There are no British examples of such equipment ; the small Royal Air Force freighter now on order, the A.W. " Argosy," resembles rather the last generation of transports such as the " Packet " and the " Noratlas "—this is explained by the fact that the order was placed not when the requirement arose but after a machine of slightly different dimensions had been developed as a private venture for civil use.

The strategic transport, which may or may not be able to air-drop cargoes, is—notwithstanding the conspicuous presence of such machines as the C-132 " Cargomaster," the vital role of which is to airlift the " Thor " weapon system and any other Western missile except the " Blue Streak"—still not an established entity. The reasons for this all stem from its consumption of fuel ; only a nation with interior lines of communication, such as the U.S.S.R., or with an exceedingly ambitious network of bases, such as are maintained by S.A.C., can be confident of flying to the places it needs to reach, and even then it is more than probable that supplies of fuel to bring the freighter back will not be found there. The nuclear aircraft, when achieved, will clearly dissolve these difficulties ; it is most likely to take the form of a flying boat, since it would be highly demanding in aerodromes and also liable to render a base untenable if it was damaged during its sojourn, but this would be inconvenient only to the U.S.S.R. Thus at present the strategic transport is making no substantive progress ; the one " global " project, capable of taking any item of equipment to any theatre, the Douglas C-132, was abandoned at the mock-up stage, and the machines coming into being are principally established civil designs modified to accept bulky freight by swinging the tail to one side.

The Transport Command equipment at present is, of course, strictly limited to machines that could be called conversions of civil aircraft, the " Comet " for passengers depending upon numerous refuelling bases of dubious security, and the " Britannia " for freight requiring a lift to render loading and unloading possible. If it were decided to modify a British aircraft to obtain a high-speed freighter, it would presumably be necessary to swing the nose and make the nose leg " kneel." It should be observed that the Short " Britannic " is a far more heavily modified Bristol " Britannia " than is the Canadair CL-44 ; nevertheless, the design is by no means dictated by military requirements without compromise (it has, for instance, integral tanks) and it will be recalled that for some decades this constructor has been interested in primarily civil aircraft.

Machines such as these are still essentially dependent on flying fields of some nature, and hence involve the concentration of supply lines at an airhead. For the distribution of these supplies, or for smaller scale operations where the effort needed to make and protect an airfield is not justified, hovering machines, typically helicopters, are usually postulated. Whether the theoretical increase in movement capacity afforded by air movement compared to, say, R.A.S.C. convoy is realised depends very largely upon the speed of loading and unloading. Since an aircraft is not usually tolerant of hurried loading with such items as guns and vehicles, an attractive solution is a rotorcraft which carries a pallet or pod externally, giving the operational advantages of a wheeled semi-trailer vehicle and, even more important, reducing the time for which the expensive and vulnerable aircraft is stationary in the forward zone. This concept has taken tangible form in the hands of, particularly, Sikorsky, but the derivatives built in this country by Westland Aircraft, Ltd., do not exploit it ; the prototypes of the " Westminster " (S-56) have the form of a " flying crane," in that they have no interior stowage, but can accept load only when airborne, thus increasing the difficulty of the ascent and alighting manœuvres and the drag during cruise. The true helicopter tends to be limited to short-distance hauls by its low speed and high fuel consumption, but a nearly related machine, the v.t.o.l. autogiro such as the " Rotodyne," would appear to be at least equally suitable for the role of heavy hauling in the forward areas, with the additional merit of sufficient range to perform airborne landings where opposition is not heavy—as an extreme case of limited war, the exercise of " air control " over colonial territories would appear to be greatly facilitated by a vehicle that can rapidly establish a well-equipped force of infantry in almost the roughest country and, moreover, extricate them. It seems reasonable to say that the supply of forward units other than against opposition, in which case the ground effect machine or the high-powered v.t.o.l. able to make use of cover become necessary, is already technically possible and that the absence of such provision to-day is not the fault of the aircraft constructors.

It cannot seriously be supposed that in the future, any more than in the past, the aircraft and other industries within Great Britain will be able to provide the entire range of equipment needed by the fighting services. While, however, weapons shared with other nations can obviously be based on greater investments of capital and engineering effort, there exist the dangers that the weapons needed by this country might not have been developed by any nation willing to supply them, and that development in different countries may proceed along corresponding instead of complementary courses. These possibilities appear the more significant because, at least in this country, great difficulty is found in assigning to the effectiveness of a weapon quantitative values which can be set against the cost : thus, one sees the Royal Air Force deprived of the great but ill-defined increase in the deterrent potential of the " Thor " that would be endowed by mobility because of the relatively low but definite cost of the " Cargomaster." It may be trusted, however, that this virtual obsession with cost must now have been discredited, since to deploy as weapons equipment as far behind the state of the art as the " Blue Streak," " Britannic," " Comet" " Firestreak " and " Sea Vixen," is to invite foreign powers to believe that the Royal Navy and Royal Air Force are equipped to impress the " owners " rather than to intimidate the unfriendly.

Obituary

MR. WILLIAM DIXON, M.I.Mech.E., M.I.E.E., M.Inst.F.

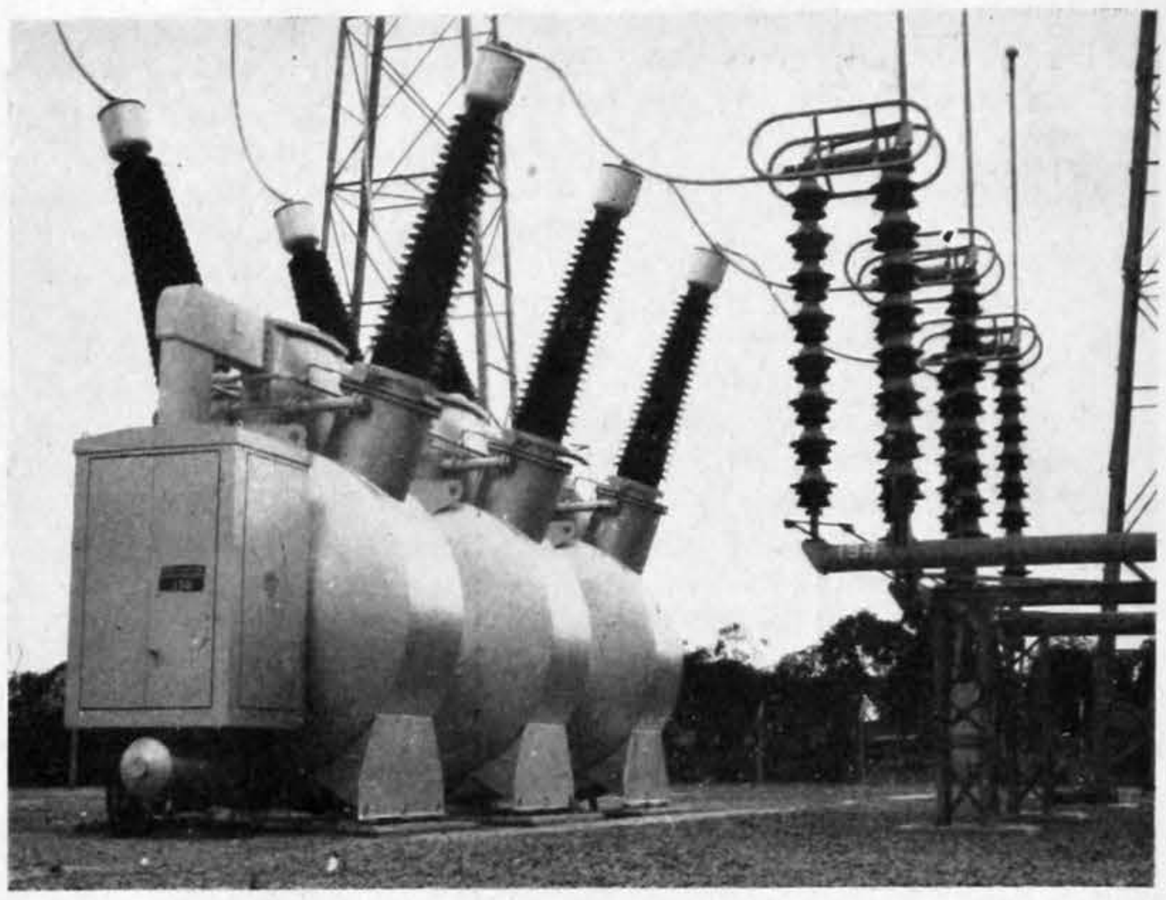
We learn with regret that Mr. William Dixon, a partner in Merz and McLellan, died on December 31 last, at the age of seventy-one, after a short illness. William Dixon began his technical education at Armstrong College, Newcastle. After a period of practical training with C. A. Parsons and Co., Ltd., he was on the technical staff of the company. In 1911 he left to join Merz and McLellan as a junior engineer. He returned to this firm of consultants after serving in the Royal Engineers during the 1914–18 war, and he was taken into partnership in 1937. For many years he was the senior partner in the firm's Newcastle upon Tyne office. His interests in consultancy ranged over the whole field of electricity generation and supply, and he was closely concerned with many power schemes in London, the North East of England and overseas. Mr. Dixon served as chairman of the North Eastern Centre of the Institution of Electrical Engineers in the 1945–46 session.

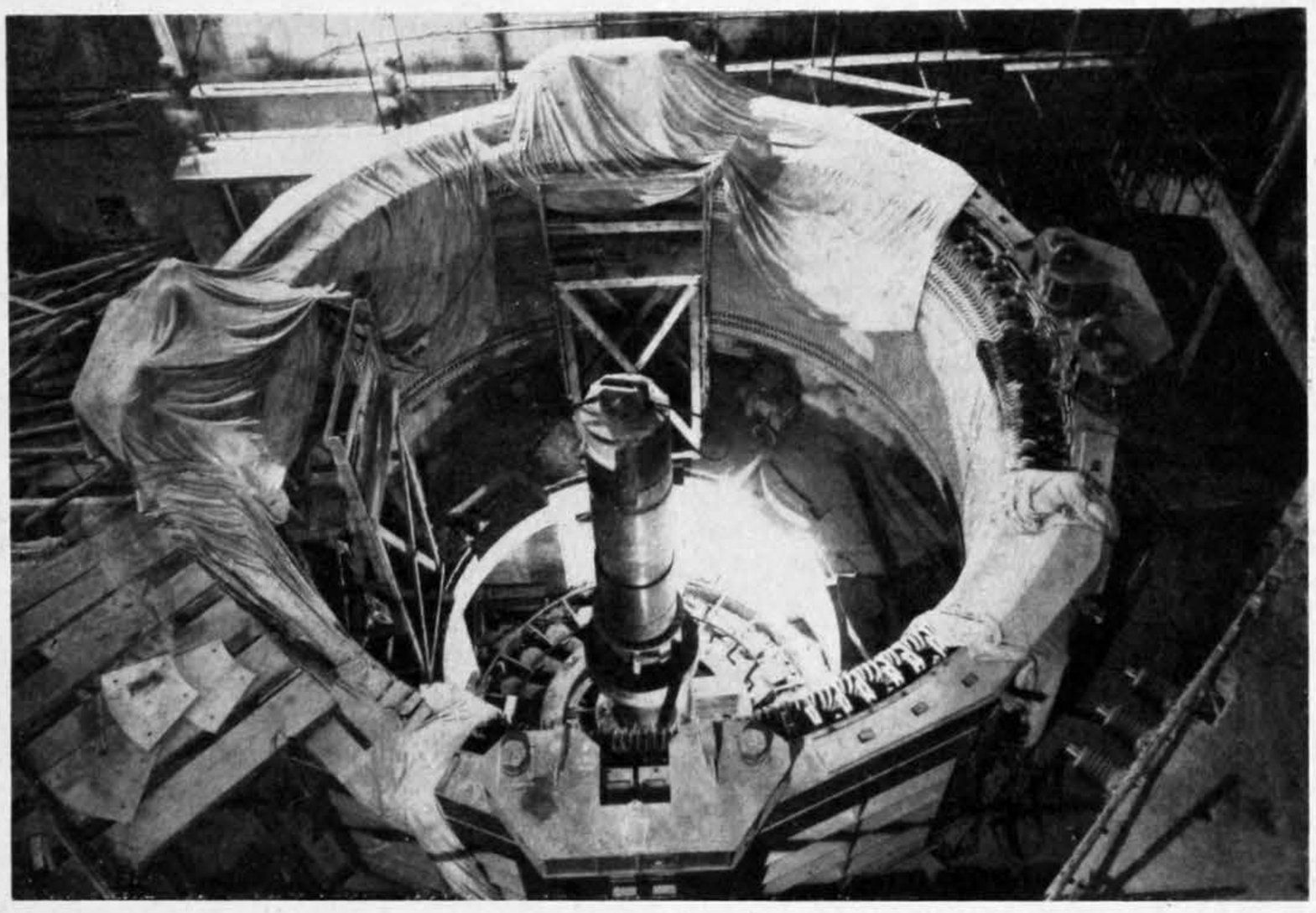
Machine Tool Exhibition.—For two weeks commencing Monday, January 18 next, an exhibition of machine tools will be held by Monks and Crane, Ltd., Garretts Green Lane, Birmingham, 33. More than sixty machines to be exhibited will be of Italian, Swedish, German and Czech manufacture.

Electrical Plant, Kariba

On December 28, 1959, the first of six 100MW hydro-electric generators in Kariba power station, Rhodesia, went on load. Commissioning is being supervised by Messrs. Merz and McLellan on behalf of the Federal Power Board. In the Kariba scheme on the Zambesi, about 300 miles downstream from Victoria Falls, an ultimate installed capacity of about 1500MW of generating plant is envisaged, with an estimated annual output of 9000 million kWh. The first stage now under construction includes a dam to create an artificial lake covering about 2000 square miles, a diversion tunnel and an underground power station housing six 100MW turbine-generators. A second underground power station of 800MW to 1000MW, to be built on the other bank of the Zambesi, is proposed for the final development.

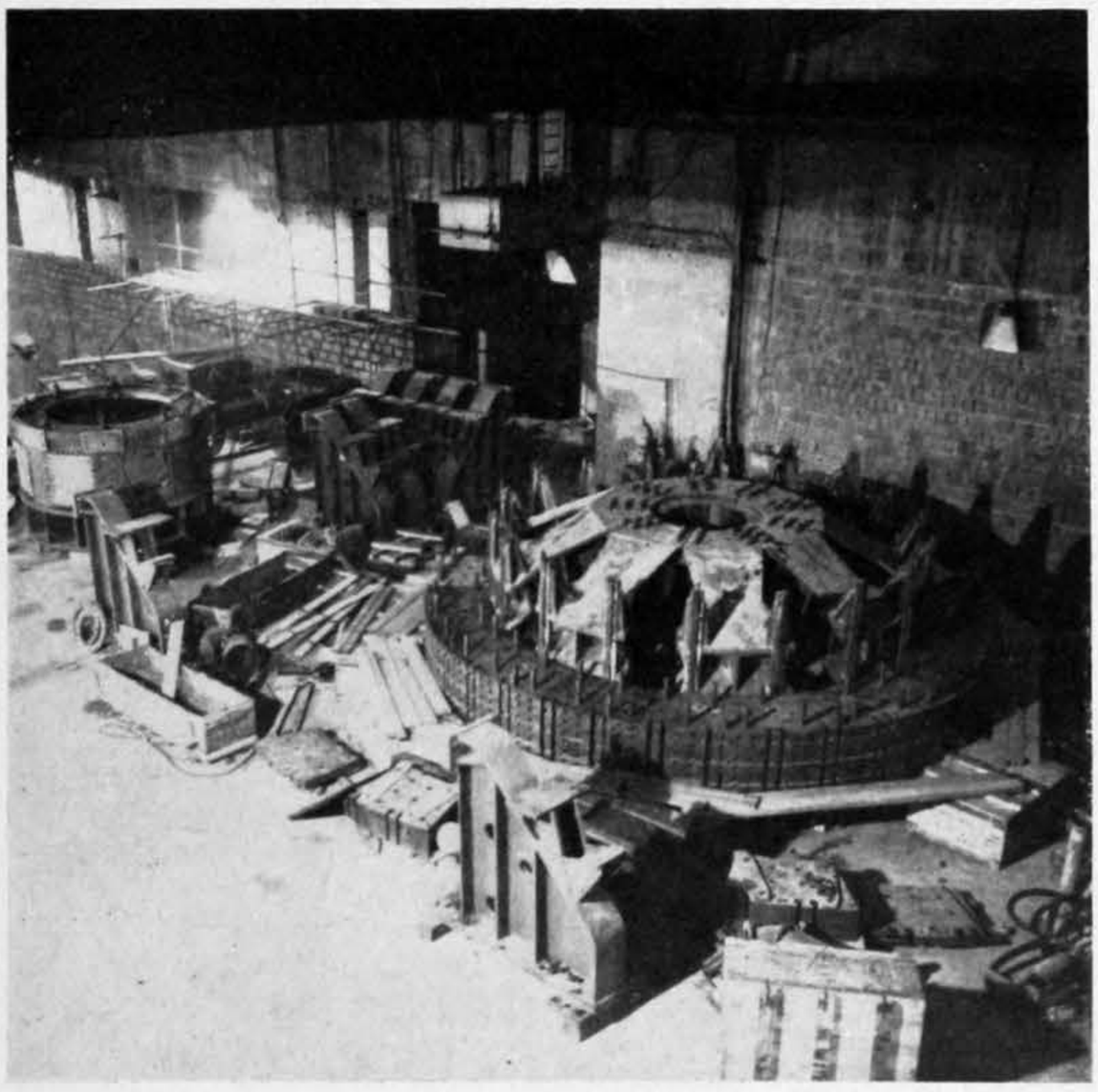
Power is transmitted by overhead lines at 330kV with a switching station at Kariba and substations at Kitwe, Norton, Salisbury Sherwood, Bulawayo and Lusaka. For these seven substations the A.E.I. switchgear division, Willesden, is supplying twenty-five 7500MVA lenticular oil circuit breakers and over 100 isolators. Sixteen of the oil circuit breakers have been shipped and some of these have been commissioned at Kitwe (illustrated, RIGHT), Lusaka and Kariba. Shipments of circuit breakers are being made at the rate of one per month.

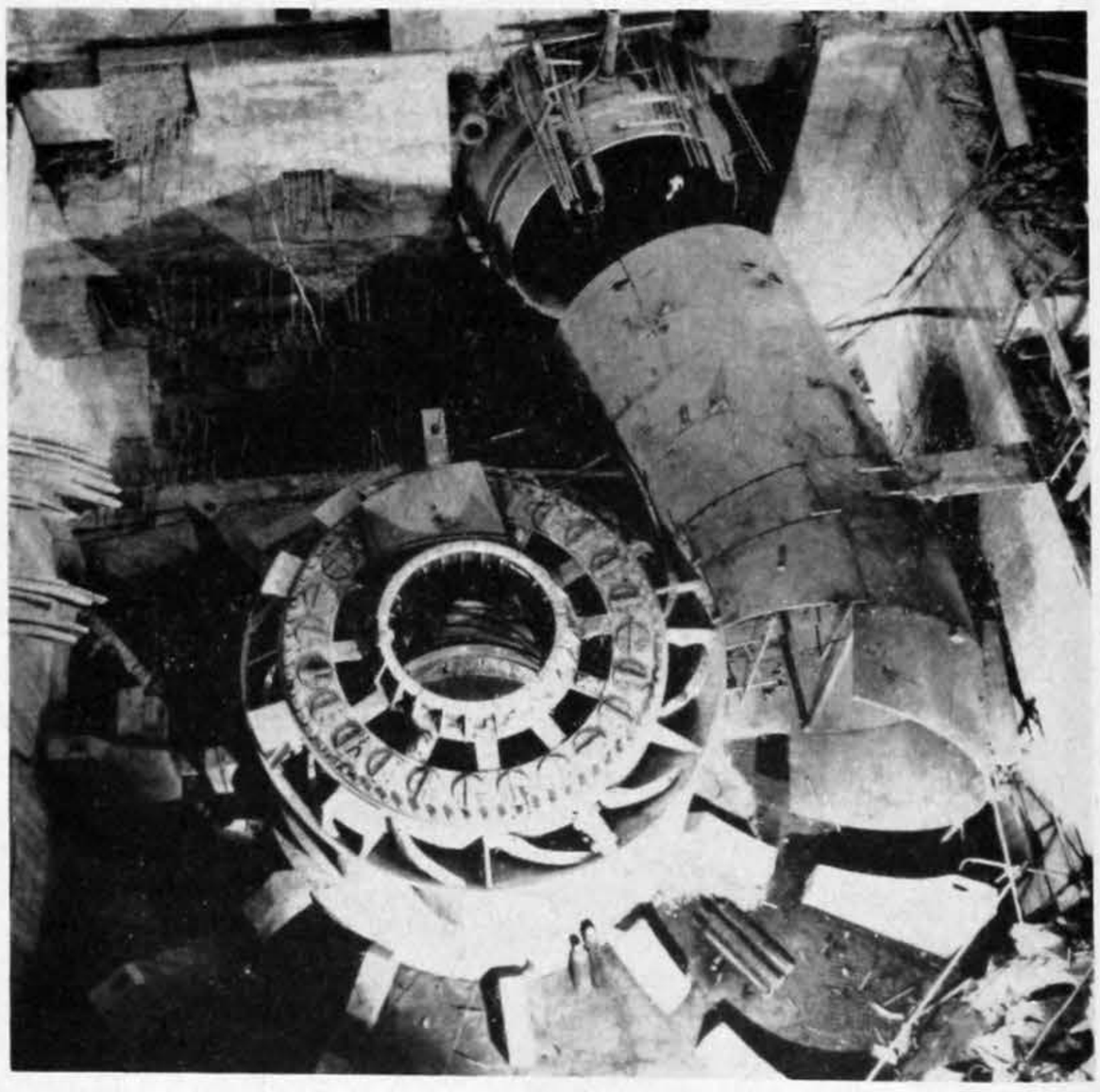




The six generators for the first stage are being supplied by the A.E.I. heavy plant division, Manchester. Each generator is coupled to a Francis turbine made by Bovings, Ltd., and is rated at 100MW at 0·9 power factor lagging, 18kV, three-phase, 50 c/s at 166·7 r.p.m. Excitation is supplied by a 364kW, 360V, d.c. machine, fitted to the top of the alternator shaft (which has a thrust bearing and a guide bearing immediately below the rotor) and is controlled by a rotating magnetic-amplifier voltage regulator. Fire-suppression equipment is built-in ; initiation is by thermostats in the hot end of the air circuit. The auxiliary plant includes a high-pressure oil-operated jacking system, purification equipment for governor and bearing oil, and an air compressor unit for braking. Three views of generators being erected on site are illustrated, LEFT and BELOW.

The original programme for commissioning the generators at the rate of two per year has been accelerated ; two more sets are to be commissioned this year, two in 1961 and the sixth in 1962.





Durgapur Steel Works

In our last issue we gave a brief account of the progress made to date on the building and equipment of the Durgapur iron and steel plant in West Bengal. The plant, which is being erected by Indian Steelworks Construction Company, Ltd., a consortium of British firms, is designed for an annual production of 360,000 *tons of pig iron and* 1,000,000 *ingot tons of crude steel.*

IN October, 1956, a contract was signed between the Government of India and the Indian Steelworks Construction Company, Ltd. (ISCON), for the erection of a fully-integrated iron and steel works at Durgapur. It is one of three plants being built for the Indian Government, the contracts for the other two, at Rourkela and Bhilai, being let to West Germany and Russia respectively. The value of the Durgapur contract is about £105 million ; it has been described as the " largest single export order ever obtained by Great Britain."

The Durgapur project originated in a Colombo Plan survey which was made, under the leadership of Sir Eric Coates, in 1955. Subsequently, the Indian Steelworks Construction Company, Ltd., was formed by the following thirteen British firms : Davy and United Engineering Company, Ltd.; Head Wrightson and Co. Ltd.; Simon-Carves, Ltd.; The Wellman Smith Owen Engineering Corporation, Ltd.; The Cementation Company, Ltd.; The British Thomson-Houston Company, Ltd.; The English Electric Company, Ltd.; The General Electric Company, Ltd.; The Metropolitan-Vickers Electrical Company, Ltd.; Sir William Arrol and Co. Ltd.; The Cleveland Bridge and Engineering Company, Ltd.; Dorman Long (Bridge and Engineering), Ltd., and Joseph Parks and Son, Ltd. In addition to these members of the consortium, there are several other British firms acting as sub-contractors. The financing of the Durgapur project has been assisted by a British Government loan to the Indian Government of £15,000,000 plus letters of credit, for a further £11,500,000, arranged by Lazard Brothers with British banks.

The site of the Durgapur plant, in West Bengal, covers 1500 acres. It is about 118 miles from Calcutta and lies near to the River Damodar and the hydro-electric power resources of the Damodar Valley Corporation. Durgapur is also near to the coal mining areas of Bihar and West Bengal ; there are limestone quarries in the neighbourhood and iron ore deposits within a radius of 200 miles. Thus, there is no difficulty about the availability of essential raw materials.

The Coke Ovens

The No. 1 coke oven battery, which was started up last August, was illustrated on Plate 3 in our issue of January 1. It is the first of three batteries of compound underjet ovens which are being built by Simon-Carves, Ltd., Cheadle Heath, Stockport. Each battery is arranged in two independently operated blocks of thirty-nine ovens. The three batteries, which have their own oven machines, will normally be heated by blast furnace gas, although coke oven gas can be used, if desired, when it is available. The gross coking time is approximately nineteen-and-a-half hours and, when they are all completed, three batteries will have a combined throughput of 5200 tons of dry coal a day, making about 3900 tons a day of run-of-oven coke, of which approximately 3300 tons will be $+\frac{3}{4}$in size suitable for the blast furnaces. The $-\frac{3}{4}$in coke screened out on the primary screens will be graded into three sizes on a domestic screening plant and stored for loading on to rail wagons.

Coal Preparation Plant

The coal preparation plant, which has been built by Simon-Carves, Ltd., includes a washery capable of treating an input of 360 tons an hour of 3in–0 raw coal. This washery is a single unit having two " Drewboy " dense-medium primary separators in parallel, each with a capacity of 160 tons an hour, followed by a secondary " Drewboy " separator with a capacity of 140 tons an hour for producing a middles fraction. This, in turn, is followed by an " Acco " feldspar jig washbox with a capacity of 120 tons an hour of $\frac{1}{2}$in–0 raw coal.

The washed coal for coking is blended on the Robins Messiter system. The coal is deposited on open ground in long parallel stockpiles by travelling wing trippers, the coal varieties being layered down successively in such a way that each stockpile contains the ingredients of a complete coking blend. The coal is reclaimed by travelling rakes moving continuously to and fro over the cross-section of the stockpile, so that a correct coking blend is continuously removed, blended in the action of removal, and deposited on underground reclaiming conveyors which deliver to the coking plant.

Boiler Plant

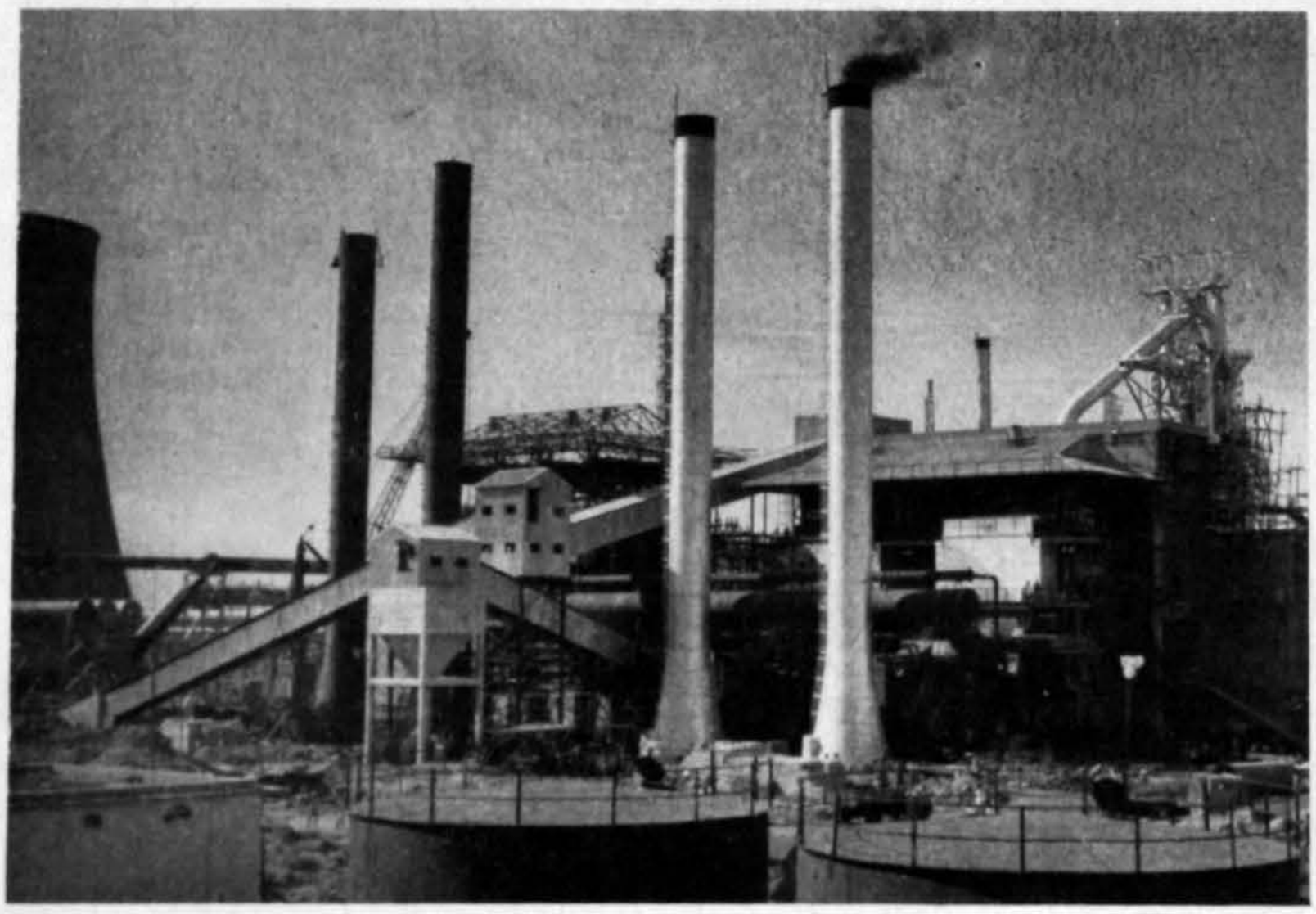
In addition to the coke ovens and coal preparation plant, Simon-Carves, Ltd., is responsible for the by-product and sulphuric acid plants being built at Durgapur. Another part of this firm's contract is for the power station boiler plant. The main function of the power station is to supply high-pressure steam for the blast furnace turbo-blowers. The boiler plant comprises four water-tube boilers, each with a continuous maximum rating of 150,000 lb an hour of steam at 500 lb per square inch and 775 deg. Fah. from feed water at 250 deg. Fah. Two of these boilers are fired by blast furnace or coke oven gas only. The other two are arranged for firing by blast furnace or coke oven gas or, alternatively, by coal or coke breeze which can be burned either separately or by sandwich firing. The boiler firing aisle is enclosed in the power station, but the boilers themselves are in the open. An accompanying illustration shows the boiler plant together with its fuel and ash handling equipment.

Blast Furnace and Material Handling Plant

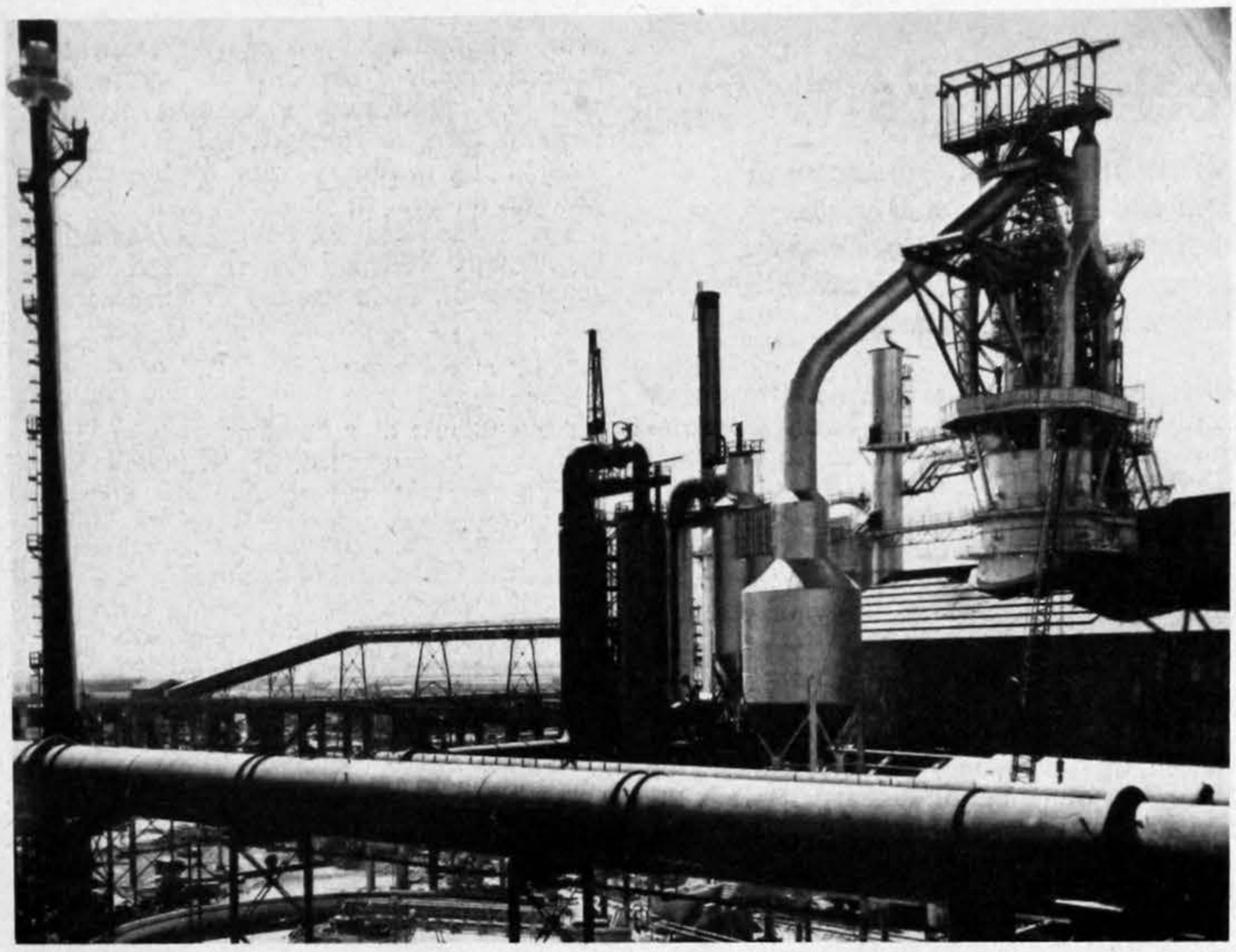
The design, purchasing and contracting of the iron-making plant at Durgapur have been undertaken by Head Wrightson Iron and Steel Works Engineering, Ltd. The iron-making plant can be primarily divided into the following sections of work : the handling of iron ore, limestone and other miscellaneous materials from the wagon sidings via either a blending plant or limestone screening house to the blast furnace stock-house bunkers ; the three blast furnaces and all their ancillary equipment ; gas cleaning plant and pig casting plant.

On Tuesday, December 29, the first of the three blast furnaces was commissioned by the President of India, Dr. Prasad. This furnace is illustrated herewith. Each of the three furnaces is capable of a daily material production of 1250 tons of iron, with an estimated average coke consumption of 2000 lb per ton of iron and an average limestone consumption of 700 lb per ton of iron. Two of the three furnaces will normally be engaged in the production of iron for use in the steelmaking plant, while the third furnace, when available, will be producing foundry iron for internal consumption in the works foundry, or for sale.

Materials are charged into the furnace through a McKee-Head Wrightson revolving distributor. The revolving receiving hopper is 6ft 6in in diameter, with three supporting rollers, hold-down rollers and side rollers, with a manganese steel bell seat. The distributor is driven by a 10 h.p. a.c. motor



Power station boiler plant and fuel handling equipment



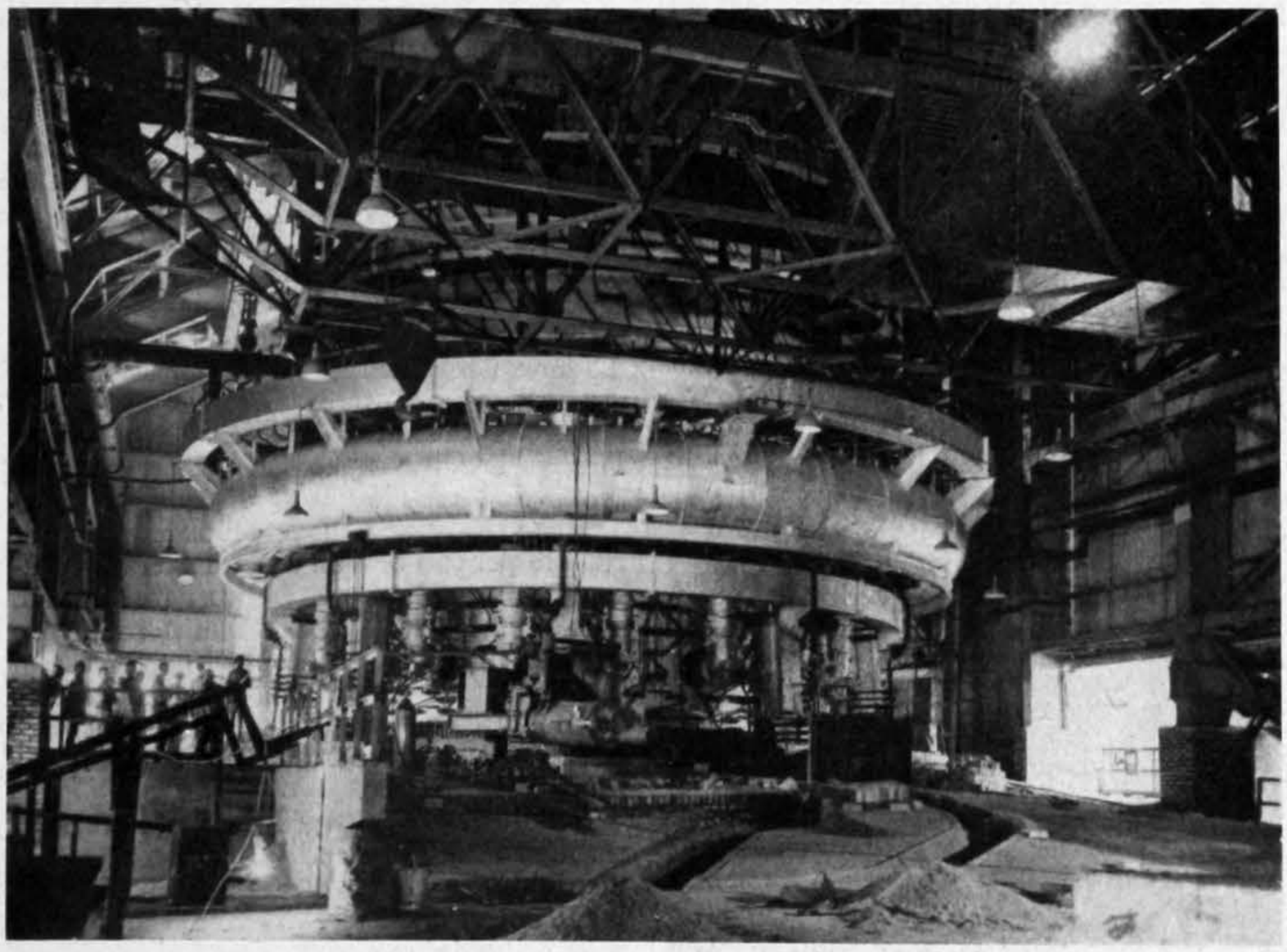
The No. 1 blast furnace is designed for a daily output of 1250 tons of iron

through worm gearing, with selective reversing control and dynamic braking. The small bell is 7ft diameter (in halves), weighing approximately 5 tons, and the pneumatic bell hoist operated by the cold blast can be driven, in an emergency, by the compressed air system for the plant. The large bell is a steel casting 15ft 6in diameter, with a 53 deg. side angle, weighing approximately 25 tons. The large bell hopper is a steel casting, with a 15ft 10in top diameter and a 14ft 9in diameter seat, weighing approximately 33 tons ; the hopper capacity is approximately 1700 cubic feet.

All the equipment is designed to enable the furnaces to be operated at a later date at a high top pressure of 10 lb per square inch. Each furnace has a hearth diameter of 27ft, with eighteen tuyeres and an effective working volume of approximately 41,400 cubic feet. The furnace hearth, bosh and inner wall are lined with " A " quality firebrick blocks, with an additional carbon brick lining inside the hearth cooling staves. One set of hematite iron cooling plates are provided inside the hearth jacket, eleven rows of flat plate copper coolers being provided for the bosh and seven for the stack. Each furnace has three hot blast stoves with a total heating surface in each stove of approximately 229,000 square feet. The stoves are of the two-pass design with side combustion chambers of elliptical cross-section of 55 square feet area, the stove shells being 26ft diameter and 110ft high.

The estimated total gas made from three furnaces will be 18,000,000 cubic feet an hour and the gas cleaning plant is designed to clean this quantity to a maximum dust content of 0·004 grain per cubic foot. After passing through the primary and secondary dust catchers of the two static tower gas washers, the washed gas from each of the three furnaces is passed into an electrostatic fine cleaning plant common to all three furnaces. This will consist of eight Head Wrightson Research Cottrell wet tube electrical precipitators, each of 25ft diameter with 400 8in tubes. Each precipitator is equipped with a selenium rectifier, a 35kVA, three-phase, 50 c/s, 400/75,000V transformer/rectifier, and a 35kVA regulating transformer to maintain a preset value constant to within ±1 per cent, regardless of supply voltage fluctuations.

Hot metal from the blast furnace producing foundry iron and surplus basic iron are to be transported by rail in ladles of 90-ton nominal capacity to the pig casting plant. This plant will consist of two double-strand pig casting machines, with a rated capacity of 60 tons of pig per casting hour on each strand.



The hearth area of the No. 1 blast furnace

New Year Honours

THE list of New Year Honours was published last Friday, January 1. It includes announcements, as follows, of honours to be conferred on engineers and others associated with the engineering and allied industries.

Baron.—Sir George H. Nelson, Bt., chairman of The English Electric Company, Ltd.

Baronet.—Mr. J. K. Vaughan-Morgan, director of Morgan Crucible Company, Ltd.

Knights.—Dr. W. H. Glanville, director of the Road Research Laboratory, Department of Scientific and Industrial Research ; Mr. Joseph Latham, deputy-chairman, National Coal Board ; Mr. J. F. Lockwood, chairman of Electric and Musical Industries, Ltd.; Mr. A. B. Waring, chairman and managing director of Joseph Lucas (Industries), Ltd.

C.B.—Mr. L. G. Gale, director-general of armament production, War Office ; Mr. R. H. Weir, director-general of engine research and development, Ministry of Aviation ; Mr. H. F. Willis, chief of the Royal Naval Scientific Service.

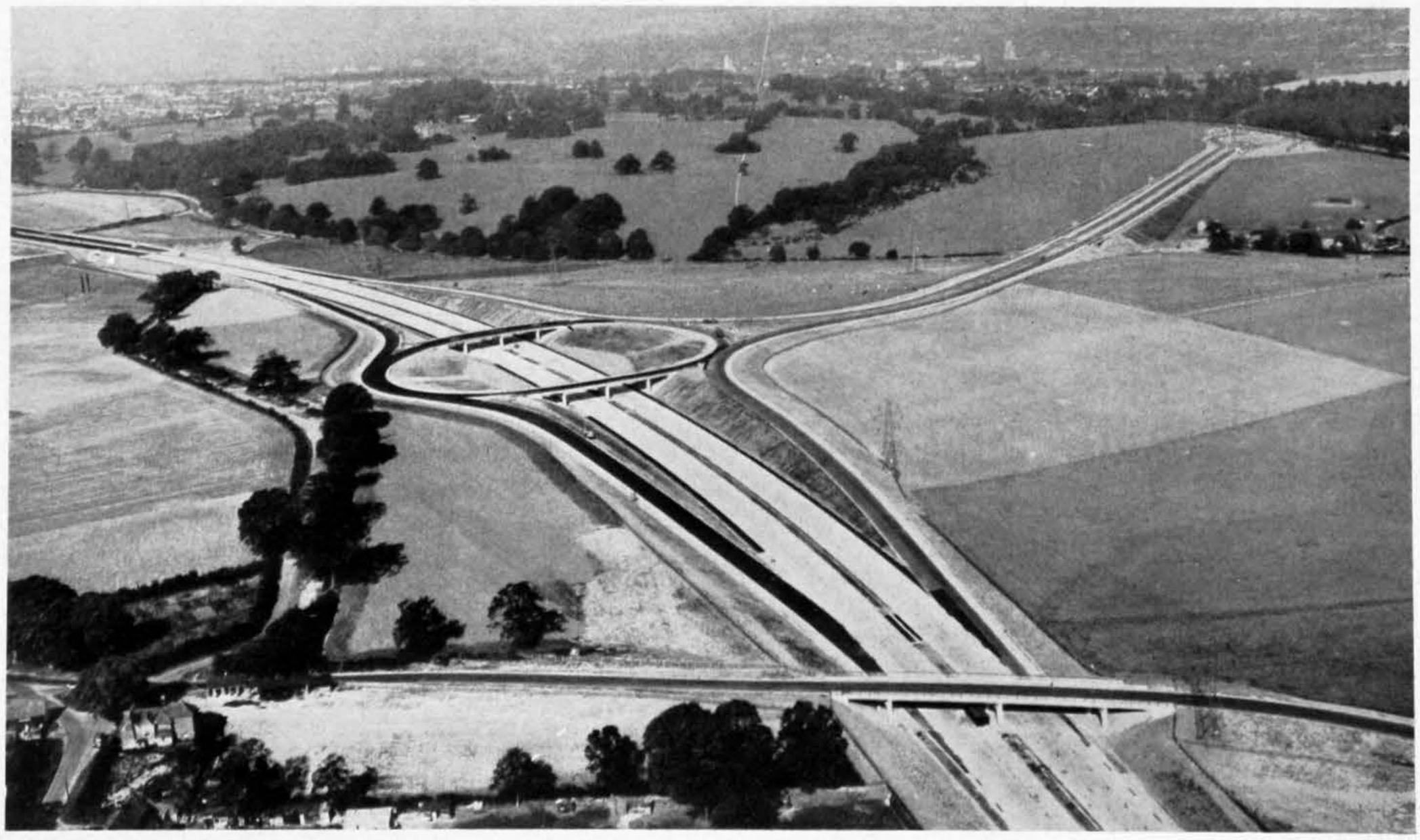
K.B.E.—Mr. J. R. Farquharson, general manager, East African Railways and Harbours Administration ; Rear-Admiral Sir Matthew Slattery, chairman and managing director of Short Brothers and Harland, Ltd.

C.B.E.—Mr. J. C. Ogilvie Burns, chief engineer, Department of Health for Scotland ; Mr. D. D. Cruickshank, general manager, Renfrew, Dalmuir and Dumbarton works of Babcock and Wilcox, Ltd.; Mr. L. J. Davies, director of research and education, British Thomson-Houston Company, Ltd.; Mr. Sam Green, managing director of Remploy, Ltd.; Mr. N. P. Newman, president of the Joint Iron Council ; Mr. A. J. Nicholas, managing director of South Wales Switchgear, Ltd.; Mr. T. B. Nicol, engineer-in-chief, Metropolitan Water, Sewerage and Drainage Board, State of New South Wales ; Mr. H. T. Pledge, keeper at the Science Museum ; Mr. H. T. Ramsay, director, Safety in Mines Research Establishment, Ministry of Power ; Mr. John Sharples, general manager and deputy chairman, Central Electricity Board, Federation of Malaya ; Mr. H. A. J. Silley, chairman of R. and H. Green and Silley Weir, Ltd.; Mr. Frank Williams, controller, sound broadcasting engineering, British Broadcasting Corporation.



1959 Our pictorial review of engineering progress during the past year is continued in the ensuing supplement. We start with illustrations of two outstanding civil engineering schemes which were completed in 1959. ABOVE is the St. Lambert lock at Montreal, the first lock of the St. Lawrence Seaway. This vast scheme was inaugurated last summer, and has been fully described in this journal. The illustration shows construction still in progress, on the road and rail spurs serving the two lifting bridges at the lock. In the background is the Seaway canal and the Jacques Cartier bridge, which was reconstructed by a complicated sequence of lifting operations to give 120ft headroom at the canal.

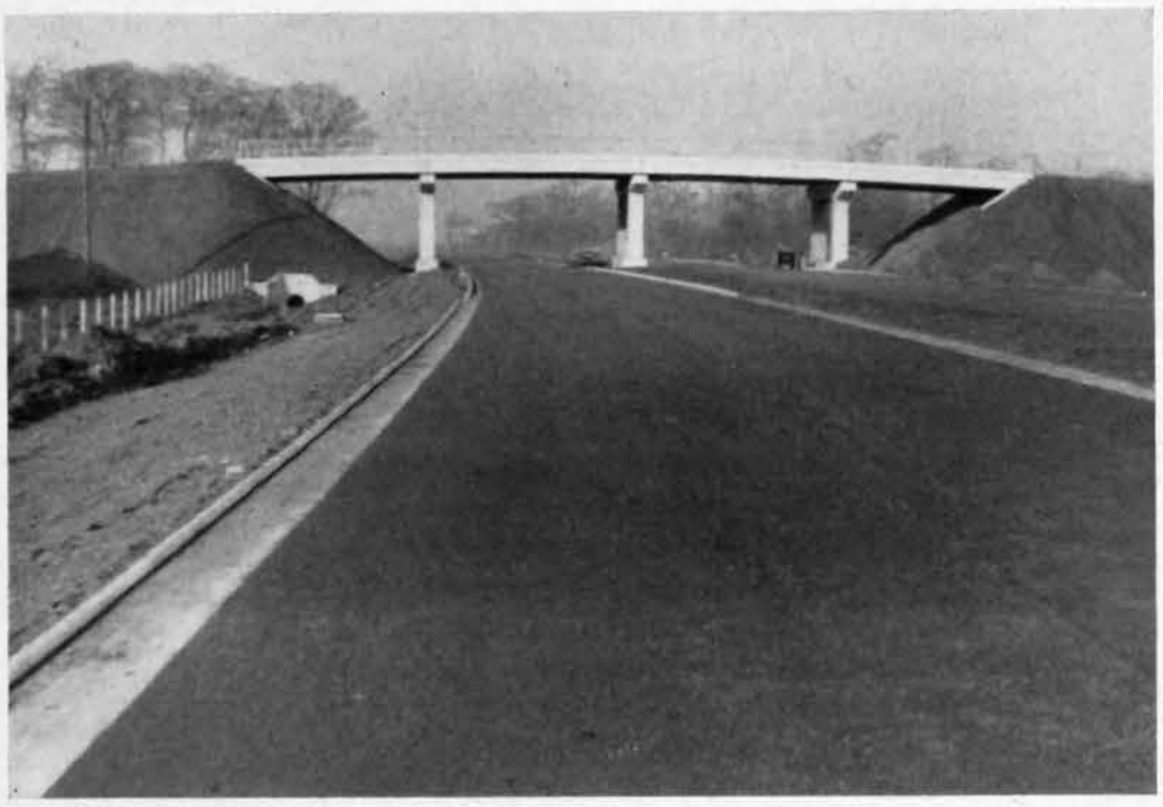
The LOWER illustration shows the Pepperstock interchange on the M1—the first substantial motorway to be built in this country. All told, about 75 miles of motorway, most of it of dual three-lane construction—was built in nineteen months. Full description "The Engineer," November 6 and 13 last.

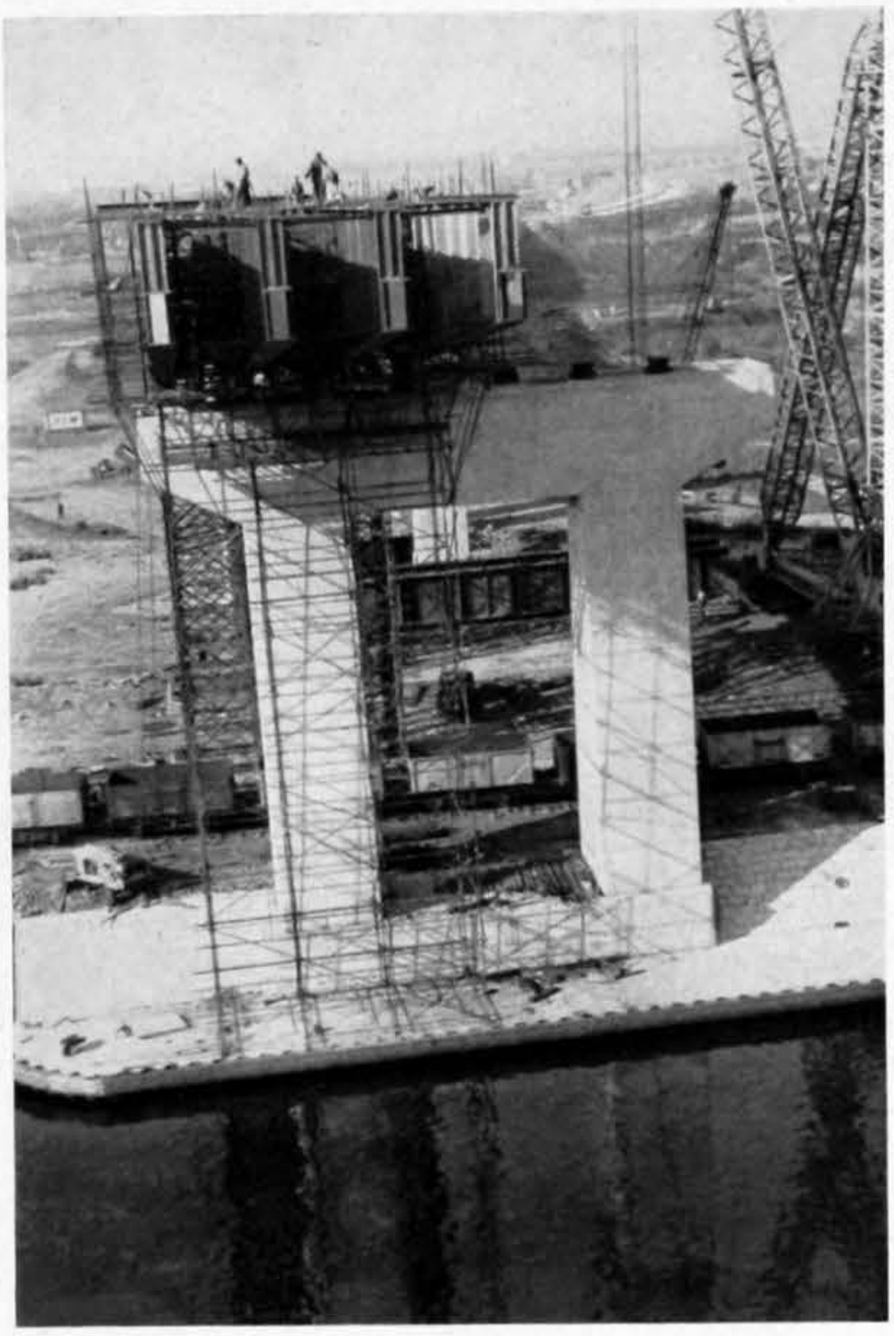




Road Construction in Lancashire

The principal feature of the Stretford–Eccles by-pass motorway is the Barton High Level Bridge over the Manchester Ship Canal (ABOVE and RIGHT) which is an eighteen-span viaduct 2425ft long with a central span of 310ft. The superstructure is of steel, with a concrete deck. The road is an urban motorway with two-lane carriageways and four, intermediate, two-level junctions. It is about 6 miles long, starting at A.56 (Stretford) and leading to A.575, but later it will continue northwards to A.580. Road works have included importing over 3,000,000 tons of hard filling. The carriageways have a 6in layer of crusher-run stone, on a sub-base of variable thickness, followed by an 8in layer





of wet-mix ; the carpet base coat is of hot rolled asphalt, sprayed and chipped, with a hot-rolled asphalt surface with precoated chippings to be laid six months after opening. Main contractors : Wilson Lovatt and Son, Ltd. (Salteye Culvert) ; G. Dew and Co., Ltd. (Barton bridge) ; Gee, Walker and Slater, Ltd.; and A. E. Farr, Ltd. LEFT, Grange Farm bridge over the motorway in Eccles.

Lancaster by-pass motorway is 11·62 miles long, with dual 24ft carriageways, capable of being widened to 36ft. It forms part of the North–South through route, and has twenty-seven bridges, mainly with prestressed concrete decks. The bridge over the River Lune (BELOW) is an open spandrel arch in reinforced concrete (span 230ft, rise 44ft) with a length of 400ft. Construction calls for 1,700,000 cubic yards of excavation, about 10 per cent of it peat. The carriageways consist of two-course hot rolled asphalt finished with precoated chippings, on 9in of cement-bound wet-mix, on 6in of crusher run stone. Contractor : Sir Lindsay Parkinson and Co., Ltd.

Both roads were nearing completion at the end of the year, and were designed under the direction of Mr. James Drake, the county surveyor and bridgemaster. For the Lancaster by-pass, the Lancs C.C. are the Ministry of Transport's agents.



Mannheim-Ludwigshaven Road Schemes

With increasing interest and urgency in urban road schemes at home, it is particularly instructive to learn what is being done to handle urban traffic in the German towns of Mannheim and Ludwigshaven, which lie on opposite sides of the Rhine. We show BELOW the approaches on the Mannheim side of the Rhine bridge connecting the two towns. In the foreground, and turning off to the right, is a railway. The highway bridge has three lanes in each direction, the central pair of lanes having tram tracks on them. There are four roads serving the bridge, and the system of approaches separates each traffic stream

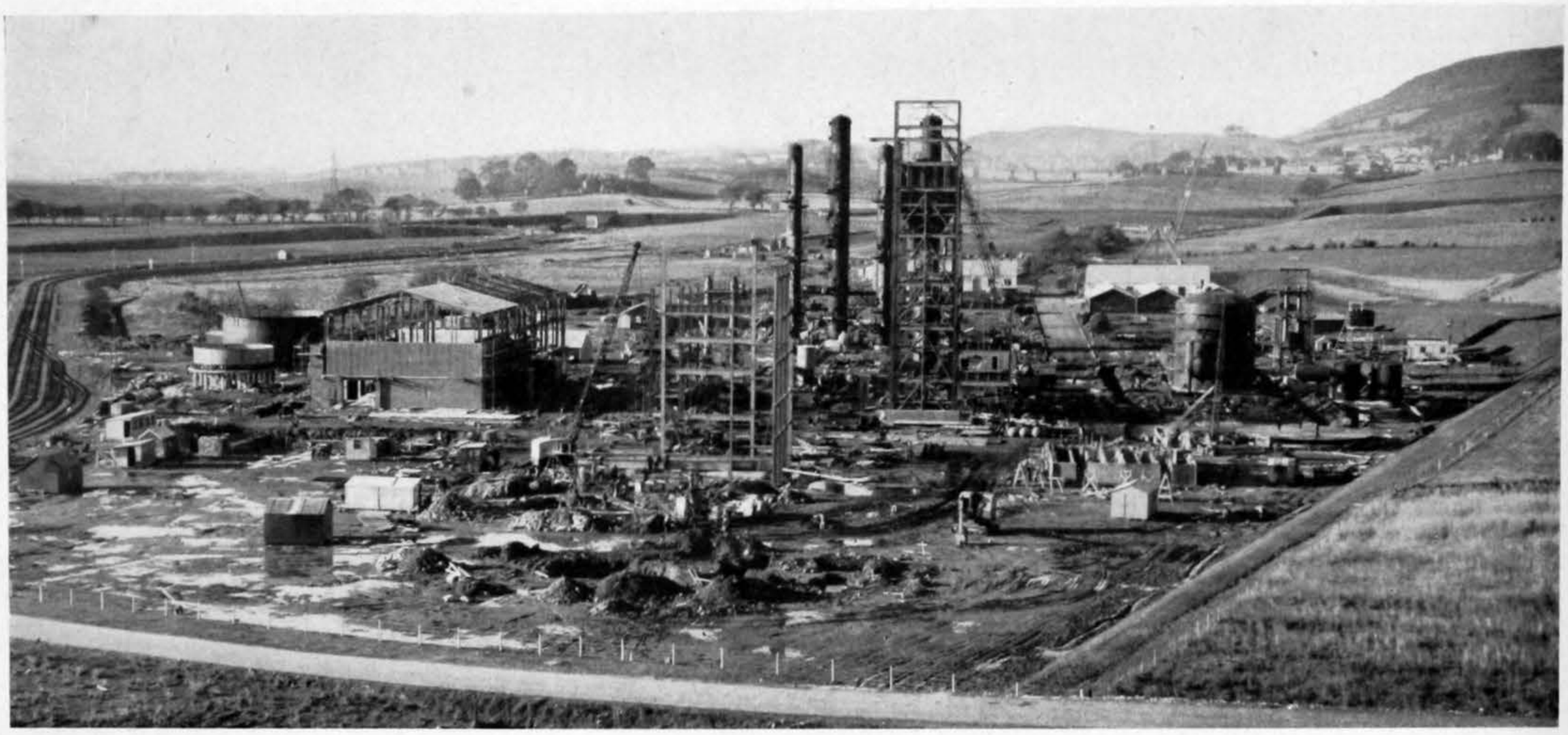




entering or leaving it. There is also a separate curved ramp for trams, and separate paths for cycle tracks and pedestrians. The effect of this comprehensive approach system, which was completed last October, has been to increase the capacity of the bridge by 50 per cent. Although the site has not been "tidied up," ABOVE RIGHT, the tramway ramp and pedestrian bridge are characteristic of the good appearance of the structures, and of the junction as a whole. There are twenty structures in the approaches.

An elevated roadway system is being built on the Ludwigshaven side of the bridge, to serve the centre of that town, and connect directly with motorway routes. We show, LEFT, a typical "mushroom" in prestressed concrete for a section of elevated road, where a dual three-lane road with an overall width of 25m is carried on a series of these single supports, spaced 25m apart. This design is novel, and is considered to be an advance. With several "mushrooms" in series, one is anchored, and in others the circular column is carried on roller bearings.



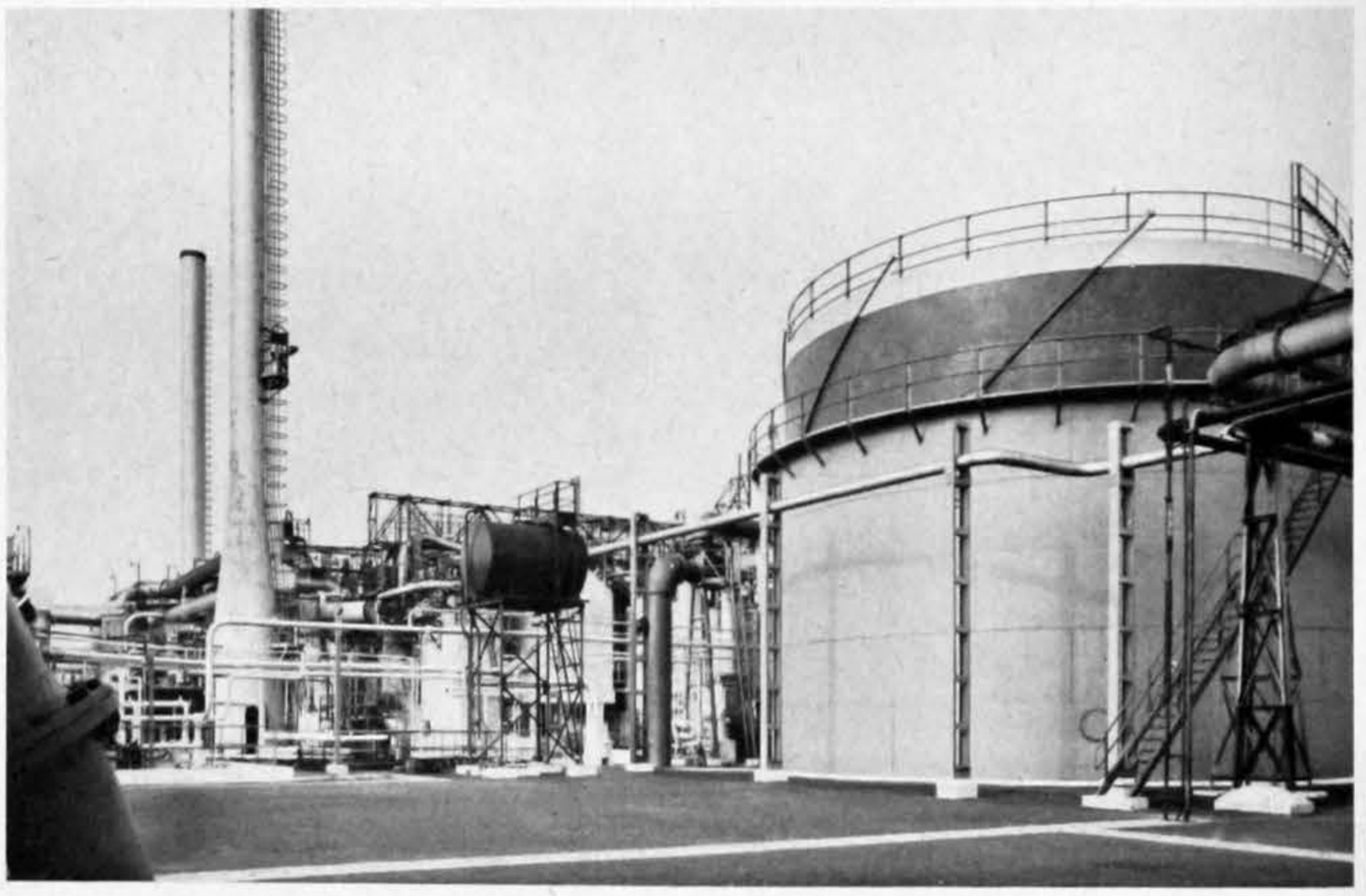


Gas Works

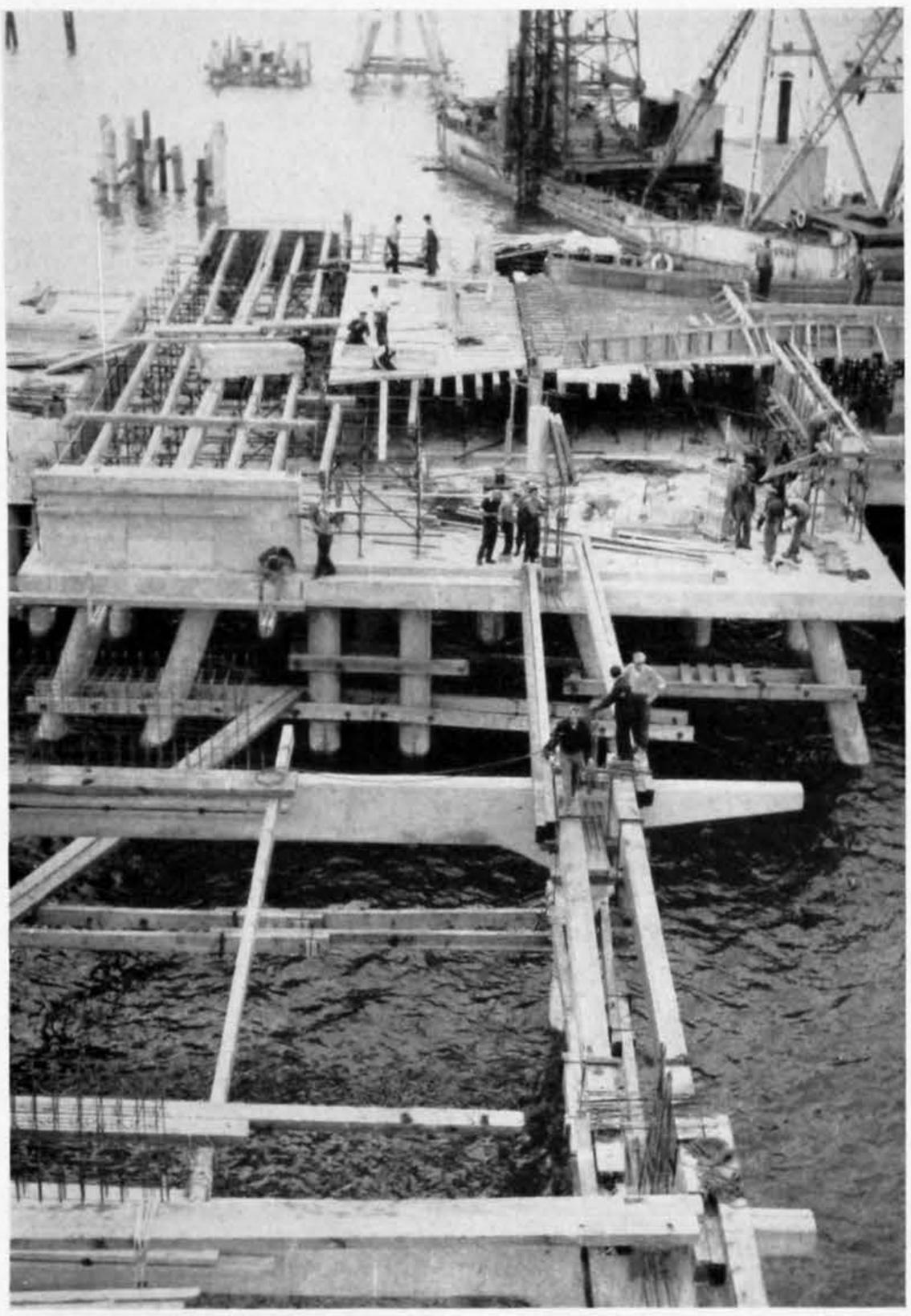
During the past twelve months the gas industry of this country maintained the steady progress of recent years in modernisation. An interesting outcome of this programme was the gas reforming plant at the rebuilt Romford gas works which was put into service early this year (see "The Engineer," May 29, 1959). This plant takes surplus refinery gas from the Shell Haven and Coryton refineries, some 16 miles away, through a 24in high-pressure main, and one part of it can be seen RIGHT. The size of the site has not been extended but the new plant has resulted in a tenfold increase of capacity to some 44,000,000 cubic feet of gas a day, making it one of the largest producers of town gas in the country. The plant incorporates four "Onia-Gegi" units supplied by Humphreys and Glasgow, Ltd.

The illustration at the top of the page gives a general impression of the progress which has been made at the site of the high-pressure Lurgi complete gasification plant being built at Westfield for the Scottish Gas Board. This plant will use low-grade coal from a nearby open-cast working and is being built at a cost of some £6,600,000. It is being built in stages, the first of which will be in service towards the end of 1960 and have an output of 15,000,000 cubic feet of gas a day. The second stage of the plan will double this output. The plant will feed gas into a high-pressure grid serving an extensive surrounding area of the countryside. (See "The Engineer," October 30, 1959). The main contractor for this plant at Westfield is Humphreys and Glasgow, Ltd. Approval for the construction of another Lurgi complete gasification plant at Coleshill, near Birmingham, has recently been given by the Minister of Power. Plans for this plant have been prepared by the Woodall-Duckham Production Company, Ltd., and it will cost some £8,845,000.

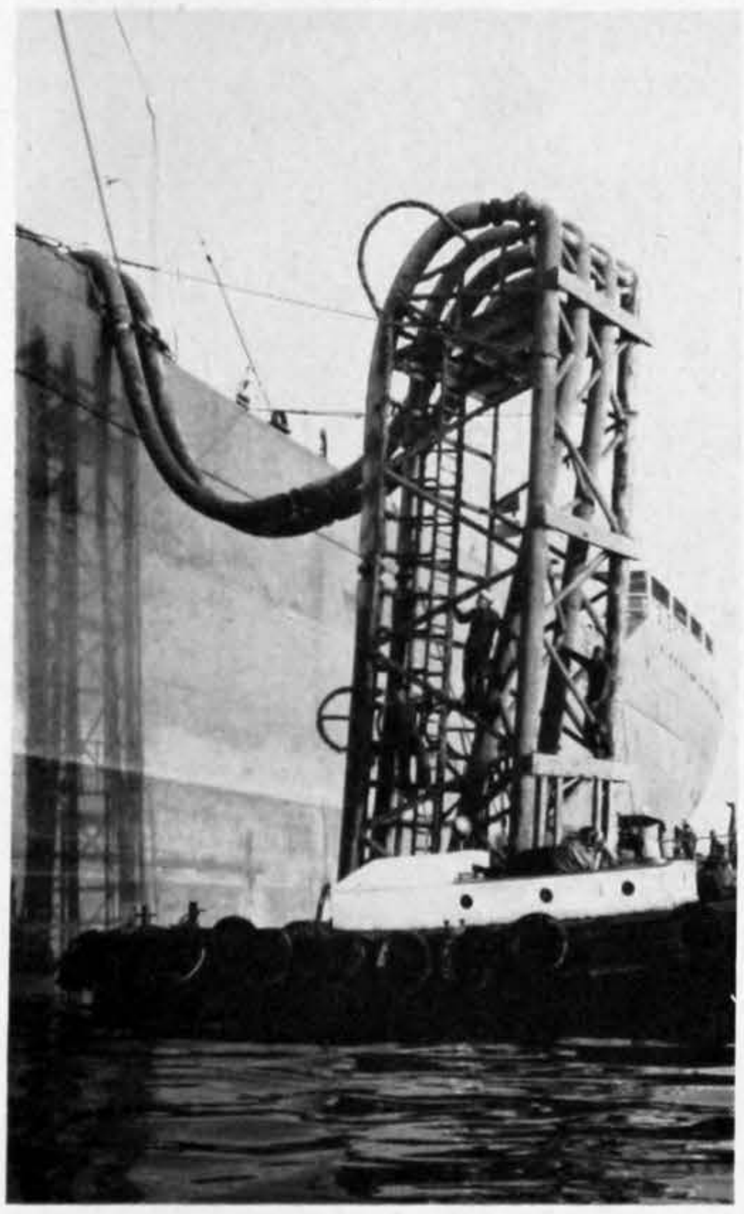
An important addition to the gas-making capacity of the West Midlands Gas Board was made with the opening of a carbonising plant at the Pleck works in Walsall. This plant comprises two identical retort houses shown in the lower illustration on the RIGHT. Each house contains forty-eight continuous vertical retorts built by Woodall Duckham and Co., Ltd. ,and the designed capacity of the plant is 12,000,000 cubic feet of gas a day.











Tanker Terminals

Contrast in methods is evident at the two jetties for very large tankers at Milford Haven. The Esso jetty, designed and built by John Mowlem and Co., Ltd. (ABOVE), is 3500ft long. It has prestressed precast piles up to 140ft long with a concrete structure, largely precast, above. Fenders are steel H-beam piles bearing on buffers at deck level.

The Angle Bay jetty for B.P. (consultants Rendel, Palmer and Tritton : contractor, Christiani and Nielsen, Ltd.) BELOW, has berthing heads of steel piled cofferdams, concrete-filled and with gravity fenders. The approach is of precast concrete, post-tensioned, on steel box piles up to 110ft long.

Comparison with the novel device shown on the left invites the speculation whether the large tanker jetty—one of the more difficult and expensive constructional tasks now demanded from the civil engineer—will perhaps be largely superseded in the future by the "Hoister" or something similar.

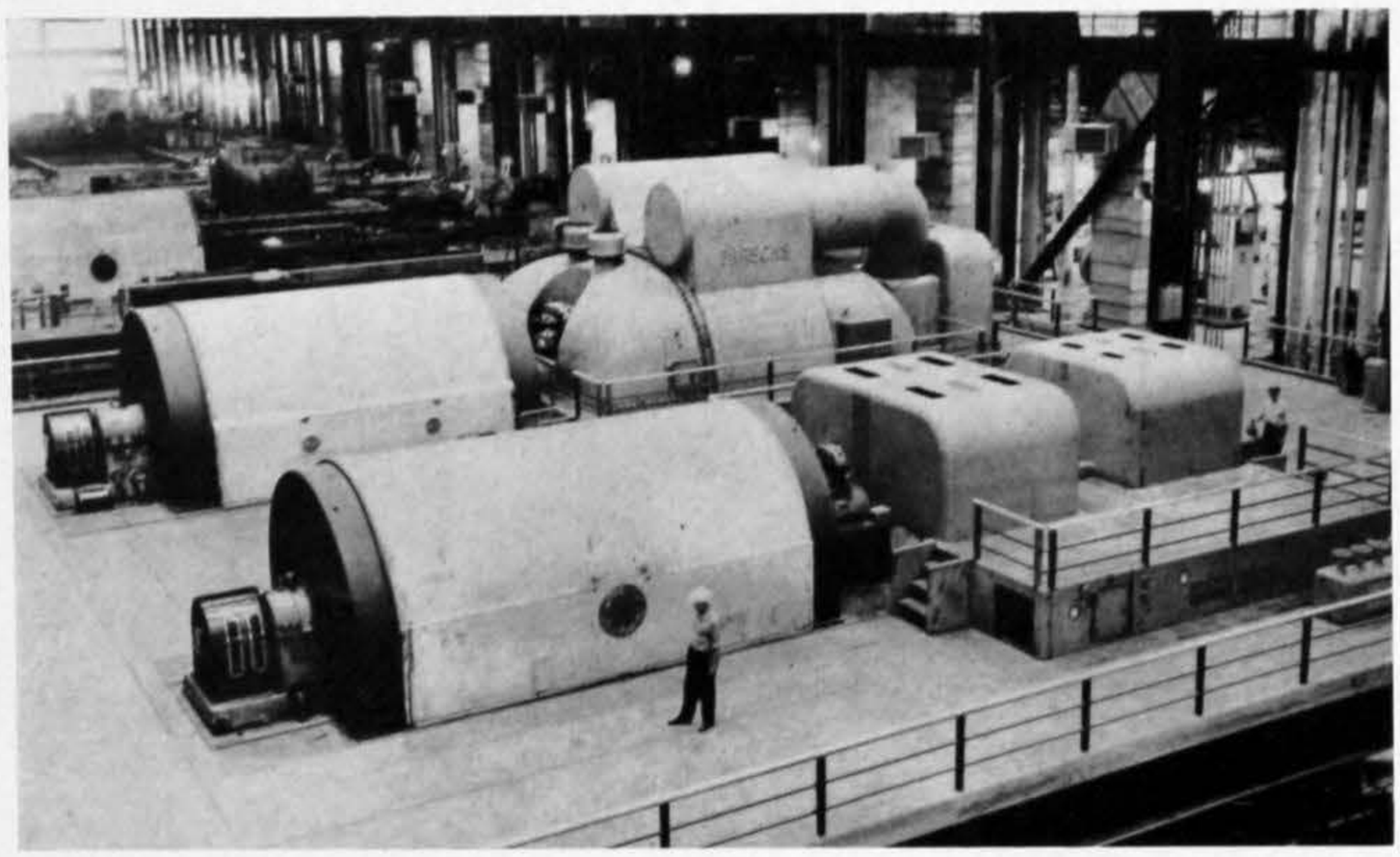


The Hartley "Hoister" installed at Mina-al-Ahmadi (ABOVE) lies flat on the sea bed at a pinned anchorage. Pipelines pass from shore installations along the sea bed, to a flexible connection at the pin. Buoyancy tanks are emptied to bring the hoister to the position shown when lengths of flexible hose give rapid rates of loading. See "The Engineer," October 2, 1959.

Generating Sets

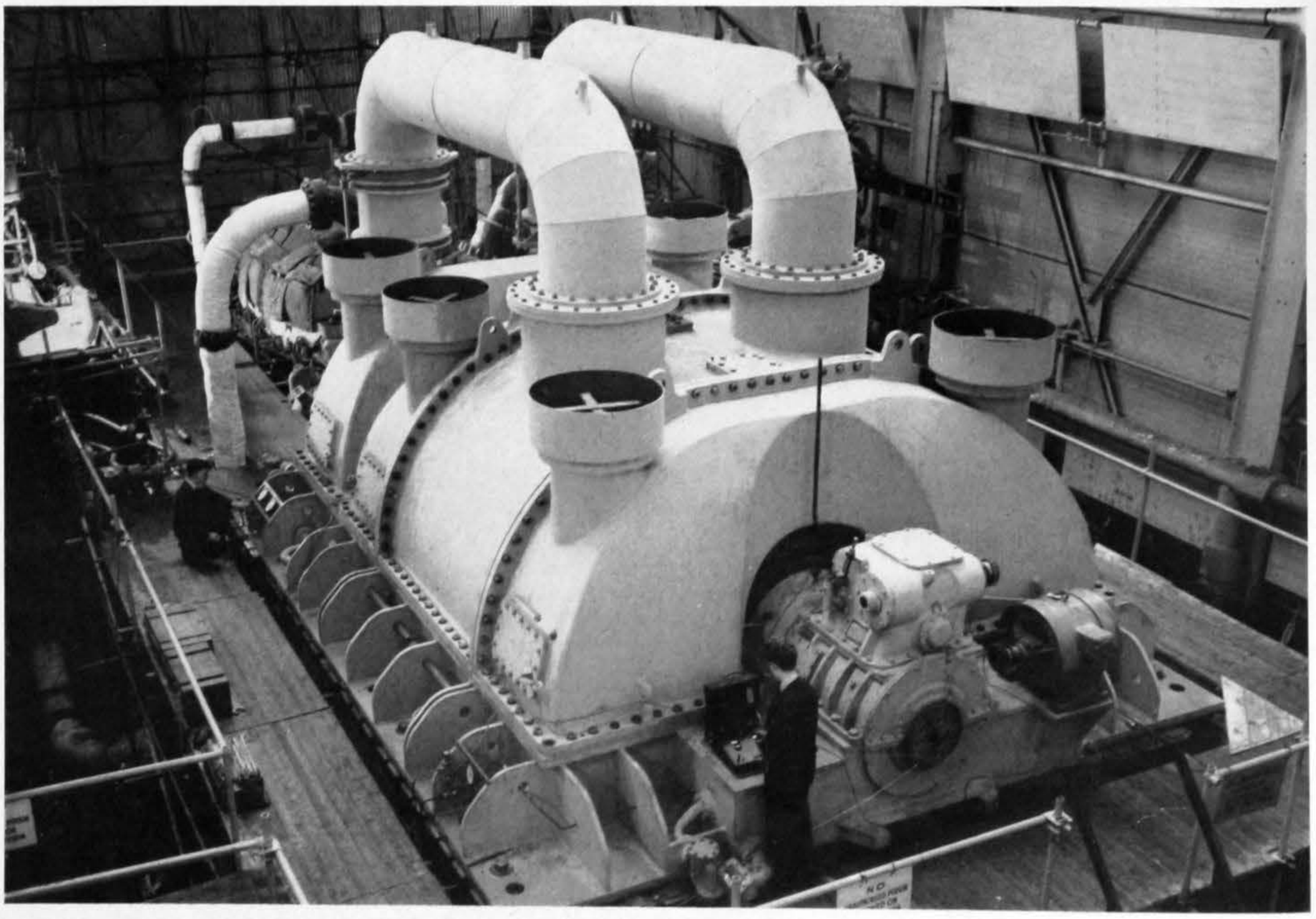
The Northern Outfall sewage works at Beckton provides an interesting application of self-contained gas-turbine power plant. Gas generated in the sludge digestion plant is sufficient for the full power requirements of the power station machinery (RIGHT), including five gas-turbine blowers and three gas-turbine alternators, each driven by 960 b.h.p. open-cycle two-shaft gas turbines. Waste heat recovery will improve the overall efficiency of the installation to about 50 per cent as described in our issue of October 30, 1959.





A 200MW set (LEFT), described as the largest turbo-generator set in service in the Commonwealth, is one of four similar units being supplied by C. A. Parsons and Co., Ltd., for the Richard L. Hearn generating station, Toronto. It is a cross-compound machine with an h.p. and i.p. 3600 r.p.m. turbine in one line and an l.p. and i.p. 1800 r.p.m. turbine in the other, each line driving a 100MW hydrogen-cooled generator. The steam conditions at the stop valve are 1800 lb per square inch at 1000 deg. Fah. with reheating to 1000 deg. Fah. between the h.p. turbine and the first i.p. turbine. Both generators are separately excited and operate at 60 c/s, 13·8kV and 0·85 p.f., and the rotors are direct cooled by hydrogen at 30 lb per square inch.

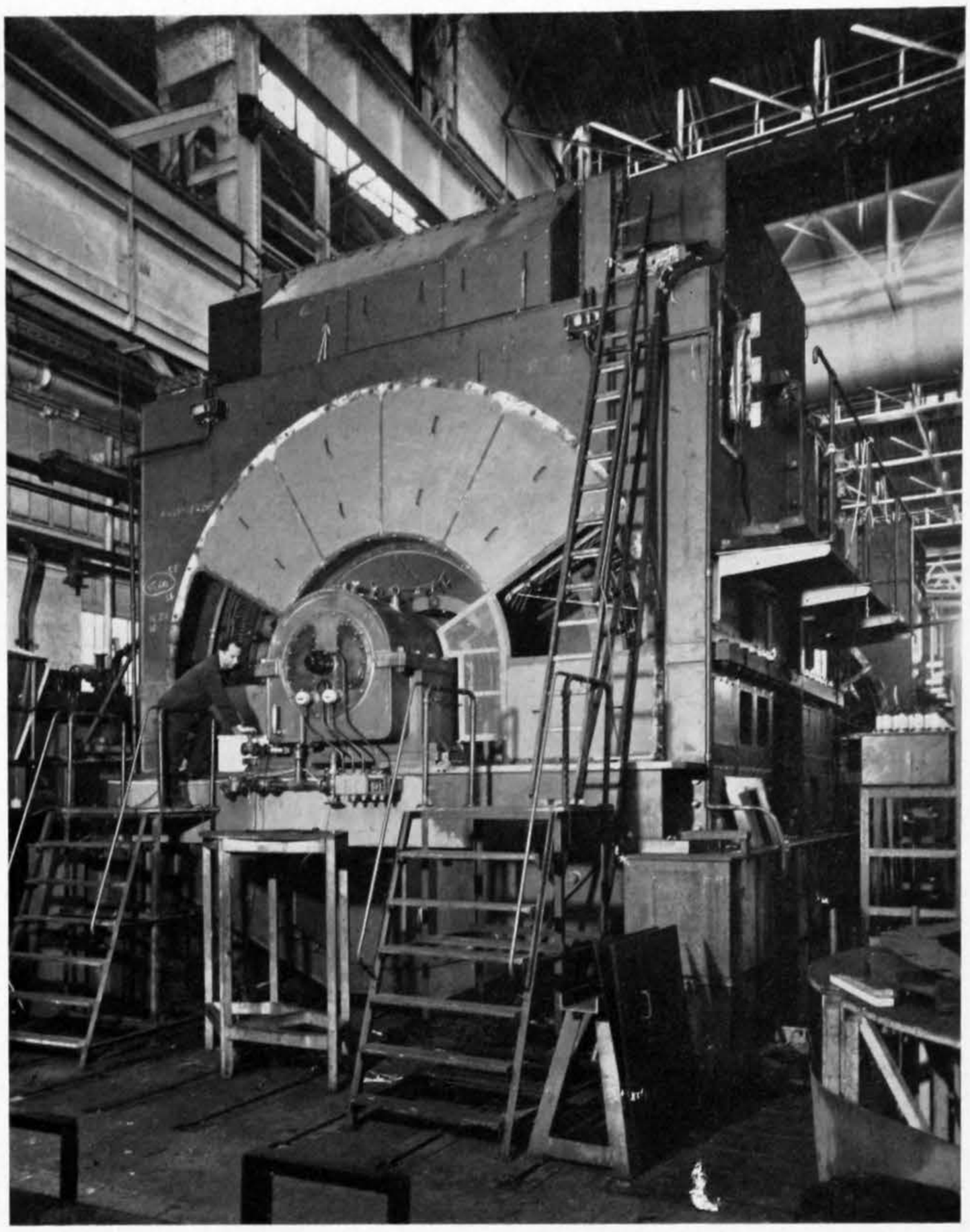
The first 200MW steam turbo-generator in Great Britain went into service at High Marnham, Notts, on October 15. It is the first of five ; the turbo-generator was built by the English Electric Company, Ltd., and the boiler unit by International Combustion, Ltd. The turbine (BELOW) was described in "The Engineer," Volume 201, 1956, page 662. It is a three-cylinder 3000 r.p.m. machine having a double-casing high-pressure cylinder for stop-valve steam conditions of 2350 lb per square inch at 1050 deg. Fah. with reheat to 1000 deg. Fah. between h.p. and i.p. cylinders.

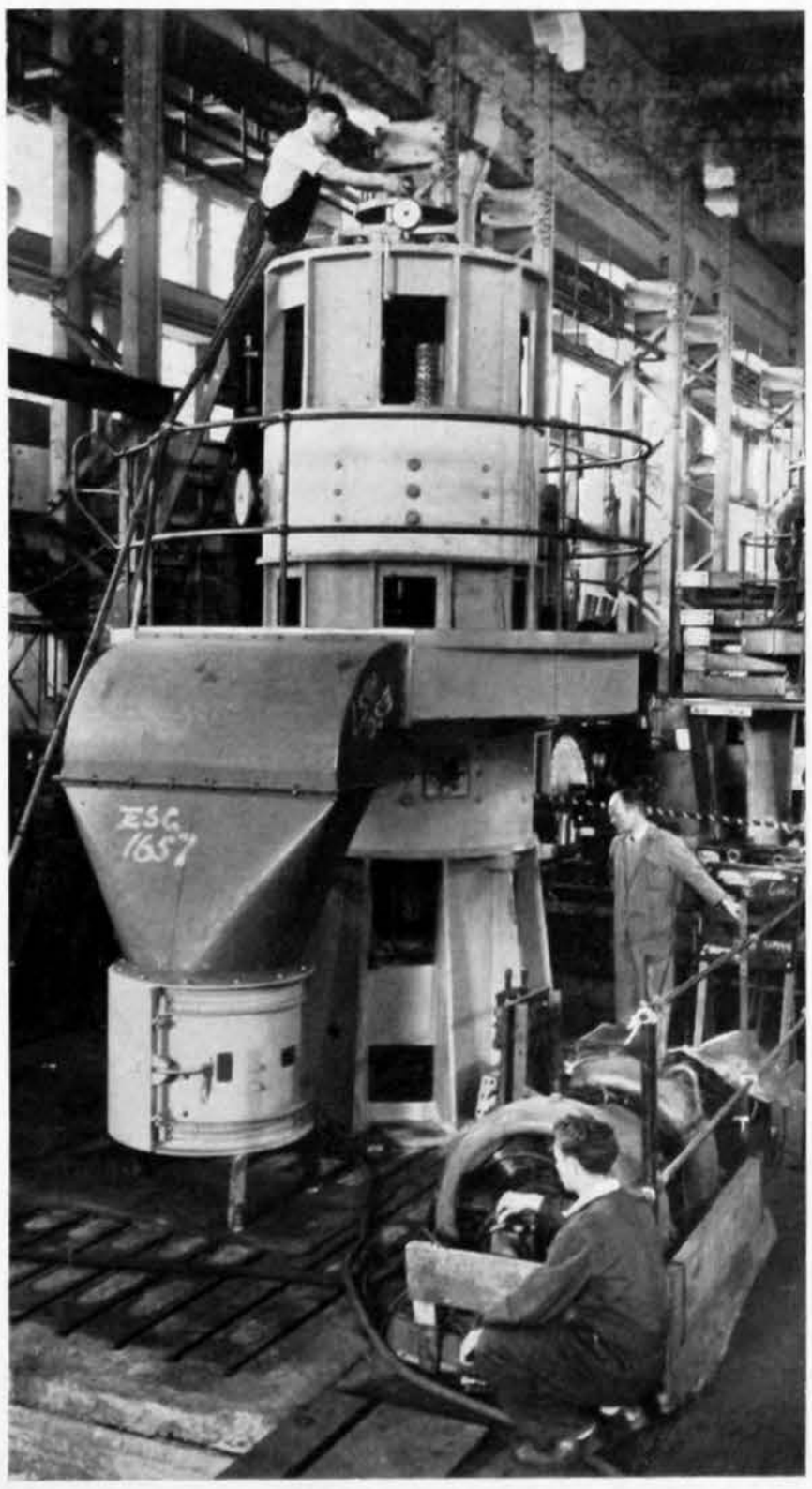


Electrical Machinery

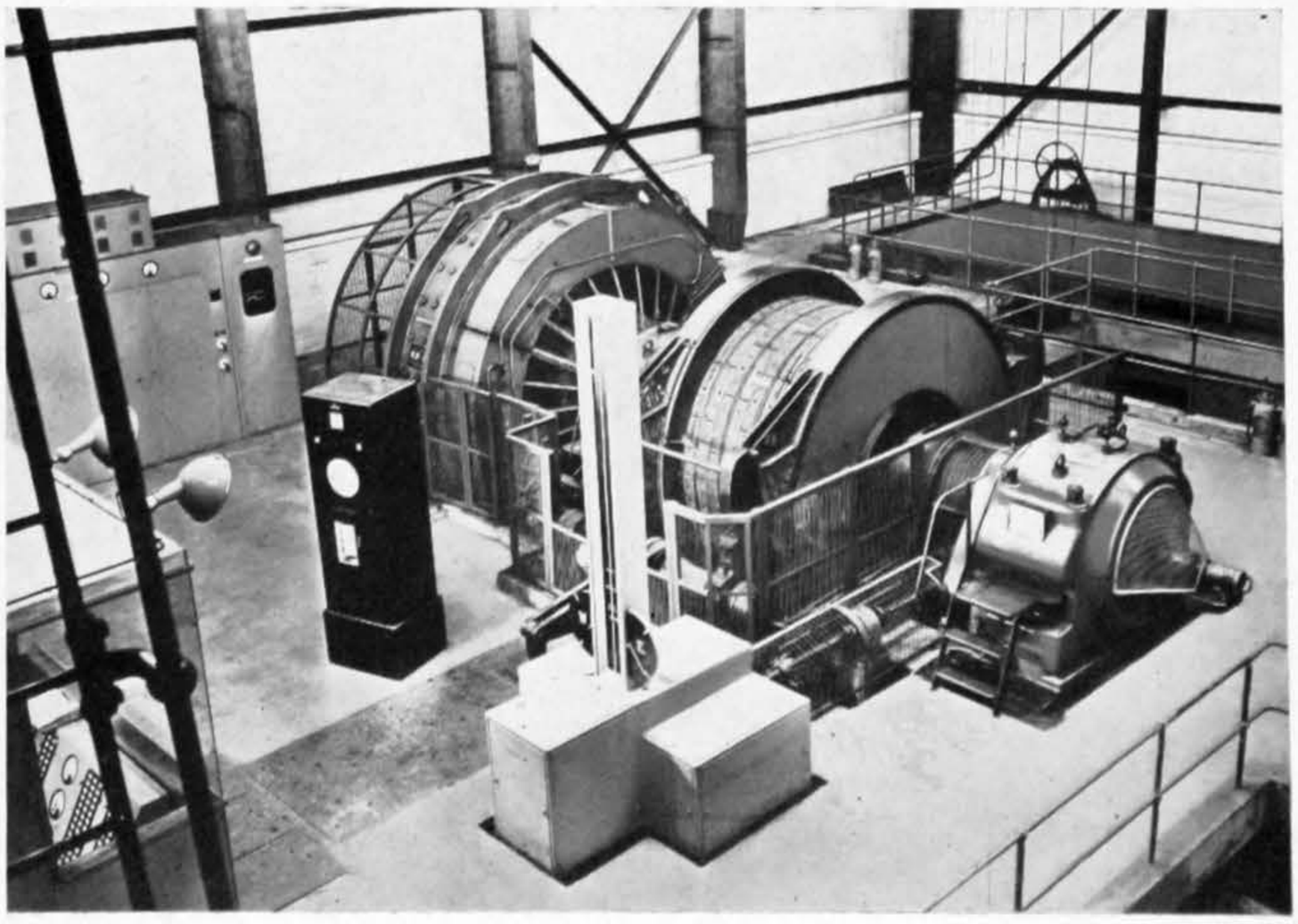
The propulsion motors for the twin-screw turbo-electric passenger liner "Canberra" are believed to be the largest to be built for marine service. Each of the motors is a 42,500 s.h.p., 147 r.p.m. double-unit machine with closed air circuit cooling. The picture, RIGHT, shows the port motor ready to be dismantled for shipment after official tests in the Rugby works of the A.E.I. heavy plant division. Cooling air is circulated through this machine by motor-driven fans mounted on top of the stator frame and sea water is used as the secondary coolant. We show the forward end of the motor, parts of the stator and rotor coils and the rotor connections and bushgear.

The "Canberra" is being built by Harland and Wolff, Ltd., for the P. & O. Steam Navigation Company, Ltd.





One of the sixteen gas circulator motors for Hunterston nuclear power station is shown, LEFT, under construction in the Witton engineering works of The General Electric Company, Ltd. Each motor is a vertical shaft, double-armature, shunt-wound d.c. machine, developing 2354 h.p. at 1040 r.p.m. at 1230V. Direct current for the motors will be supplied from twelve-phase grid-controlled mercury-arc rectifiers. The gas circulator is a single-stage centrifugal blower which is housed inside, and at the base of, the steam generator shell ; a separate pressure casing is therefore dispensed with. A unit similar to that illustrated is already installed on site where it is being used for tests on the gas circulator system.



An overhung armature as illustrated on the RIGHT is used in the new tower-mounted friction winders at Warsop colliery, No. 3 area, in the East Midlands Division of the National Coal Board. The motor shown here is rated at 1638/2120 h.p., 77·3 r.p.m., and drives the skip winder in No. 2 shaft. The motor has Ward-Leonard control with the laminated exciter closed loop system to compensate for the volt drop in the cables connecting the motors with the motor-generators which are at ground level. No. 2 shaft has a four-rope winder, with two 8-ton skips, giving an output of 400 tons per hour from a depth of 1421ft. The electrical equipment was supplied by A.E.I. heavy plant division.

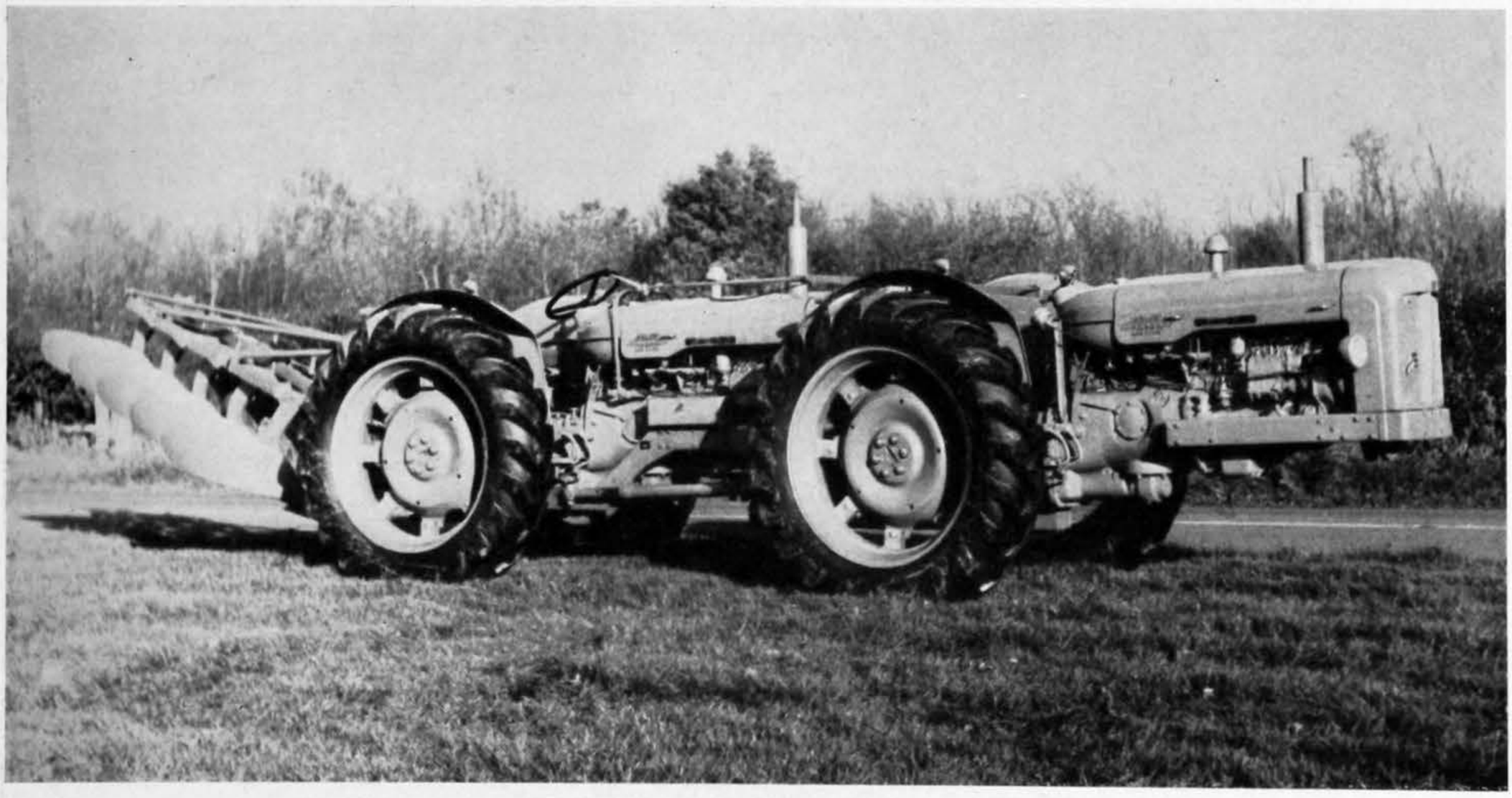


Tractors The four-wheel-drive tractor illustrated ABOVE has been built by Bray Construction Equipment, Ltd., primarily to enable one-way ploughing to be carried out under difficult land conditions. A five-furrow plough is mounted at each end of the tractor, both ploughs being raised and lowered hydraulically. In work, the tractor is driven alternately forward and in reverse. There is power steering of the front wheels which are on a fixed axle ; the back axle is free. The power unit is a Ford six-cylinder diesel engine which develops 96 b.h.p. at 2250 r.p.m. The ploughs have been built by John Suckling, Ltd., most of the components coming from Ransomes, Sims and Jefferies, Ltd.

Another tractor development, LEFT, is the Massey-Ferguson, Ltd., "702 Yellow Equipment" for building-site work and similar industrial use. The tractor, a 37 b.h.p. diesel-engined machine, is equipped with a front-mounted shovel and a rear-mounted digger.



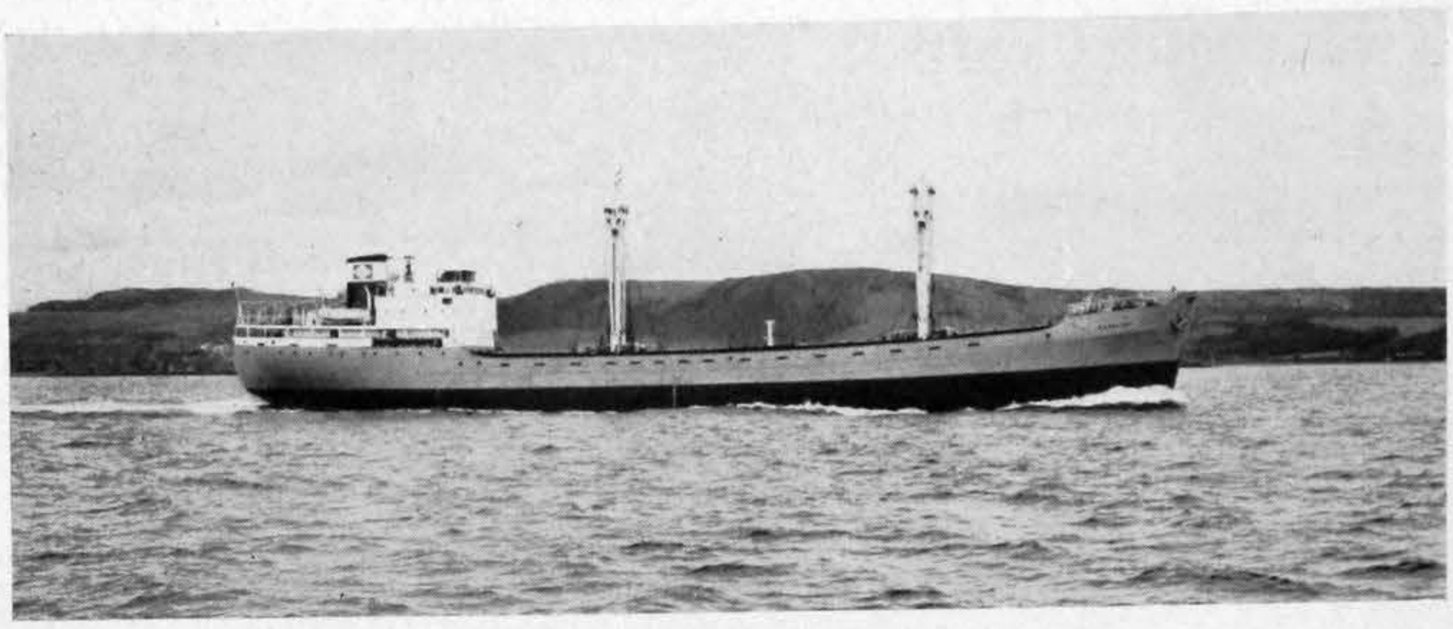
To cater for heavy cultivation work, Ernest Doe and Sons, Ltd., has devised the "Triple D" four-wheel-drive tractor assembly shown BELOW. Two Fordson "Power Major" tractors are coupled head to tail by means of a steel turntable fitted below the engine of the rear tractor. This combination provides approximately 100 b.h.p.



Coasters

The bulk cargo carrier "Macaulay" completed by Henry Robb, Ltd., for the Chine Shipping Company, Ltd., carries a deadweight of 6600 tons on 23ft 6in mean draught and the following dimensions: length between perpendiculars 345ft, breadth 54ft, depth 29ft. There are four hatchways, eight 5-ton derricks, electric-hydraulic winches and Macgregor hatch covers, and the service speed of 12·5 knots is maintained by a six-cylinder Sulzer diesel engine of 3000 b.h.p. at 150 r.p.m.

Alexander Hall and Co., Ltd., delivered the self-trimming raised quarter deck collier "Ballylesson" to John Kelly, Ltd. The ship measures 205ft length between perpendiculars, by 33ft 9in beam by 14ft 6in deep, and carries 1350 tons deadweight on 14ft mean summer draught. There are three holds, and electric power is supplied by three 40kW diesel-driven generators, while a six-cylinder British Polar diesel engine developing 1005 b.h.p. at 265 r.p.m. gives the ship a loaded speed of 11·5 knots.





Ferries

The "Carisbrooke Castle" was built for the passenger and motor vehicle service between Southampton and Cowes by John I. Thornycroft and Co., Ltd., and described in "The Engineer" dated June 5, 1959. Forty-five motor cars and 500 passengers are carried on the following dimensions: length on waterline 180ft, breadth 40ft, depth 10ft 7in, draught 6ft. The service speed is 14 knots and propulsion is by two Crossley eight-cylinder diesel engines each of 900 b.h.p. at 450 r.p.m.

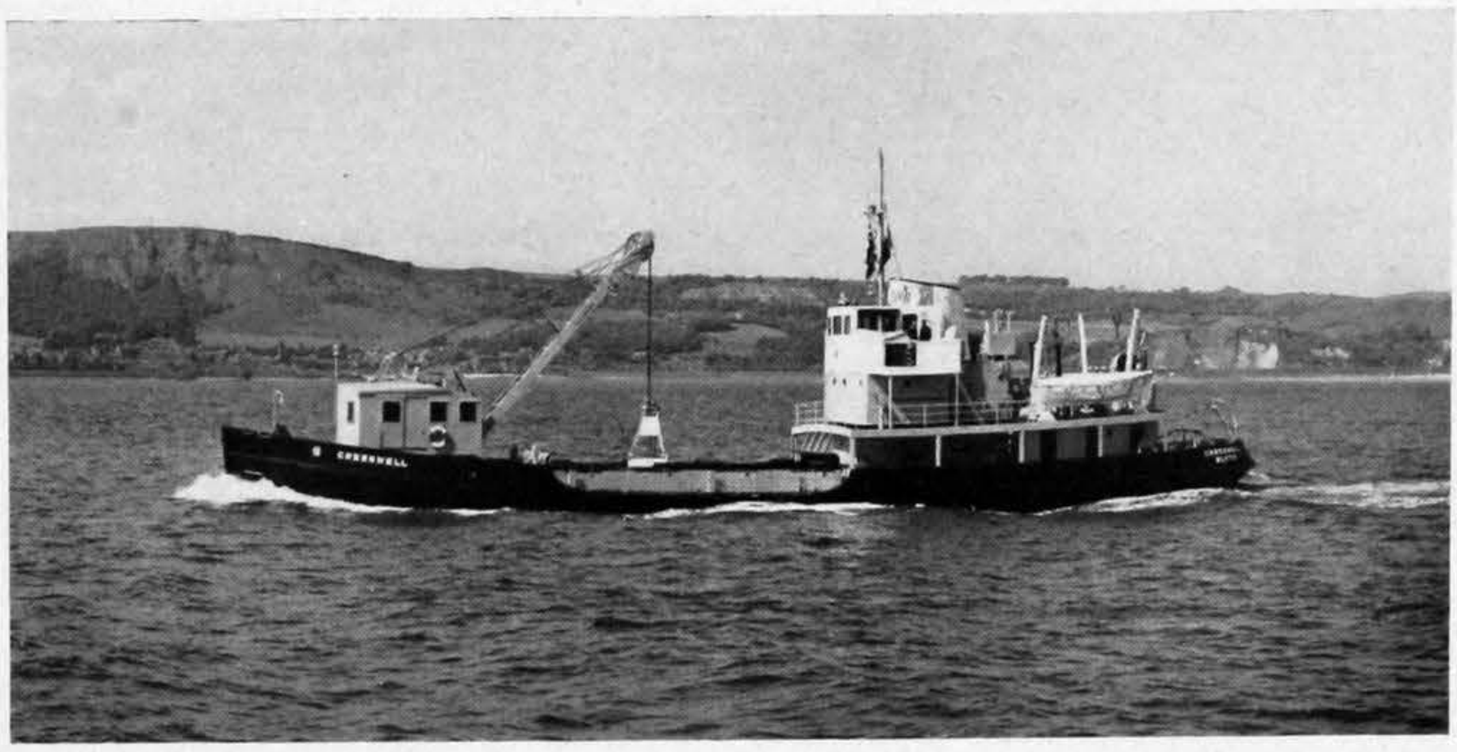
W. Denny and Brothers, Ltd., completed the "Maid of Kent" for the British Transport Commission's service between Dover and Boulogne, and the following are the main particulars: length between perpendiculars 348ft; breadth 59ft; depth 18ft 3in; draught loaded 13ft mean; deadweight 830 tons; speed 20¾ knots, and 1000 passengers. There is a bow lateral-thrust Voith Schneider propeller and the electrical installation consists of four 300kW Allen generators. Propulsion is by two sets of double reduction geared turbines developing a total of 11,500 s.h.p. at 270 propeller r.p.m. when supplied with steam at 350 lb per square inch and 650 deg. Fah. by two Babcock and Wilcox water-tube boilers burning oil fuel under forced draught.

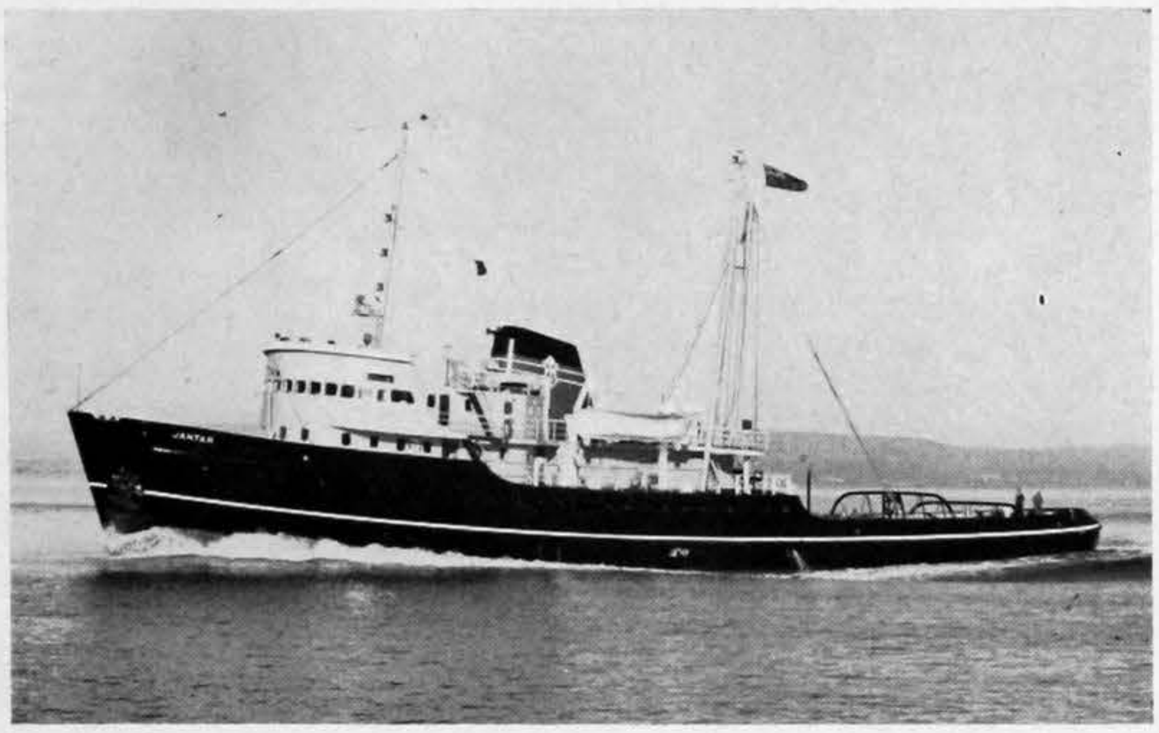




Harbour Craft

The motor grab dredger " Cresswell " (RIGHT) was built by Henry Robb, Ltd., to the order of the Blyth Harbour Commissioners. Her principal dimensions are: length between perpendiculars 128ft 6in, breadth moulded 28ft 6in, depth moulded 12ft. Hopper capacity is 300 cubic yards, and loaded speed 10 knots. For dredging operations there is a Priestman diesel grab having a grabbing radius of 30ft and able to work to a depth of 50ft below water level. There is one 70 cubic foot mud grab and one 55 cubic foot sand grab. Propulsion is by a Crossley two-stroke diesel engine developing 700 b.h.p. at 350 r.p.m.





Charles Hill and Sons, Ltd., completed the rescue and salvage tug " Jantar " (ABOVE) for the Polish Salvage Company. Her main particulars are : length between perpendiculars 60m, breadth 11·89m, depth 5·79m, draught aft 5·50m, trim by stern 1·97m, displacement loaded 1650 tons. The towing winch has a capacity of 300 fathoms of 6in wire and also operates a 10-ton derrick. A Merryweather salvage and fire pump is fitted, also three 150kW generators. Propulsion is by two seven-cylinder National pressure-charged diesel engines each rated at 1575 b.h.p. driving a single screw through a Hindmarch/M.W.D. reverse reduction gearbox. The static bollard pull is 25 tons.



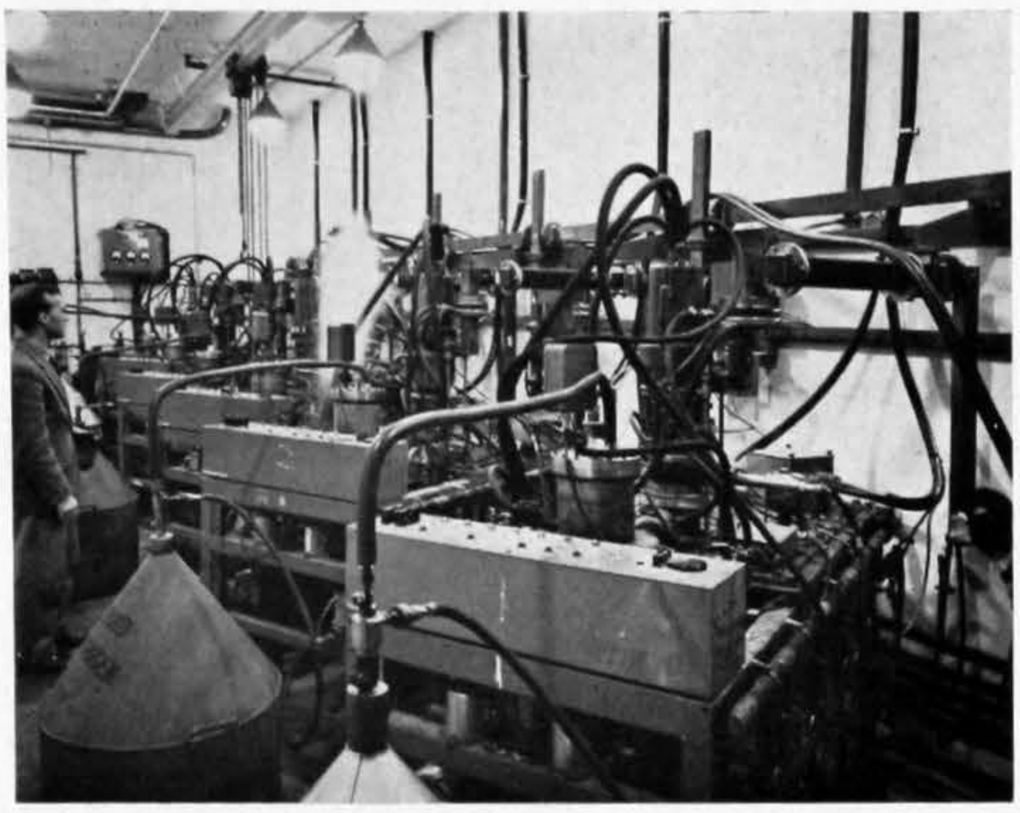
The Ribble Navigation and Preston Docks Board took delivery of the twin-screw tug " Charles Hearn " (ABOVE) from the Victoria shipyard of Henry Robb, Ltd. The tug, which is designed to work on a mean draught of 9ft, has a length between perpendiculars of 86ft, a breadth moulded of 23ft, and a depth moulded of 11ft 6in. There is an electric windlass forward, fitted with large warping drums and electric steering gear. Two spring towing hooks are mounted amidships and ballast tanks are provided to ensure adequate propeller immersion. Power for propulsion is provided by two five-cylinder Crossley engines capable of developing 740 b.h.p. at 300 r.p.m.

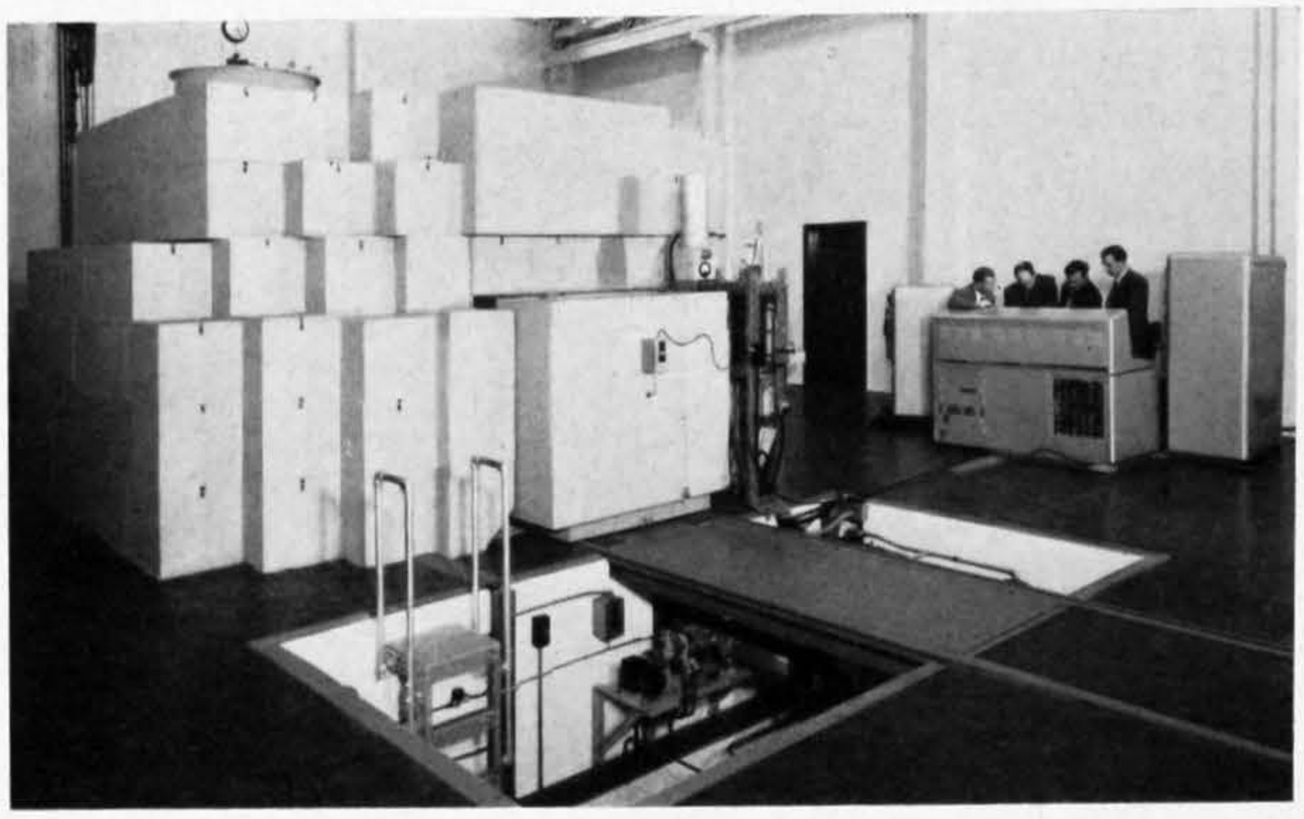


The tug " Sun XXI " (ABOVE) was constructed by Philip and Son, Ltd., for W. H. J. Alexander, Ltd., and the vessel measures 100ft length between perpendiculars by 25ft 6in breadth moulded by 12ft 8in depth moulded. The windlass and capstan are electric and power is provided by two 62½kVA, 440V, 60 c/s diesel-driven alternators. Each set includes a two-stage air compressor and a hydraulic pump for the electric/hydraulic steering gear. In the engine-room is a six-cylinder Mirrlees pressure-charged diesel engine, rated at 1400 b.h.p. at 375 r.p.m., driving the propeller at 125 r.p.m. through a Hindmarch/M.W.D. reverse reduction gearbox.



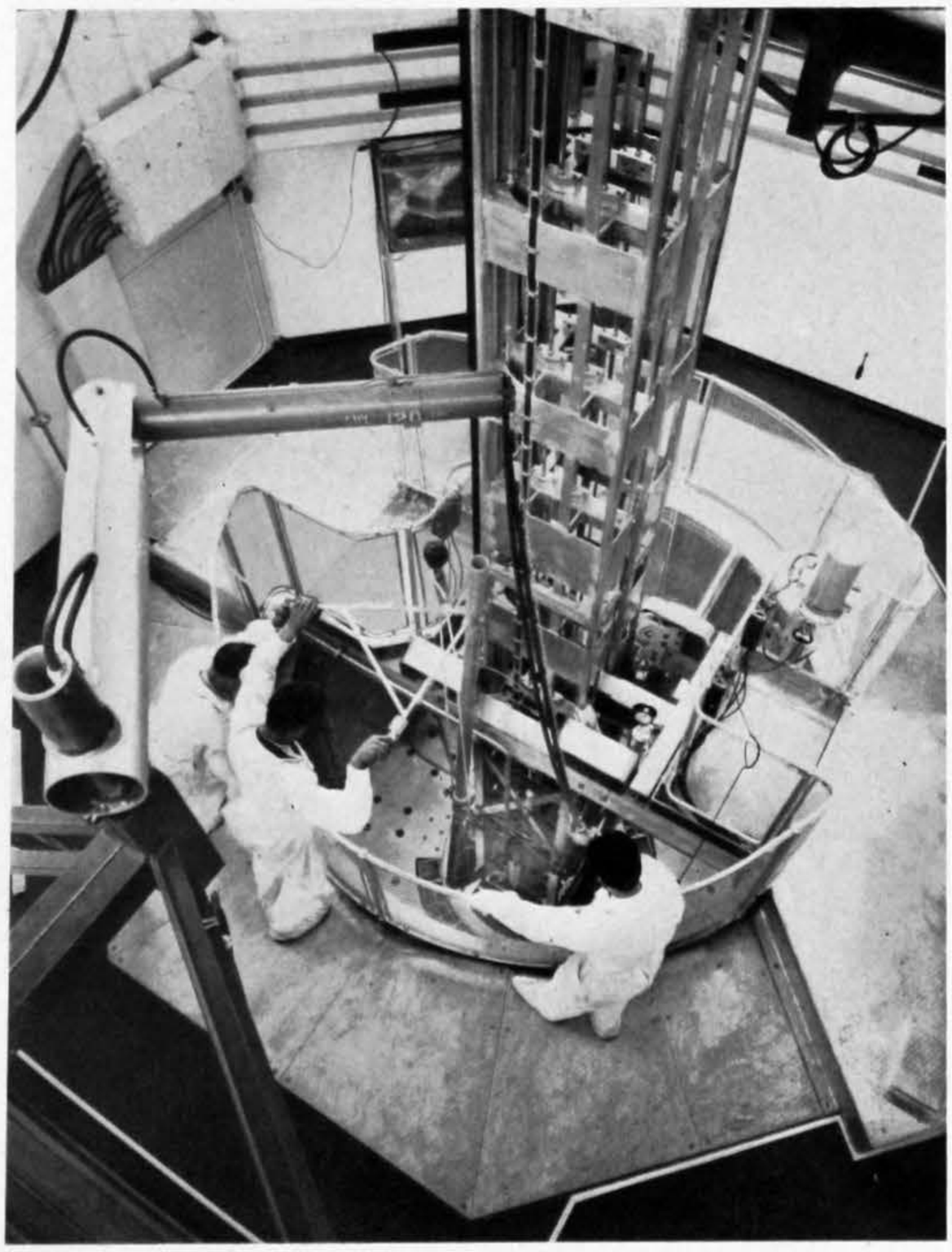
The tug " Stackgarth " (ABOVE) has been built for service in Milford Haven, by Richard Dunston, Ltd., and on trial the ship attained a free running speed of 12 knots and a bollard pull of 21·25 tons. The dimensions are, length between perpendiculars 115ft, breadth 28ft 6in, depth 14ft, and the equipment includes two Merryweather fire and salvage pumps delivering 1500 gallons per minute at 100 lb per square inch. Electrical demands are met by two 75kW and one 40kW diesel-driven generators and the ship, which is fitted with a Kort nozzle, is propelled by a British Polar diesel engine of 1300 b.h.p. at 300 r.p.m. driving through a Hindmarch/M.W.D. gearbox.





Nuclear Research

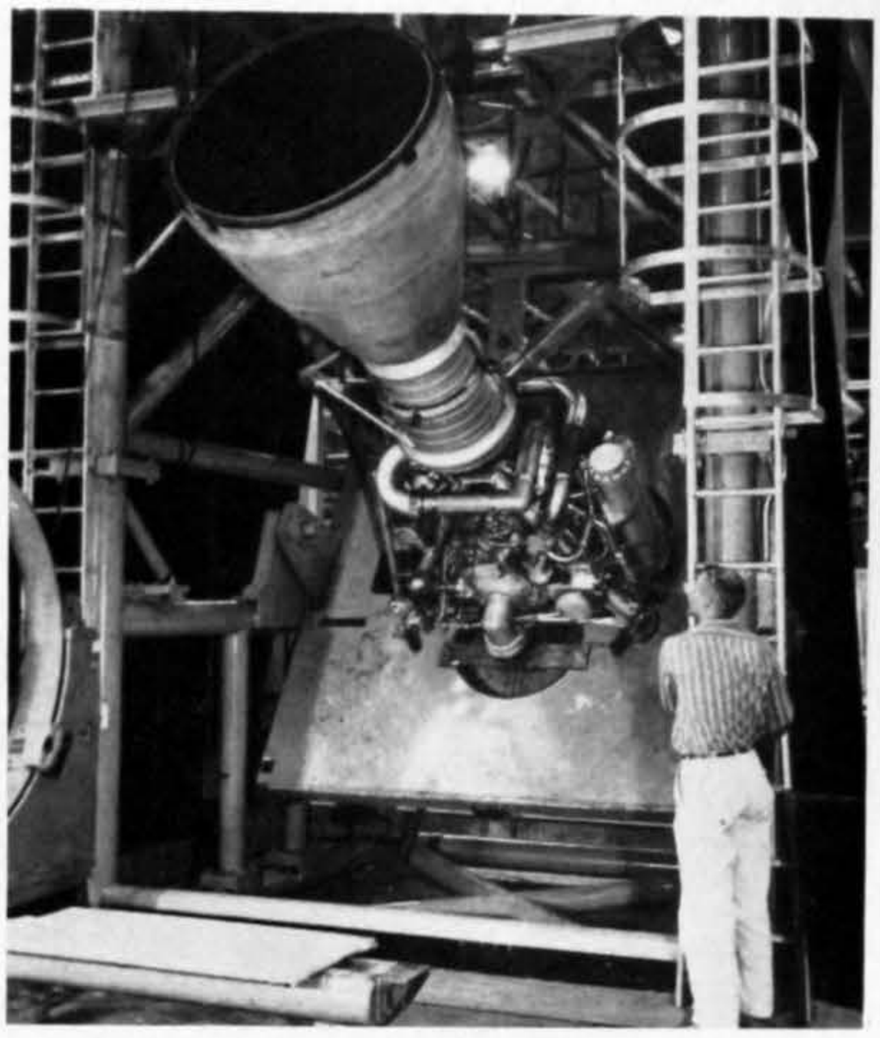
Four typical installations for nuclear research are illustrated here. The neutron laboratory (klystron room TOP LEFT) of the U.K. Atomic Energy Authority is intended for neutron time-of-flight experiments for obtaining, *inter alia*, reactor design data. The equipment consists of a powerful pulsed neutron source embodying an electron linear accelerator in conjunction with a multiplying target assembly ("The Engineer," November 20, 1959). A private nuclear research reactor, "Jason" (TOP RIGHT) has been built by the Hawker Siddeley Nuclear Power Company, Ltd., at Slough, where it is being used for work such as the development of the company's proposed organic reactor for ship propulsion. It is cooled and moderated witn light water and has twenty experimental holes ; maximum flux at 10kW, $1{\cdot}5 \times 10^{11}$ neutrons per square centimetre per second ("The Engineer," April 10 and December 4, 1959). Another private research reactor is "Merlin" (BOTTOM LEFT), at the research laboratory of Associated Electrical Industries, Ltd., at Aldermaston Court, Berks ("The Engineer," August 14 and November 13, 1959). Among the apparatus for nuclear research at the A.W.R.E., Aldermaston, is a tandem Van de Graaff accelerator (BOTTOM RIGHT) to operate at voltages up to 12 MeV as described in "The Engineer," June 12, 1959.

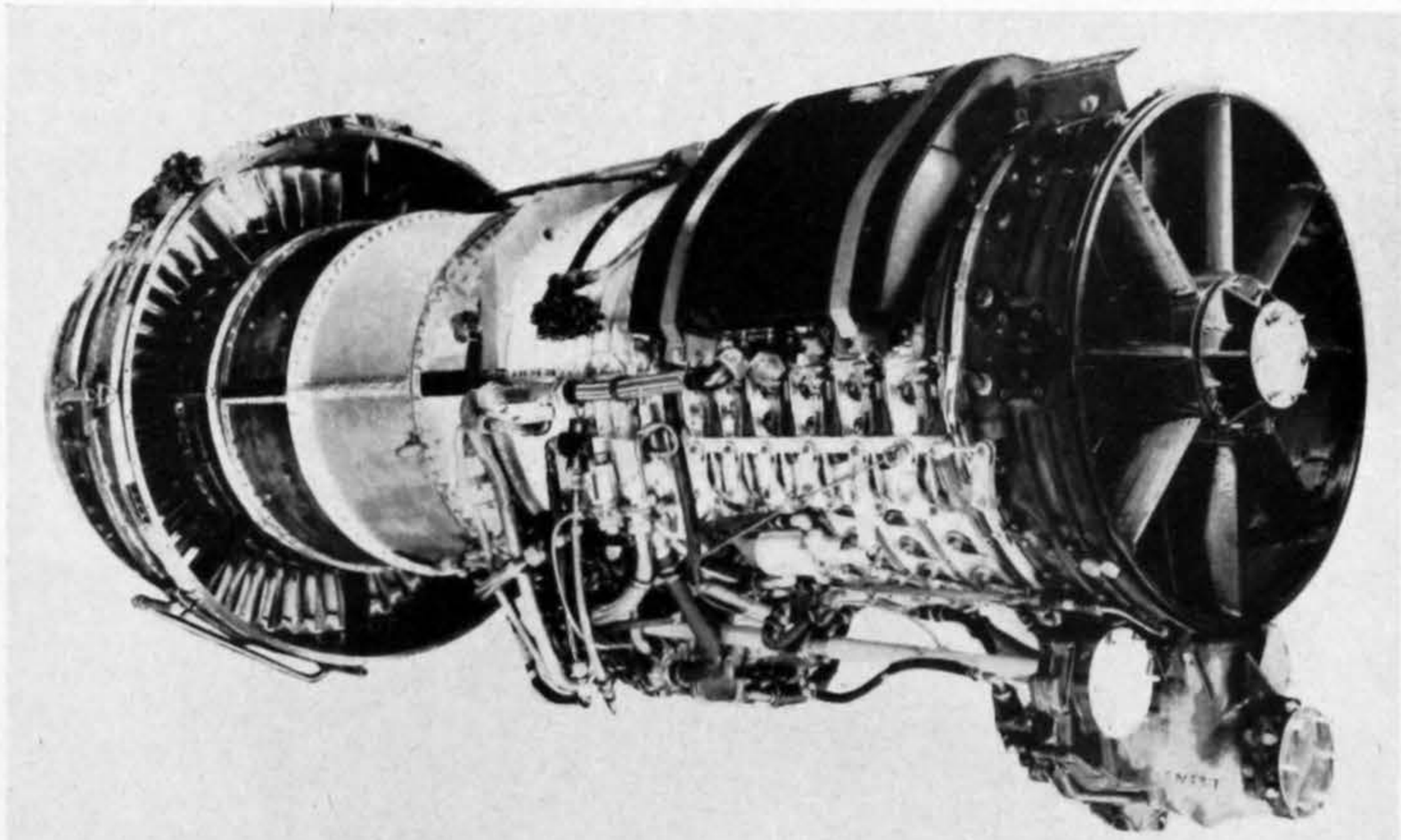




Internal Combustion Engines

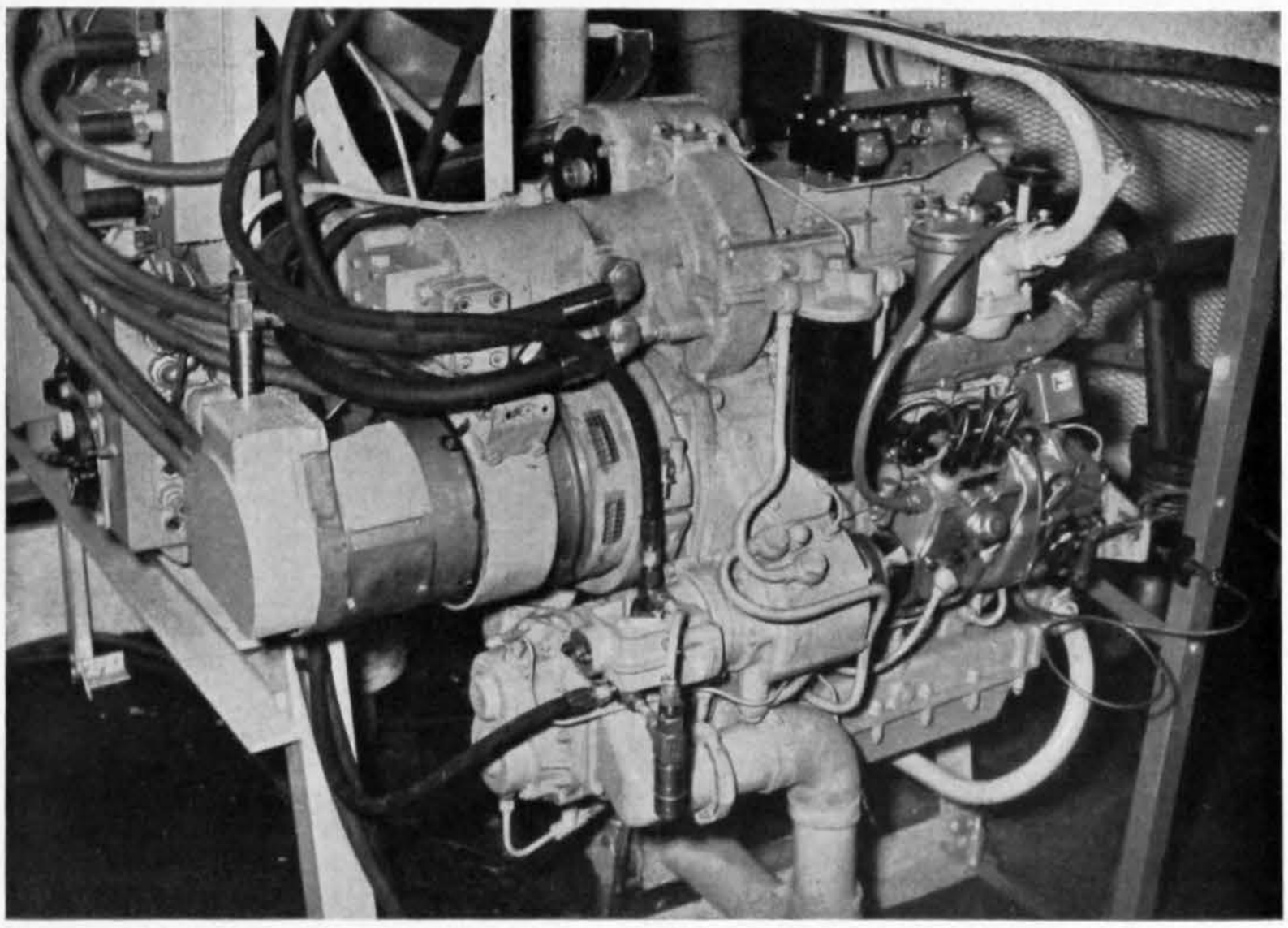
At least in the Western world, exploration beyond the atmosphere is limited by the available thrust of rocket engines. In an attempt to accelerate the development of very large plant, the United States Army Ballistic Missile Agency sponsored the construction by the Rocketdyne division of North American Aviation of " Saturn," which comprises eight separate motors of about 200,000 lb thrust each. This approach is considered well-suited to research vehicles, of which relatively few are needed, the individual rockets being closely derived from those used in missiles, while it is economic to attain reliability by designing for mission capability with any one motor out of action ; control is obtained by pivoting four motors so that at least two respond to every command. A single chamber, complete with turbo-pumps and control gear, is seen RIGHT on a test stand : the nozzle is protected by covers, but shows the typical Rocketdyne construction using numerous small tubes shaped and brazed together.





Now that civil airlines are using a significant proportion of turbo-jet engines, there has been a revival of interest in the ducted fan engine, long familiar in this country from Metropolitan-Vickers' work. The General Electric CJ-805-23 (RIGHT), for the Convair " 600 " with a maximum cruise of M. 0·9, superficially resembles the British engines, but is distinguished by the variable angle stator blading. Other manufacturers of high-pressure engines use the l.p. compressor to handle the cold flow, so that the by-pass ducts act as blow-off valves to keep the low-pressure operating line away from surge. The use of a separate fan allows every component, back to and including the high-pressure stator blades, to be reached without dismantling the remainder.

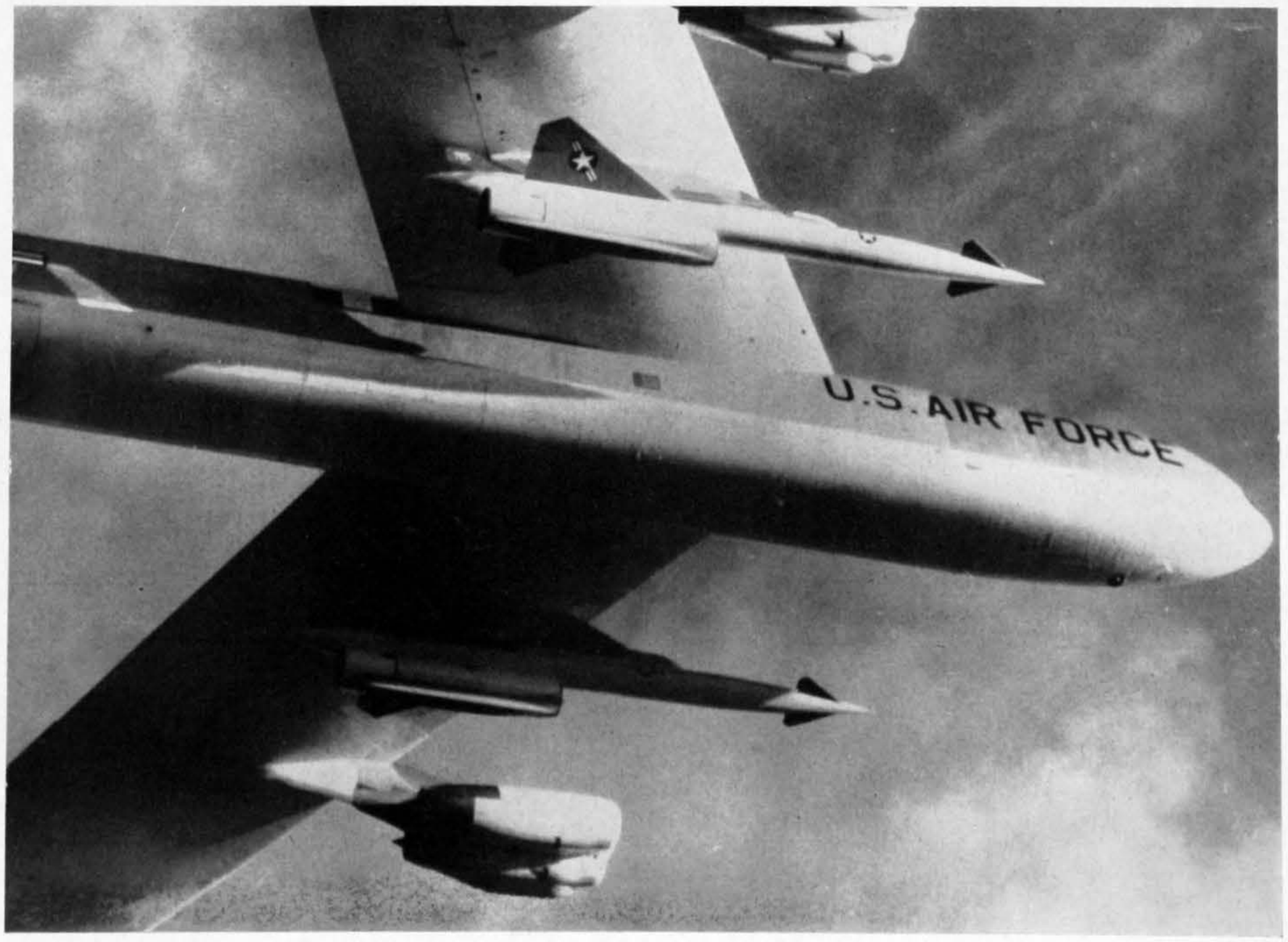
Another apparently complicated engine that is gaining fresh adherents is the opposed-piston two-stroke diesel. A range of engines with two crankshafts geared together in the manner familiar in aircraft is under development for use in fighting vehicles, the engines being expected to burn all fuels from gas oil to 80 octane petrol. The smallest engine, intended as an auxiliary with the duty of starting the main engine in a tank, has been designed by Sir W. G. Armstrong Whitworth and Co. (Engineers), Ltd., for production as the Coventry Climax H.30 : of 994·5 c.c., it is designed to run at 3000 r.p.m. and should attain an automotive rating above 40 h.p. Our illustration of an instrumented example (BELOW RIGHT) shows it complete with a 4000 r.p.m. generator : beyond the hydraulic starter pump can be seen the dogs for hand cranking. On the lubricant and fuel pump drive is fitted a hydraulic boost pump.





Supersonic Aerodynes The dividends from advances in the state of the art can be realised either in increased capability or in reduced investment, and the Northrop family of lightweight supersonic aircraft exploits the latter attraction. Small enough to be launched in zero length from the standard launcher of a " Matador " or " Mace," the fighter (ABOVE) is expected to attain Mach 2 ; like the " Talon " trainer, it is powered by two General Electric J-85 engines of 2500 lb, or 3850 lb afterburning, static thrust, but in the N-156F the injection of water behind the wedge intakes will greatly increase the engine mass flow in supersonic flight. The plan view of the N-156F emphasises the requirements of the supersonic regime, but the handling characteristics should allow use from forward airfields ; the flat under-surface of the engine bay carries simple air brakes.

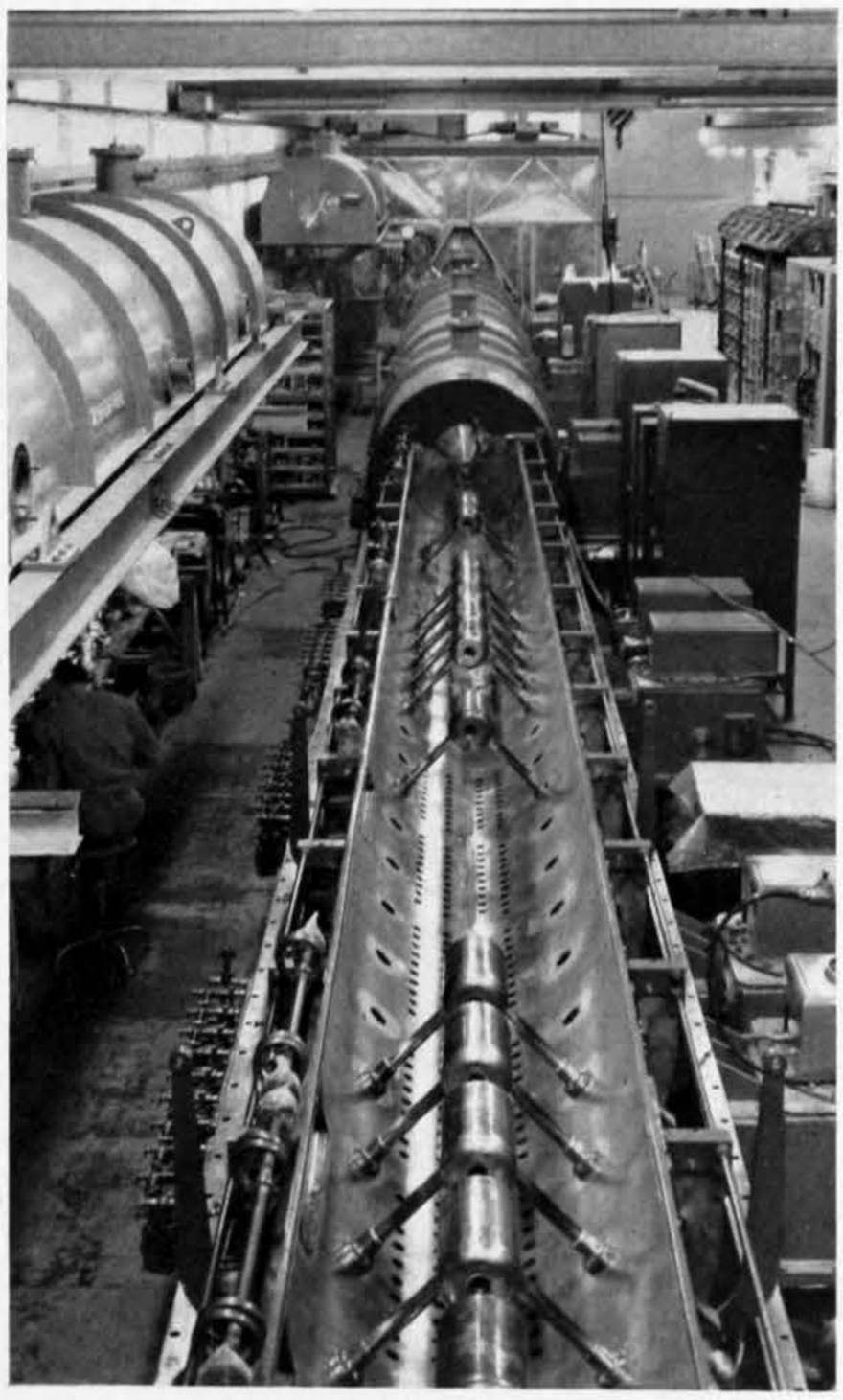
In contrast, the North American " Hound Dog " (BELOW) configuration could now be termed classical. The propulsion system is distinctive, however : instead of employing a ramjet, it uses a Pratt and Whitney J-52 turbojet. The elaboration of a two-spool engine is justified when it is realised that the variable geometry intake allows it to be used during take-off, so that the missile does not burden the B-52 when the load is prescribed by the available runway, and thus the engine will be used on many missions. It allows cruising speeds up to or over Mach 2, and the quoted range of 350 miles would seem entirely reasonable. The navigation problem is, of course, critical for long-range air-launched weapons, and the " Hound Dog " uses inertial guidance, the evolution of such systems being highly advanced in the United States of America. Fighter (ABOVE) and missile (BELOW) are 43ft and 42ft long respectively.

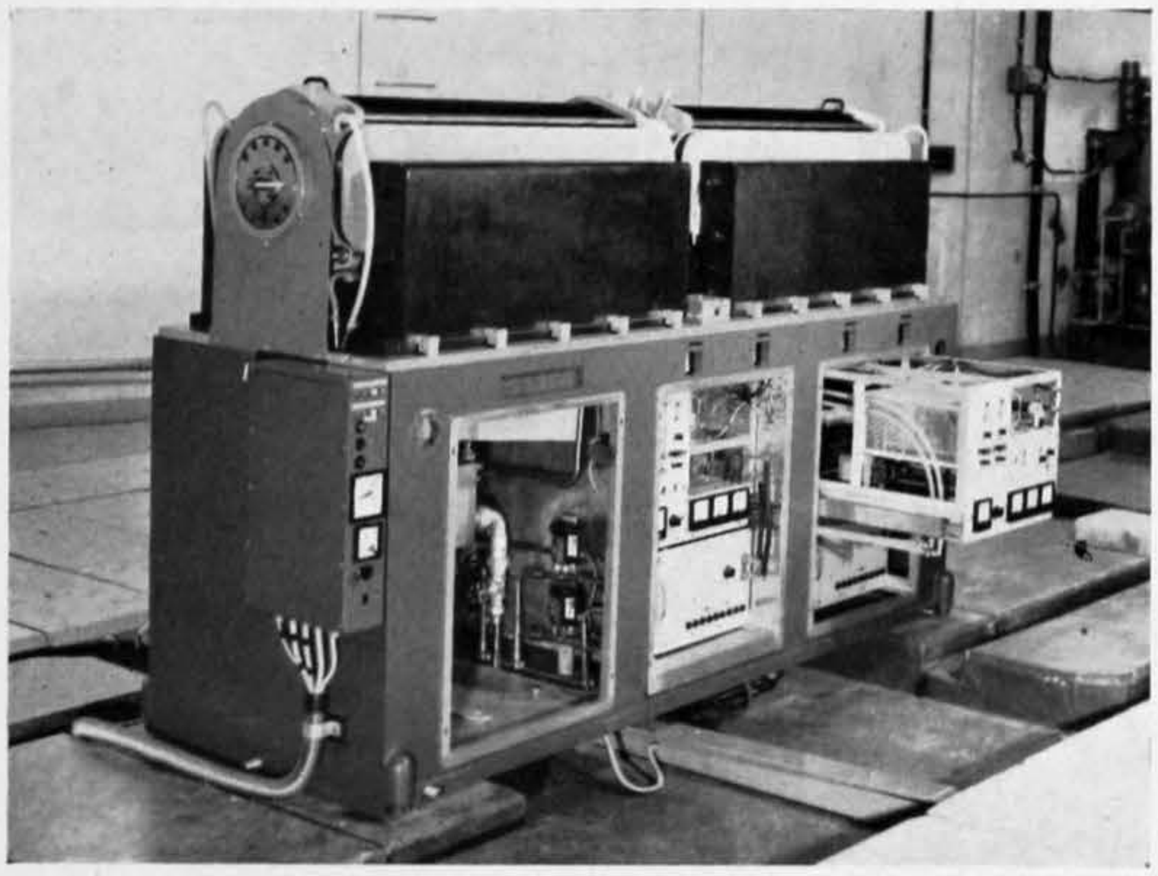


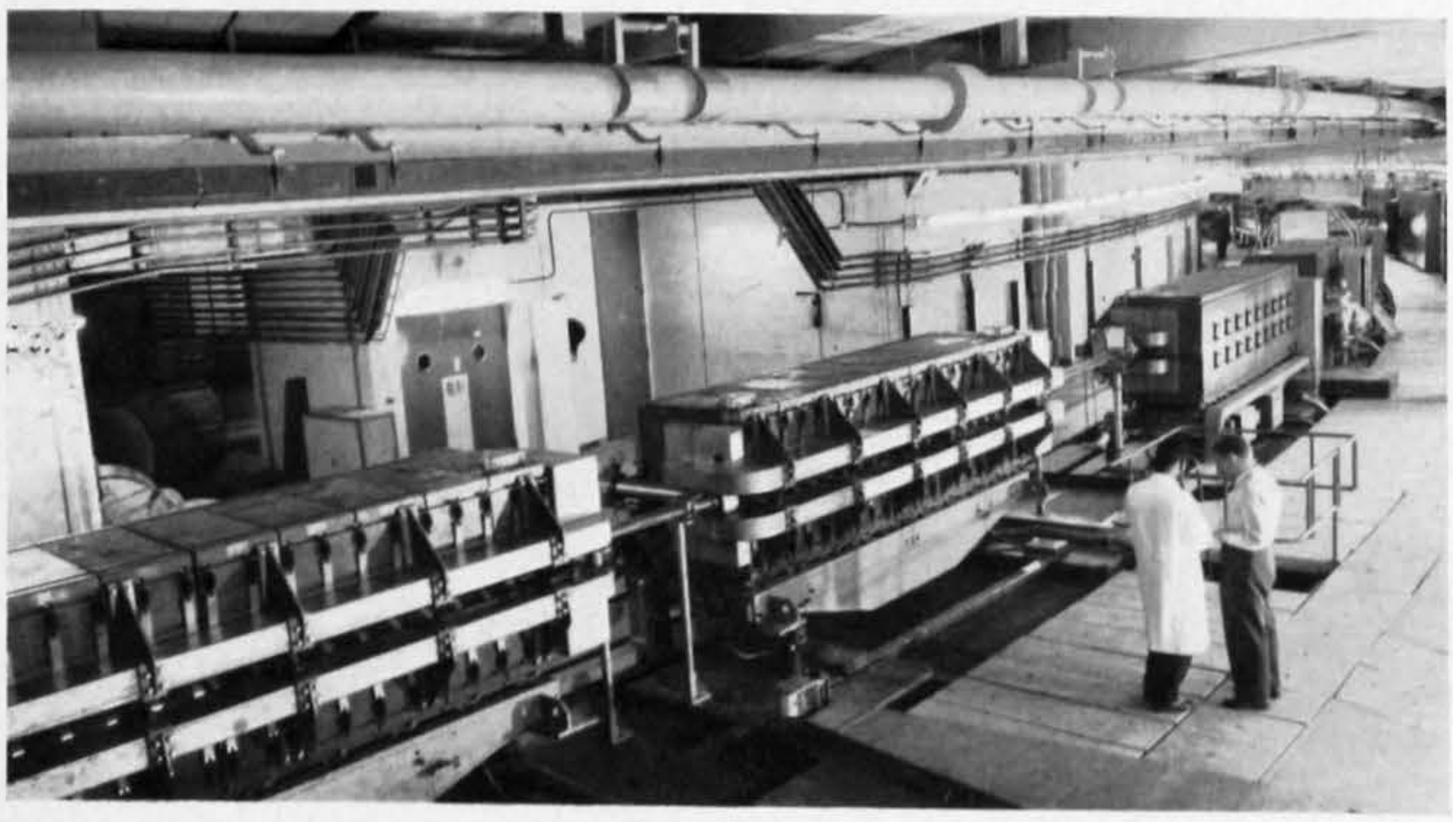


CERN Following six years of development, the 25 GeV proton synchrotron of the European Organisation for Nuclear Research (CERN) reached design energy on November 24. The machine, at present the largest in existence, accelerates protons to within 99·98 per cent of the speed of light by sending them, in about one second, 500,000 times round a 200m diameter circle, during which they are speeded up by radio-frequency fields. Injected from a 50 MeV linear accelerator, the protons are held within the 7×14·5cm vacuum annulus by a magnetic field which increases from 140 to 12,000 gauss, to correspond with their growth in mass. The magnet ring, housed in a 6×6m tunnel at the CERN laboratory at Geneva-Meyrin (TOP), consists of 100 magnet units comprising ten magnet blocks each. These units (BOTTOM), which weigh 38 tonnes apiece, were aligned to within ±0·3mm by optical means, making use of eight radial tunnels. So as to avoid disturbance from subsidence, tremors, or periodic waves such as the two-second period caused by the surf in the Bay of Biscay, the magnets stand on a 2·2×1·7m concrete ring, in turn supported elastically on eighty columns reaching into bedrock and separated from the overlying moraine. Between the magnets are focusing lenses and sixteen radio frequency accelerating units (ABOVE). Proton pulses of 200 microseconds are produced in a 500 keV Cockcroft-Walton h.t. generator and further accelerated in a 50 MeV Alvarez linear accelerator, seen (ABOVE RIGHT) from the ejection end. The last of three resonance cavities is open, showing the drift tubes across which the micro-control radio frequency is applied.

The cycle of the machine, repeated every four seconds, requires a peak power of 28MW and a mean power of 1·5MW.







Locomotives

One of the new Type 2 diesel-electric designs for British Railways to appear during the year was the North British-G.E.C. 1000/1100 h.p. B_0-B_0 locomotive with the N.B.L.-M.A.N. twelve-cylinder vee engine. RIGHT, a locomotive of this series is illustrated approaching Welwyn with a Cambridge express.



With the electrification in June of the Southern Region lines to Ramsgate, and to Dover via Canterbury, thirteen 2552 h.p. B_0-B_0 electric locomotives were built by British Railways and supplied with 750V d.c. motor-generator traction equipments by the English Electric Company, Ltd. While most passenger traffic is handled by multiple-unit sets, the locomotives work inter-regional passenger trains, express goods trains and, as illustrated RIGHT, the "Night Ferry" London-Paris-Brussels through sleeping car service.



The largest single diesel-electric traction equipment order of the year was placed with Crompton Parkinson, Ltd., for 137 power equipments for 2300/2500 h.p. Type 4 locomotives being built by British Railways. Twelve-cylinder diesel engines are being supplied by Sulzer Bros. (London), Ltd. These follow the original series of ten $1C_0$-C_01 locomotives with similar equipment which began entering service this year. The first of the class—the most powerful diesel-electric built under the original modernisation plan—is seen RIGHT operating in the London Midland Region.

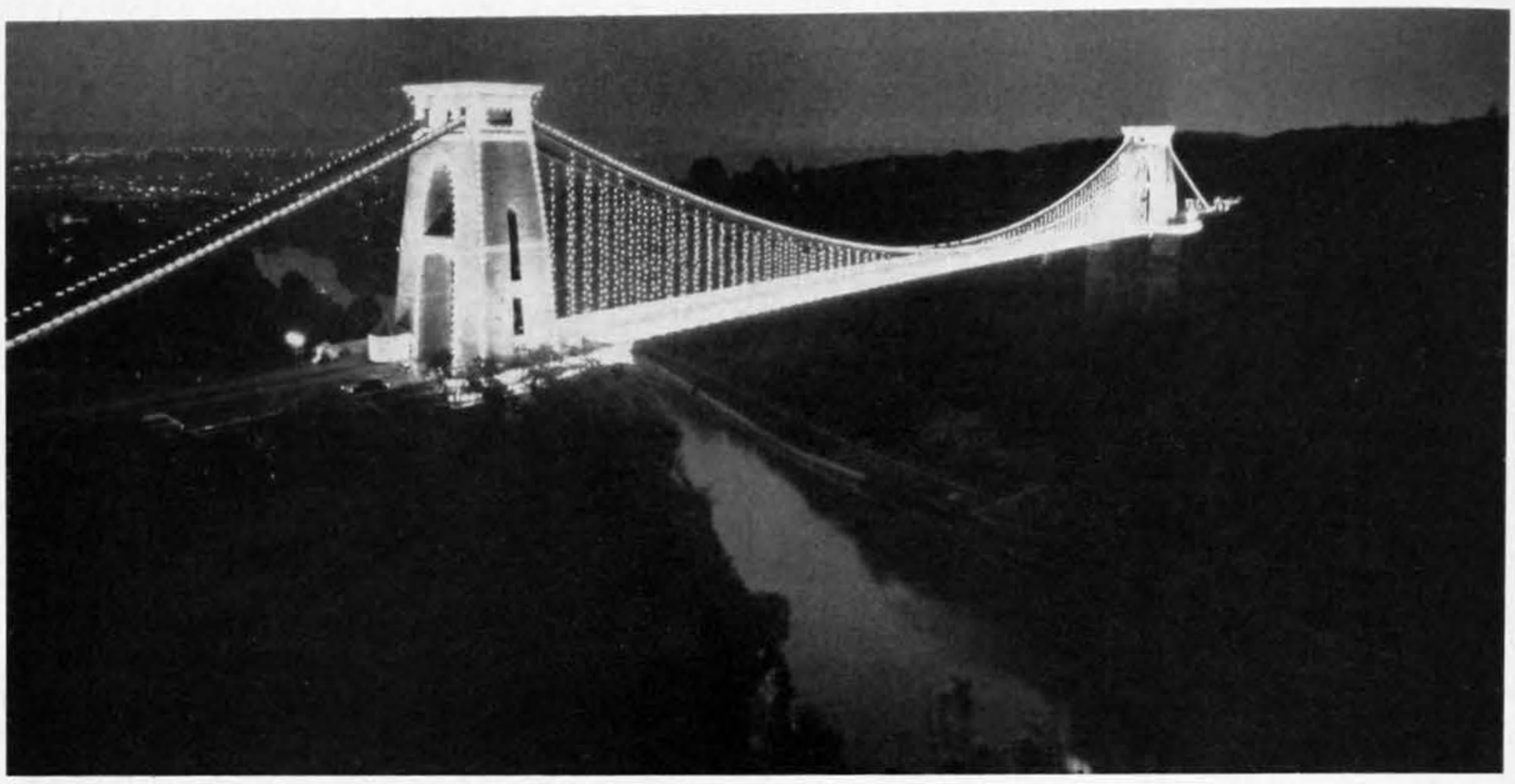


RIGHT, the English Electric-Vulcan Foundry 1100 h.p. (Type 2) B_0-B_0 diesel-electric locomotive. The diesel engine is a nine-cylinder, pressure-charged version of the eighteen-cylinder normally-aspirated "Deltic" installed in duplicate in the original "Deltic" locomotive. Extensive use is made in the smaller "Deltic" locomotive of mechanical drives for auxiliaries, both traction motor blowers, the radiator fan, and compressor being driven in this way direct from a crankshaft or through gearboxes. With the introduction of these locomotives, all the designs of the original main-line diesel programme are in service.



100 Years Ago

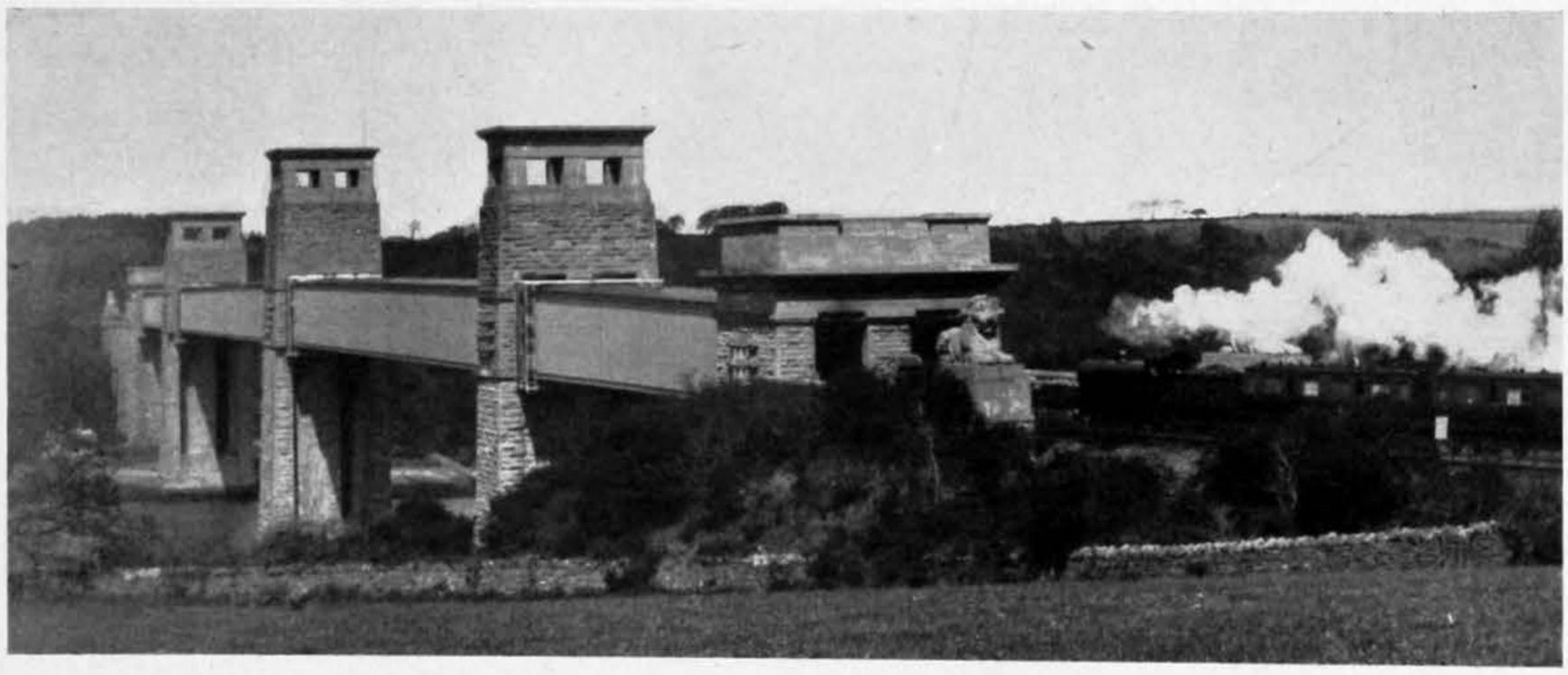
Two notable civil engineers, Robert Stephenson and I. K. Brunel, died in 1859. A plaque was unveiled last Autumn, at the Clifton bridge (RIGHT), by the president of the Institution of Civil Engineers in commemoration of Brunel ; his Royal Albert bridge at Saltash was completed in 1859, and is shown under construction in the SECOND illustration. The THIRD illustration shows the Britannia tubular bridge—built by Stephenson and completed in 1850. Another tubular bridge, the Victoria bridge at Montreal, was completed by Stephenson in 1859. Both the Royal Albert and Victoria bridges were hailed in "The Engineer" in 1859 as considerable achievements, but the extravagance of their designs was strongly criticised.





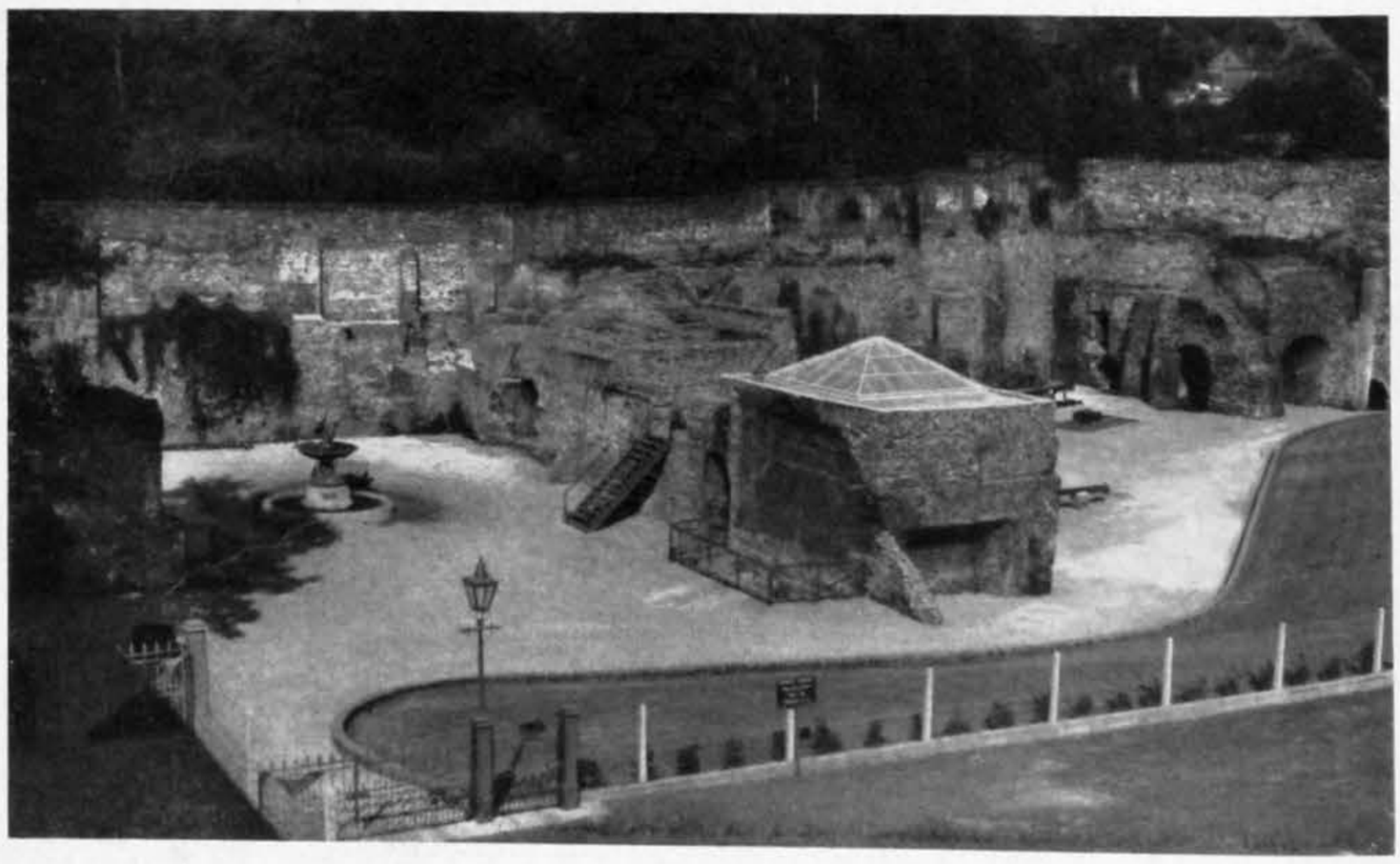
The " double throne " at the head of their profession, as the eminence of Brunel and Stephenson has been described, was not universally recognised, and, in particular, Brunel was a controversial figure. The arguments surrounding his career and achievements were again topical following the publication of a " re-appraisal " of Brunel by Mr. F. Newhouse in our issue of September 11 last, in which the veneration accorded Brunel by his biographers was questioned. These criticisms of Brunel are remarkably similar in tone to criticisms made in this journal 100 years ago, and it is quite clear that the old controversies are still alive and still vigorous.

Stephenson's career was discussed in a memoir by Mr. C. E. Lee published in our issue of October 30 last; the author asserted that Stephenson established his reputation as the foremost railway engineer of the period in 1838, with the completion of the Kilsby tunnel, and he never lost that lead. In 1959, Stephenson's centenary attracted far less interest than Brunel's.



250 Years Ago

In January, 1709, Abraham Darby I first successfully employed his process for smelting iron with coke instead of charcoal. The 250th anniversary of this achievement was celebrated last September at a meeting in Birmingham when papers dealing with various aspects of eighteenth century iron making in the Midlands were read. The furnace at Coalbrookdale which Abraham Darby used for his process was built in 1638 ; it was subsequently rebuilt in 1777, by Abraham Darby III in preparation for casting the Iron Bridge. Part of the foundation walling of the first furnace was incorporated in this rebuilding. Now, the Coalbrookdale Company, Ltd., has restored much of the original Coalbrookdale works site and the furnace, which is illustrated here. The square tower structure is actually an outer casing containing the furnace itself which is circular in section. The furnace lining of dark slag-stained firebrick is surrounded by several courses of hard red brick, the whole being set within a strong square wall and the space between packed with fire resistant material. The furnace can be entered through an arch in the forehearth. The tuyere and forehearth recesses are spanned by cast iron beams.



Shipbuilding and Marine Engineering in 1959

No. II—(*Continued from page* 26, *January* 1)

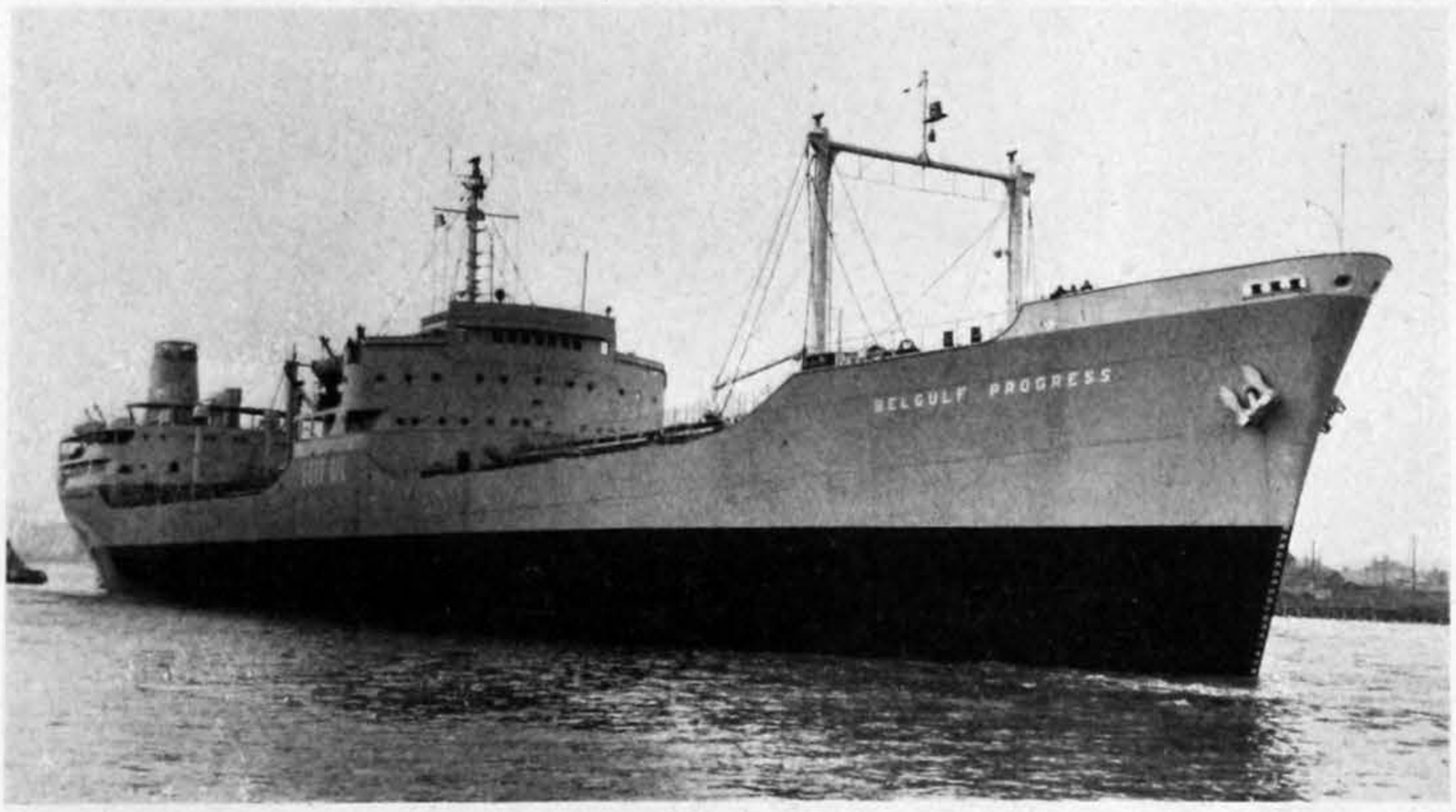
RESEARCH AND DEVELOPMENT

THE British Shipbuilding Research Association was without a director of research during the latter part of 1958, and this position was remedied at the beginning of last year with interim appointment of Sir Victor Shepheard, who retired from the post of Director of Naval Construction in 1958, in succession to the late Dr. Livingstone Smith. This appointment meant that the British Shipbuilding Research Association had a director of research of distinction, one who already had considerable experience of design and research problems and was also thoroughly acquainted with the work through his many years of association with B.S.R.A. The new director joined the Association just when it was engaged in the final stages of the negotiations with the D.S.I.R. for the renewal of the financial aid which is given to the Association from Government funds. During the year revised terms of grant for the next three years were agreed, while the shipbuilding industry stated that it will continue to provide support adequate to ensure that B.S.R.A. will be able to fulfil its role of carrying out research so that the industry may be kept fully informed of technical progress. At the same time there was a re-appraisal of the research programme with the object of giving investigations their correct order of priority as governed by the importance accorded by the industry to the problems involved. Another change within the Association was that Sir Charles Connell became chairman of the Research Board, in succession to Sir Wilfrid Ayre who had expressed a wish to retire from detailed contact with the work of the Association and who was the first chairman of Council when B.S.R.A. was formed in 1944.

An important section of the Association's work, the application of nuclear power to merchant ships, continued to be studied and the team engaged on this work was expanded to a strength of about twenty-five, including technical graduates, loaned from member firms, as well as full-time employees of the Association. Some members are at Riseley working with the development and engineering group of the Atomic Energy Authority and taking part in the detailed design studies of marine reactors. Two members have been in the United States to observe the design and construction of the N.S. "Savannah" while others undertook to review the aspects of collision at sea from the point of view of safety. Another group attended at the Winfrith Heath establishment to assist in the studies of more advanced reactor technologies which perhaps may be the answer to economic applications. Independently of the Atomic Energy Authority, other members paid particular attention to the possibilities of using, as a marine fuel, civil plutonium produced by the land power stations. Reports from the team have given the marine industry understanding of this new branch of engineering science. The work carried out means that the team is now ready to contribute towards the construction of the first British nuclear-powered ship while those members seconded from industry are



Swan, Hunter and Wigham Richardson, Ltd., completed the tanker "El Lobo" at Wallsend for Lobitos Oilfields, Ltd. The ship measures 515ft length between perpendiculars by 72ft 6in beam by 39ft 6in in depth, and carries 15,278 tons deadweight on 28ft draught. A service speed of 14 knots is maintained by a Wallsend-Doxford six-cylinder oil engine developing 6250 b.h.p. at 114 r.p.m., and two 210kW diesel-driven generators provide electrical power

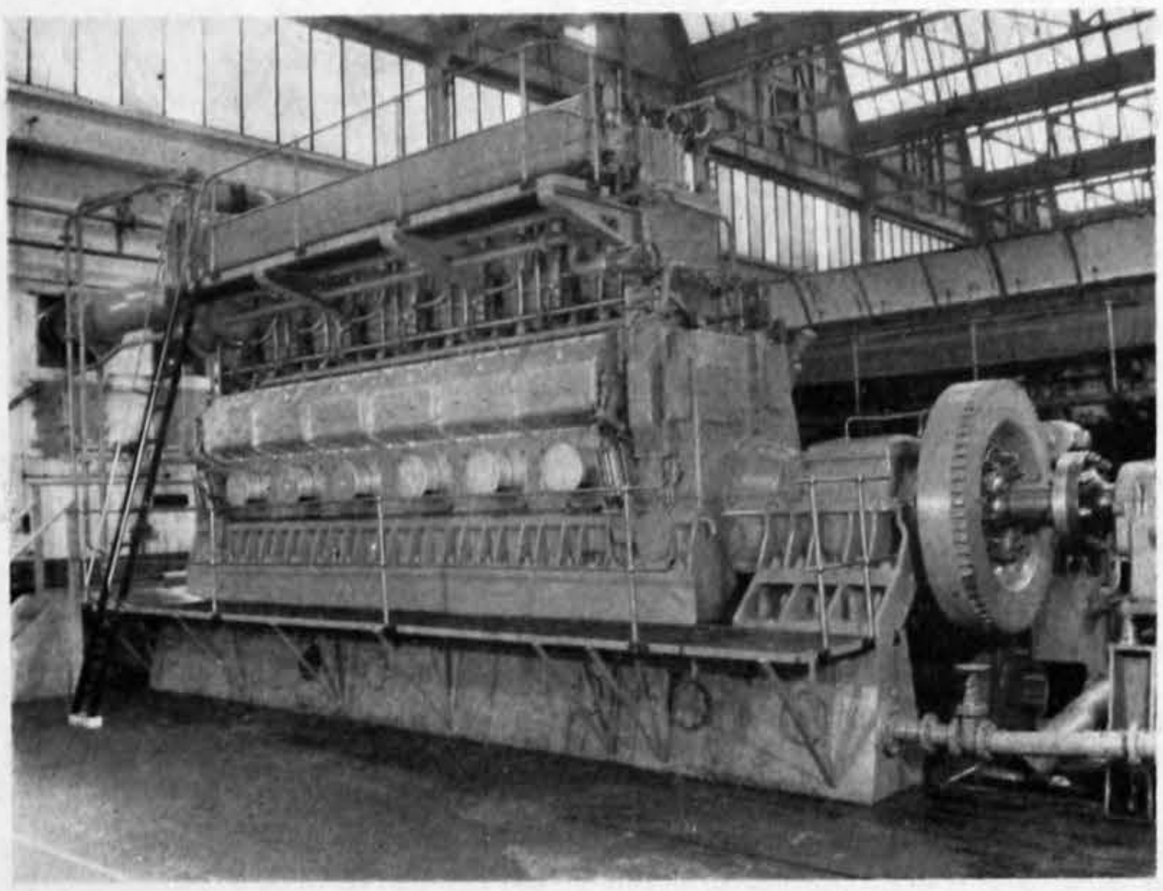


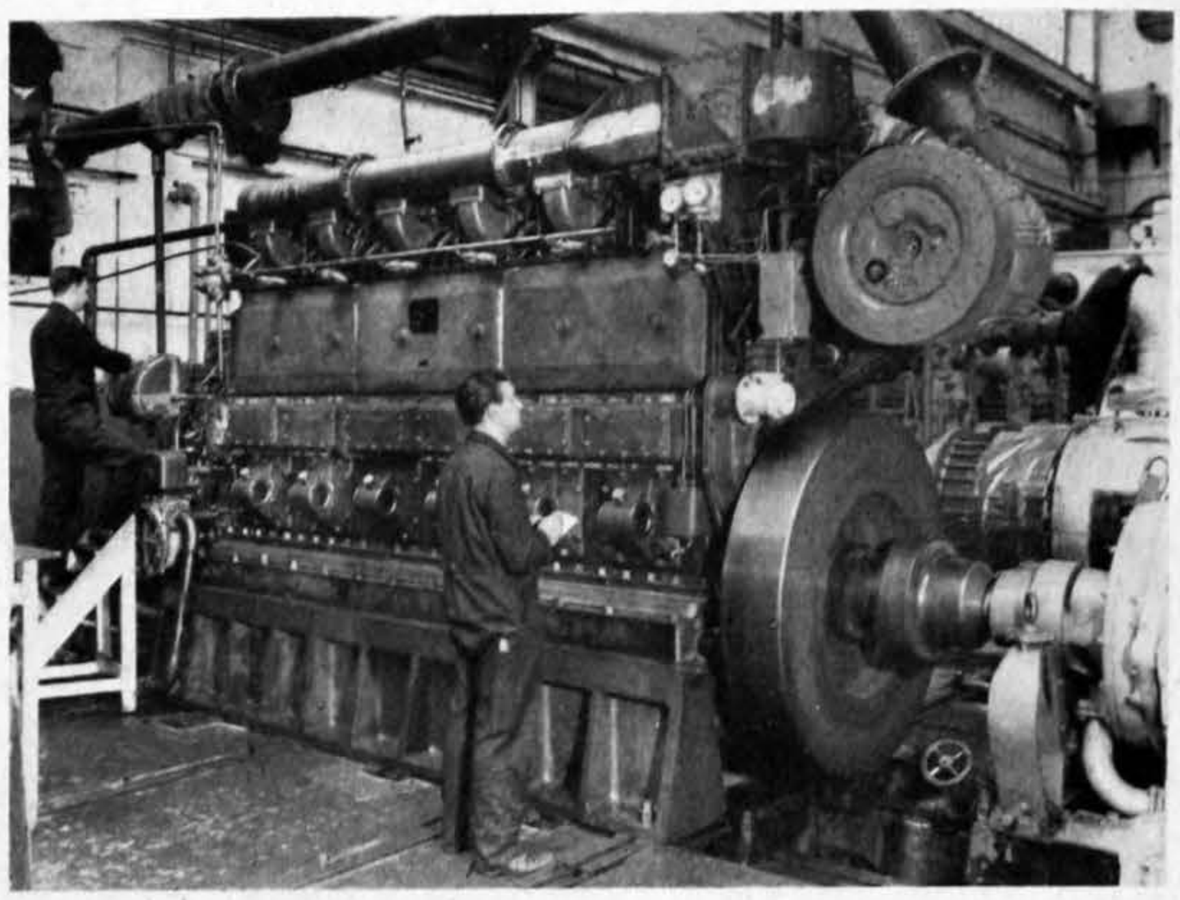
The "Belgulf Progress," of 18,000 tons deadweight, was delivered to Gulf Oil (Belgium) S.A. by the Furness Shipbuilding Company, Ltd., and the main dimensions are : length between perpendiculars 525ft, breadth 71ft, depth 39ft 3in, draught 30ft 6in. Three 700 tons per hour centrifugal pumps handle the oil cargo, two 400kW turbo-generators and one 200kW diesel-driven generator supply electrical power and propulsion is by a set of Richardson Westgarth's geared turbines of 7300 s.h.p. Two Foster Wheeler boilers generate steam at 450 lb per square inch and 750 deg. Fah.

available for the design, trial and operation of such a ship.

In the hydrodynamics programme investigations into various aspects of ship propulsion made progress, as did also the methodical series tests on the forms of ocean-going merchant ships. Although the original basic series of resistance tests were completed, propulsion tests are being continued. The effect of simultaneous changes in the beam/draught and length/displacement ratios is being recorded and when the data are complete they will be incorporated in design charts for estimating the effect upon resistance of changes in these ratios. It was considered necessary to have data outside the range of current practice and for this purpose the methodical series were extended to include models having block coefficients up to 0·85, although ships of this degree of fullness are unlikely to be built. Reports upon resistance and propulsion tests on tugs and trawlers were issued to member companies during the year.

The effectiveness of conventional bilge keels has always been a matter of interest to builders and owners, and full-scale data relating to the rolling behaviour of tankers of 36,000 tons deadweight, both with and without bilge keels, have been obtained. Comparisons are to be made with model results to establish if there is any satisfactory correlation between model and ship and, if established, then model tests will be undertaken upon different designs and sighting





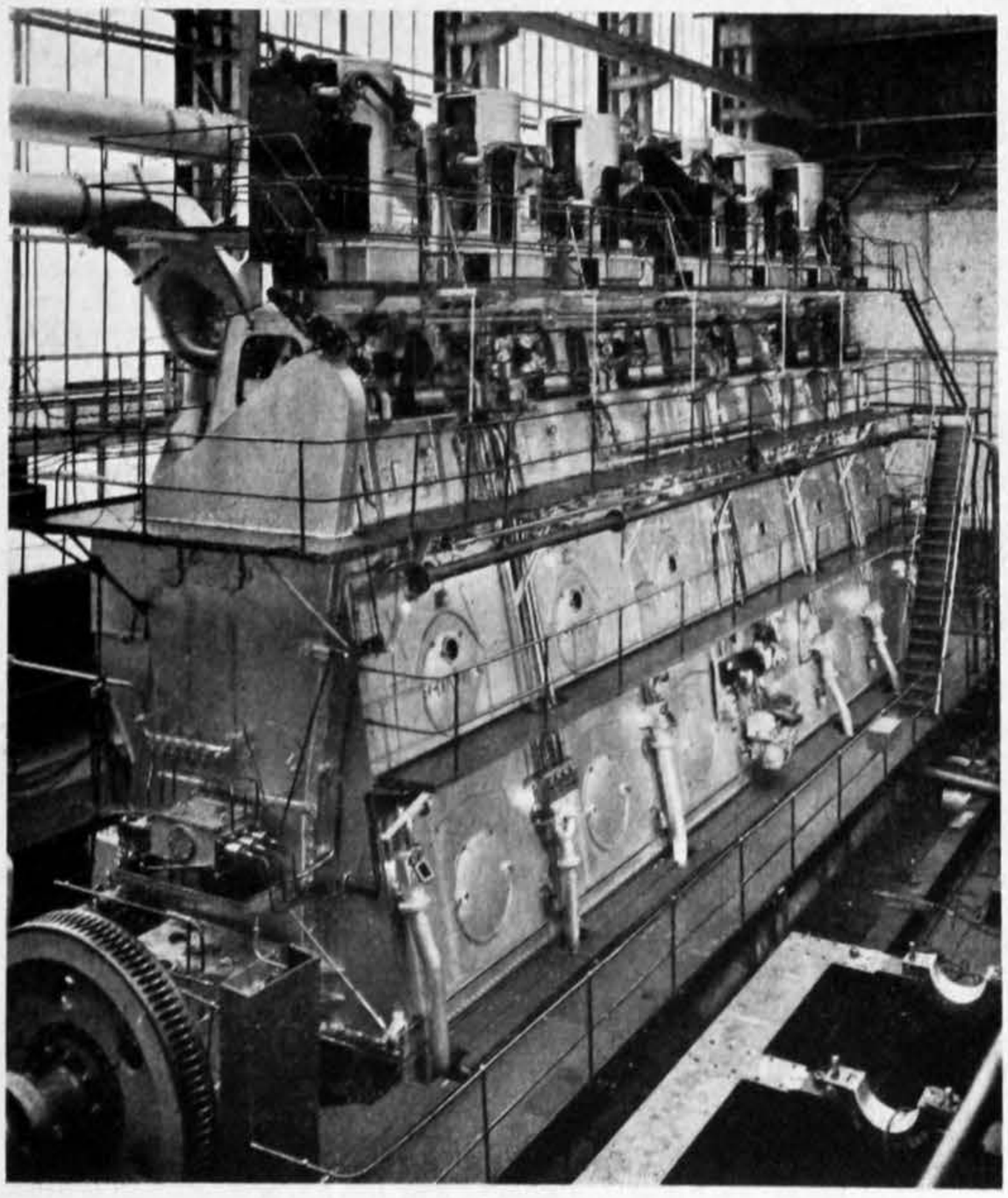
Marine Oil Engines

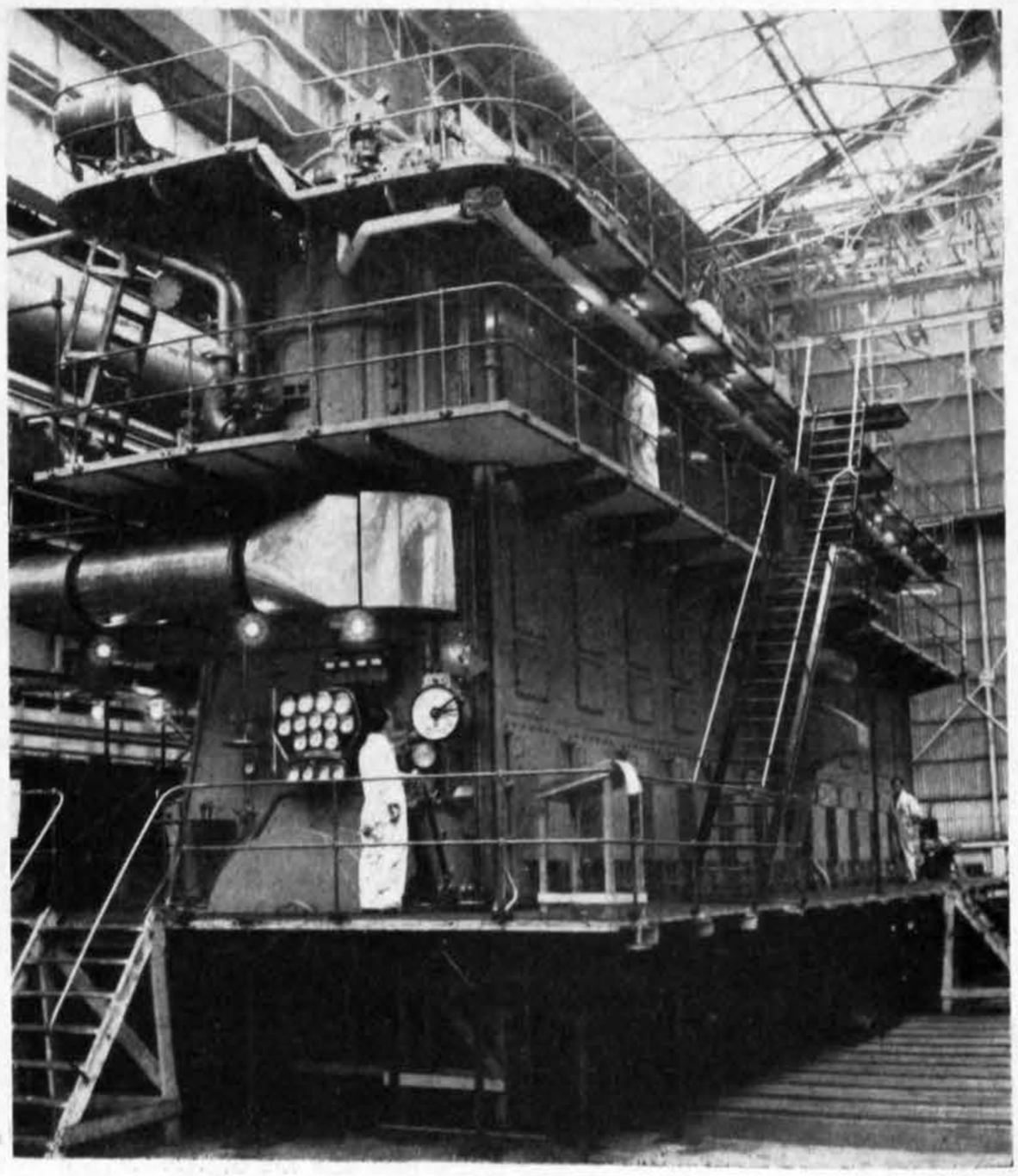
The "Monarch" class diesel engines (LEFT), designed and built by Mirrlees, Bickerton and Day, Ltd., are four-stroke, vertical, single-acting, turbo-charged engines which provide powers ranging from 1600 s.h.p. at 200 r.p.m. to 4000 s.h.p. at 300 r.p.m. at a brake mean effective pressure of 138 lb per square inch. These direct-injection, direct-reversing engines have a bore of 19in by 27in stroke and a compression ratio of 11·35 to 1. Cast iron construction has been adopted and the scantlings are such that the stresses are kept low, there being ample margin to cover any mishandling, while firing loads are taken up by long high-tensile pretensioned steel bolts which secure the bedplate, column, and cylinder block together.

The National Gas and Oil Engine Company, Ltd., designed the "Sovereign" class of medium power diesel engines (RIGHT) to power near-water trawlers and similar craft. This direct reversing unit, which is under full governor control, is of vertical, in-line, four-stroke, single-acting design and is available with six, seven or eight cylinders, either normally aspirated, turbo-charged or turbo-charged with intercooler. The engine has a bore and stroke of 12in by 15in and a compression ratio of 13 to 1 when normally aspirated, and 12 to 1 when turbo-charged. The six-cylinder engine develops 500 h.p. at 300 r.p.m. with a brake mean effective pressure of 130 lb per square inch. Cast iron is the main constructional material and special attention has been paid to engine controls and ease of maintenance.

The 70.L.B.D. "S" 6 engine (BELOW, LEFT) is the first turbo-charged engine built by William Doxford and Sons (Engineers), Ltd., to operate without scavenge pumps. As built the unit has a bore of 700mm and the stroke of the upper and lower pistons is 920mm and 1400mm respectively to give a combined stroke of 2320mm. The maximum rating is 10,450 b.h.p. at 120 r.p.m. with a m.i.p. of 116 lb per square inch gauge when equipped with two Brown Boveri V.T.R. 630 turbo-chargers. Auxiliary fans provide scavenge air under conditions of slow running and should both blowers fail. The engine is largely of fabricated construction and the design, by reducing the distance between cylinder centres, has reduced the weight, which is 480 tons.

The twelve-cylinder Sulzer Mark R.S.A.D.76 engine (BELOW, RIGHT) was built by Alexander Stephen and Sons, Ltd., for installation in the Ellerman cargo liner "City of Melbourne." The unit, which is a single-acting, reversible, two-stroke, direct injection turbo-charged engine, has cylinders at 1400mm centres except numbers six and seven. The bore is 760mm and the stroke 1550mm and the engine is rated at 15,400 b.h.p. but the service power is 14,000 b.h.p. at 114·5 r.p.m. with a brake mean effective pressure of 94·3 lb per square inch, while in shop trial 18,000 b.h.p. was developed at 125 r.p.m., the brake mean effective pressure being 110 lb per square inch. There are four Sulzer turbo-blowers and, including water and oil, the engine weighs 723 tons.





of bilge keels. This research item demonstrates builders and owners work together within the Association.

A total of nine vessels are at sea equipped with automatic stress recording gauges, to provide additional stress data, and on one vessel stress reversals exceeded the maximum value of 9 tons per square inch. Subsequent to a second vessel being subjected to stresses of the same magnitude, gauges having a range up to 13 tons per square inch were fitted. In addition, statistical strain gauges have been fitted to the weather ship "Weather Reporter" in order to gain information on the correlation of the magnitude of stress reversals and wave heights as measured on the wave height recorder with which the ship is equipped. It is hoped to use a cargo liner for similar investigations.

Experiments to determine the bending moments set up in regular waves have been carried out in the St. Alban's tank of Vickers-Armstrongs, using the model of a cargo ship, and a report is nearly complete. It is planned to test a tanker model in a similar manner and later to test models encountering waves other than just head on. In conjunction with Lloyd's Register, the resources of the Glengarnock structures testing station were fully employed and a report was prepared on the full-scale tests on end connections of tanker bottom longitudinals. The strength of swedged bulkheads was the subject of another report, and on the strength of the results the work is to be extended to test deeper swedges in heavier plating.

Observations were carried out on a number of ships as part of the investigations into vibration, while work was completed on the vibration of panels representative of ships' plating, due consideration being given to entrained water effect and the damping effect inherent in the vibration of plating. Tests on propeller-excited vibration have been planned and the programme will be carried out in association with the ship division of the N.P.L.

With the exception of steam and gas turbines, which are the province of Pametrada, all forms of propelling machinery were the subject of investigations of a practical nature. These included an investigation into the forces and stresses induced in piping under advanced steam conditions and the first stage, carried out at room temperature on a two-dimensional piping system, was completed. Tests at more elevated temperatures have been made and work is in hand on a three-dimensional system. To support these laboratory tests, it is essential to have stress measurements taken on pipes in service and, to make this possible, electrical resistance strain gauges to operate at elevated temperatures are being developed.

The problem of preventing smoke from the funnel descending on to the deck has long engaged the attention of the Association, and a paper on the subject was given to the Institute of Marine Engineers. This has been supplemented by a report, issued to members, which records the results of the observance of the behaviour of smoke emitted from funnels of various designs and over a range of uptake velocities. Simple rules for ensuring that smoke will keep clear of the deck were embodied in the report and were successfully applied to modify the design of a funnel of a cross-channel ship.

Noise as related to a free-piston gas generator has been examined and measurements taken, both on the test bed and on board ship. The Association's two-stroke engines at Barrow continued to be used for investigations concerning scavenging and supercharging and complementary to this work is that undertaken by Liverpool University on behalf of B.S.R.A., on the problems of unsteady flow in the exhaust system.

As a result of research into the ventilation of cargo holds, it has been possible to present the data graphically to enable the air flow in a hold, in association with various designs of ventilator head, to be calculated. The most effective and economical way of heating cargo oil tanks provided a subject for experiments in which a scale model of a conical heating coil was placed in selected positions in a model of a wing tank. The flow patterns of the oil were noted and the optimum location of the coil determined. This work, carried out at the Imperial College, London, has clearly indicated how the heating of a viscous oil takes place and negotiations are in hand to enable full-scale check tests to be made. During the year, research into the corrosion fatigue of mild steel in the water cooling circuit of diesel engine pistons was completed, as was also that concerned with the corrosion of tubes in Scotch boilers.

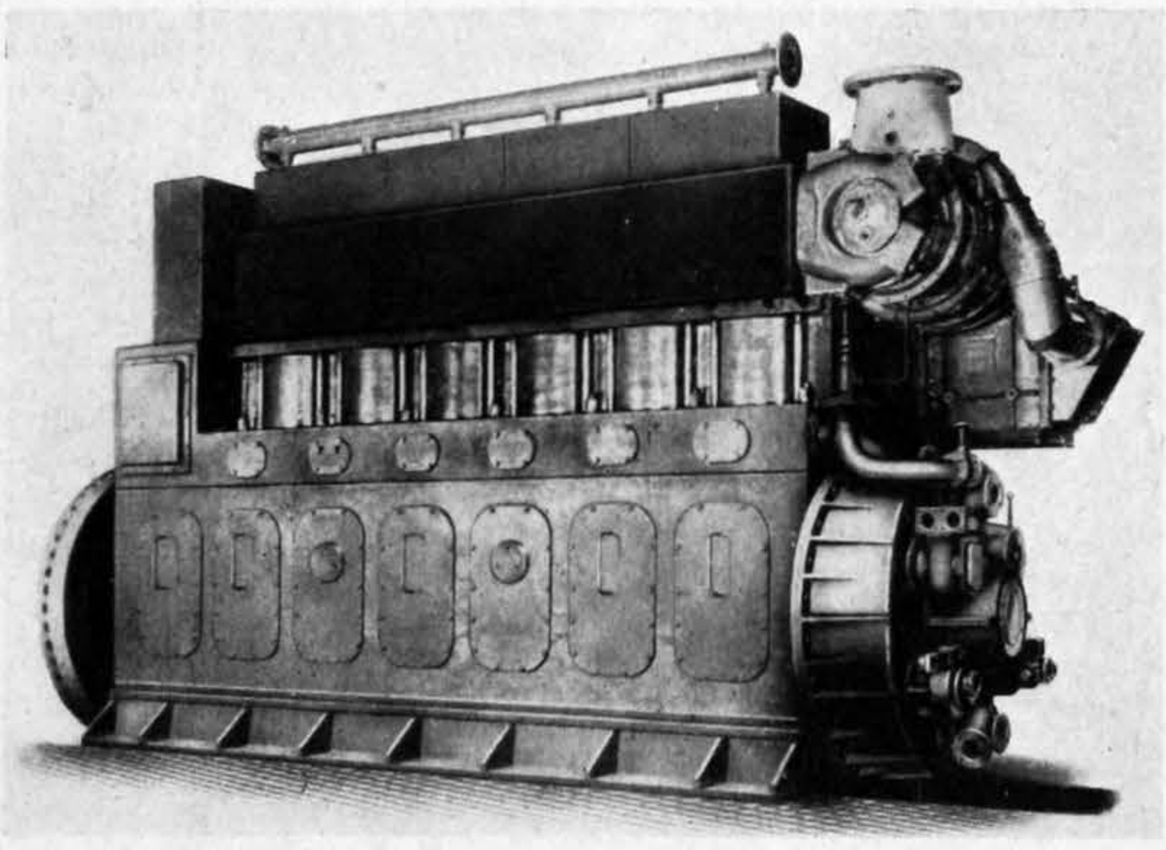
Ship performance is the subject of a section of the research programme and trials on the "Weather Reporter" served to initiate a joint research programme into sea-keeping by B.S.R.A., the N.P.L. and the National Institute of Oceanography. Instrumentation for the trials, which lasted while the vessel was on station, included means to record data on rolling, pitching, heaving, wave heights and sea conditions. Recordings were in digital form, punched on paper tapes which can be fed directly into an electronic computer. This year, similar tests are to be carried out on "Cairndhu" and also model tests under sea conditions simulated in the sea-keeping tank forming part of the facilities of the Ship Hydrodynamics Laboratory, opened at Feltham on October 19 by the Duke of Edinburgh.

Among the full scale work in hand during the year was a programme of measured mile trials on two 18,000-ton deadweight tankers to determine the loss in performance with the elapse of time and the amount of the loss recovered after dry-docking. To date seven such trials have taken place, the latest of which related to a ship having been in service four-and-a-half years, and indicated that the same improvement in performance was not obtained as on previous occasions. In order to ascertain the extent to which the new ship trial performance can be regained it is hoped that one of the hulls will be cleaned by special methods to obtain an as-new hull surface condition. The economics of ship operation will determine if such work can be justified.

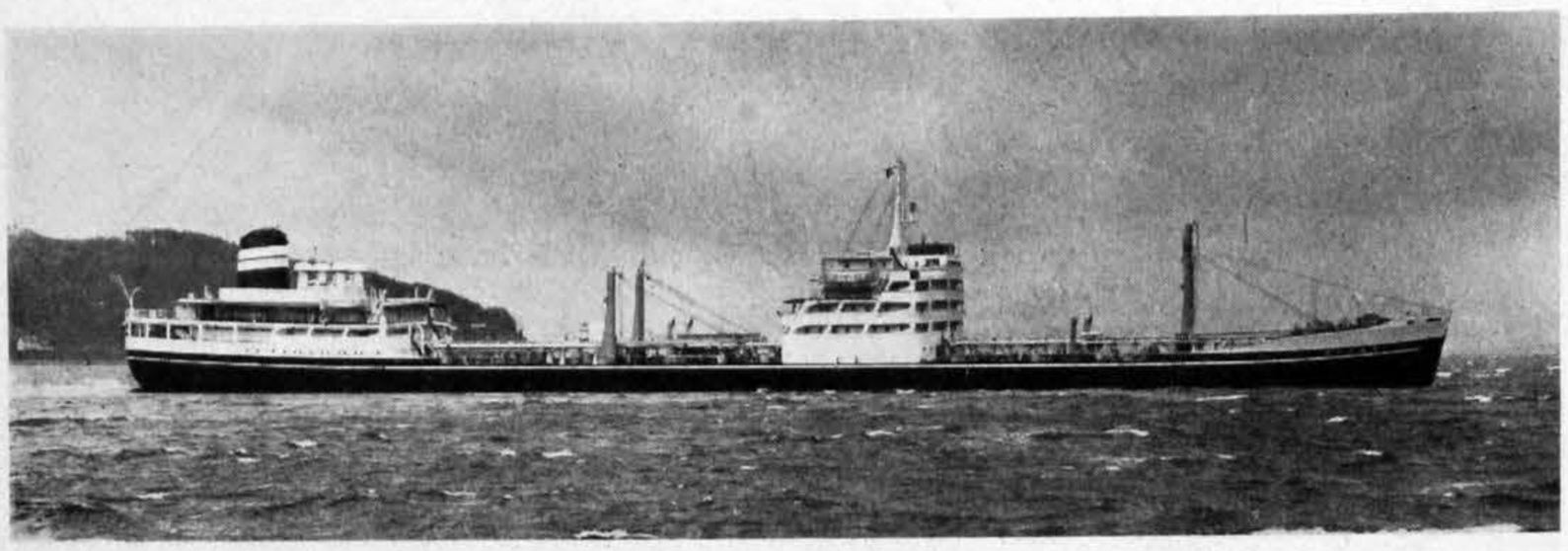
Eleven reports were sent to member firms and seventeen contract reports were prepared



The Eagle Tanker Company, Ltd., took delivery of the "San Ernesto," which was built by Smith's Dock Company, Ltd., and carries a deadweight of 18,100 tons on 29ft 8in draught and the following dimensions: length between perpendiculars 530ft, breadth 69ft 3in, and depth 39ft. There are thirty-three cargo oil tanks, four 400 tons per hour cargo pumps, two 400kW turbo-alternators, and one 200kW diesel-driven alternator. Propulsion is by one set of Hawthorn Leslie two-casing double reduction steam turbines of 7500 s.h.p.



The "AT" diesel engines built by Ruston and Hornsby, Ltd., and described in "The Engineer" of March 6, 1959, are either turbo-charged or turbo-charged and intercooled and are available with five to nine cylinders, with a horsepower range from 622 to 1420 at 500 r.p.m. Bore and stroke are 12½in and 14½in respectively; brake mean effective pressure turbo-charged is 125 lb per square inch and 160 lb per square inch when intercooled



The 19,000 tons deadweight "Queda," built by Scotts' Shipbuilding and Engineering Company, Ltd., forms part of the P. and O. tanker programme, and the main dimensions are : length between perpendiculars 534ft, beam 71ft 8in, and depth 39ft 6in. There are twenty-seven cargo oil tanks, some being cathodically protected, and two pump rooms each fitted with two 500 tons per hour cargo pumps. A service speed of 14½ knots is maintained by one set of double reduction geared turbines of 8000 s.h.p. at 100 propeller r.p.m.

for the Admiralty while ten contract reports were issued to individual firms, according to the latest progress report made available by the Parsons and Marine Engineering Turbine Research and Development Association. The Frigate boiler house and the High-Temperature and High-Pressure boiler house were completed. A total of 430,000 s.h.p. of Pametrada designed turbine machinery was installed in thirty-five ships and the steam turbine design section received seventy-three inquiries, six of which referred to nuclear propulsion, and carried out design studies on machinery ranging from 100,000 s.h.p. on each of four shafts to 56,000 s.h.p. on each of five shafts with steam inlet conditions ranging from 1120 lb per square inch and 1035 deg. Fah. to 850 lb per square inch and 932 deg. Fah. There was renewed interest in reheat proposals and analysis was made of the effects of varying the important parameters in the reheat cycle. The choice of feed cycles to achieve the most economic installation also received attention. As a result of the trend to fewer stages and higher peripheral speeds, &c., considerable effort was concentrated on the final l.p. turbine stages, particularly on vibration characteristics. Work commenced on the design of a more advanced steam turbine installation. Eight inquiries, of which five were for gas turbines to operate with free-piston gasifiers, were dealt with by the gas turbine design section. The reversing turbines have a two-row Curtis wheel astern turbine and the unidirectional turbines drive through a hydraulic reversing gear or a controllable pitch propeller. Also under consideration for reversing is the use of inward radial flow turbines with adjustable nozzle vanes, and a design was started for a 2000 s.h.p. unit to run at 15,000 r.p.m. and drive through epicyclic gearing.

The gearing design section was engaged on design inquiries for conventional as well as hardened and ground reduction gears. Among the former were 22,000 s.h.p. highly loaded gears and various configurations of 25,000 s.h.p. sets for oil tankers and a 60,000 s.h.p. unit for a quadruple screw installation. The latter group included a 10,500 s.h.p. single-drive dual tandem double reduction gear, a two-stage 15,000/178 r.p.m. epicyclic gear to transmit 2000 s.h.p. and a 6000 s.h.p. epicyclic reduction-reversing gear. Work was completed on the reversing unit for the Shell tanker "Auris," while development work on the ahead friction clutch resulted in the design of a double-face clutch in which friction elements and hydraulically-operated actuator are separated. A report on pressurised combustion boilers was prepared by the boiler design section and a basis plan for such a boiler finalised. Work on priming was carried out and it was found that drum internals of the horizontal perforated plate pattern are only partly effective in stopping priming.

The research department was engaged on the problems of noise reduction of machinery, and the first two sets of test gears were run and measurement made of airborne noise and vibration. Mechanical tolerance tests on a single-stage air turbine were carried out and an outline design prepared of a multi-stage turbine to supplement the work. There was a rotor critical speed investigation in hand, as were tests upon welded diaphragms and nozzle plates. Also in hand were full-scale trials on a single-stage liquid-cooled gas turbine with particular reference to the testing of rotors and blading. Work continued on gear trials and with hydraulic couplings and converters, while another research scheme concerned the performance of a mechanical flexible coupling under various conditions of loading and alignment. In the full-scale trials department the trials of the Y.E.A.D.I machinery were completed and reports prepared upon the performance of engines and boilers.

(*To be continued*)

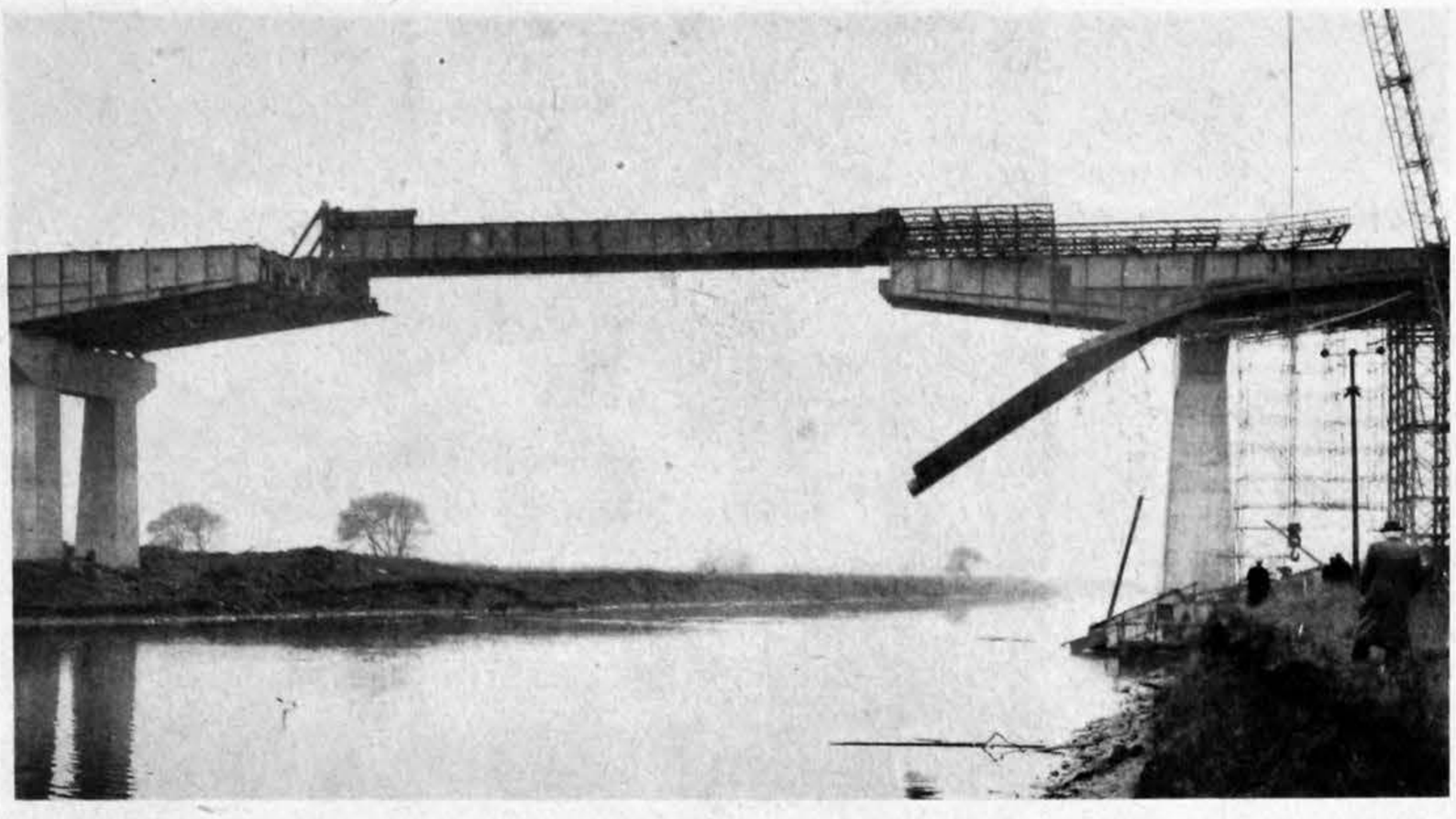
Barton Bridge Accident

IN last week's issue of THE ENGINEER we recorded, on page 30, details of the situation leading to the termination of the sub-contract for steel erection at the Barton Bridge. Recent progress in building the bridge is depicted on Plate 2 herewith, but since the pictorial section of this issue went to press, an accident has occurred at the bridge, when four girders, each 256ft long, forming part of a cantilever and anchor span, collapsed. The two illustrations herewith clearly show what occurred. The first one shows the eight main girders of the undamaged cantilever span and it can be seen that the structure was being erected in half-widths, each involving four girders. The second view shows the assembly comprising the first four girders of the suspended span "landed" in position, with the temporary rolling-out steelwork still attached to its forward end ; in this view the assembly has still to be jacked down to its permanent seatings, which are clearly seen. On the damaged side, the four cantilever girders nearest the camera have each toppled sideways, the outermost one falling to the ground, and the three others while still resting on the pier, being unable to sustain their own weight in this position. The United Steel Structural Company, Ltd., which has supplied the steelwork for the bridge, agreed to complete the last stages of erection, after the termination of the previous sub-contract. The company has issued the following statement :

"United Steel Structural Company erectors arrived on site on Tuesday, December 29, and started working on the morning of Wednesday, December 30. The accident happened at 1.30 p.m. on December 30, only about five hours after the company's erectors had begun work. It is deeply regretted that two men, one an employee of the United Steel Structural Company, were killed. Two others were seriously injured. Several other men escaped with only slight



The Barton bridge, showing the collapsed girders of the north bank anchor and cantilever span in the foreground



Four girders of the suspended span are shown in position, but not lowered, and the four collapsed girders are in the right foreground

injuries. The main contractors, G. Dew and Co., had retained certain supervisors employed by the previous erection contractors in order to facilitate the resumption of work and in the interests of continuity.

"The proposed sequence of operations had been agreed between the Lancashire County Council engineer, the main contractors and the United Steel Structural Company. Four girders of the North bank anchor and cantilever span had previously been landed on their piers. One of the first tasks was to secure them in their final position in readiness for the erection of the four remaining suspended girders over the ship canal. It was essential to complete the bracing between the four anchor and cantilever girders before the girders could be moved into their final position and this operation was started by United Steel Structural Company's erectors immediately. It was necessary to lower the four girders slightly on jacks that had previously been set in position. Whilst this operation was in progress, the four girders toppled sideways. Three lay on top of the piers, the fourth fell to the ground. The prime cause of the accident cannot be established without a detailed investigation."

This accident is the second which has occurred at Barton Bridge. Scaffolding carrying a partly-erected span collapsed last February, and four men were killed.

Automatic Assembly of Silicon Diodes

A PLANT for the automatic assembly of ZS30 series, 500mA, double-ended diffusion diodes is now in operation at the Gem Mill factory of Ferranti, Ltd., Oldham, Lancs. This plant was designed and developed at the Gem Mill works and took fifteen months to complete. It is estimated to be capable of producing, up to the test stage, 2,500,000 diodes a year.

The new ZS30 series diodes are designed for assembly by automatic processes, but as a temporary measure pending completion of the new plant, most of the operations were done by hand. Now, however, all operations in the final assembly of the header, such as flash welding the wire on the back of it, passing through hydrogen furnace to remove oxidation, are done on automatic transfer mechanisms. As the stages of copper plating and gold plating the header assembly, and that of pre-soldering the dice to the header, lend themselves well to batch production, no automatic mechanism is used for these processes.

The mechanism used for the assembly of the lead wire to the header is controlled from a common camshaft, which enables the overall index figure, nominally eight seconds, to be varied at will. The headers, which are produced on high-speed Swiss automatic machines at another Ferranti factory in Oldham, are thoroughly washed and de-greased before they are placed into a hopper located at one end of the automatic machine (on the left of the illustration).

From the hopper, the headers are sorted and presented one at a time to a magazine. An escape mechanism releases the header down an inclined chute on to an indexing table where it is influenced into a cup by an air jet. Each time the table indexes, a vacuum arm picks up a header from the table and transfers it through 180 deg. to a second table where it accurately locates it in a nimonic alloy jig. This table then indexes round and presents the header to the lead wire and an oxy-coal-gas flame is brought into position to make the weld. After welding, the wire is measured to length and cropped accurately by transverse guillotine knives.

Then the completed header is indexed to a position where it is blown out of the jig and up, through a tube in the form of an inverted "U," to be transferred to a small hydrogen furnace where oxide created by welding is removed. After passing through this furnace, the component is collected in a container and taken away to be copper plated and gold plated in batches.

The header with solder disc and silicon dice mounted on top, and in contact with each other, are then assembled in a jig which is passed through a hydrogen furnace for about fifteen minutes. During the cooling cycle the dice adheres to the top of the header.

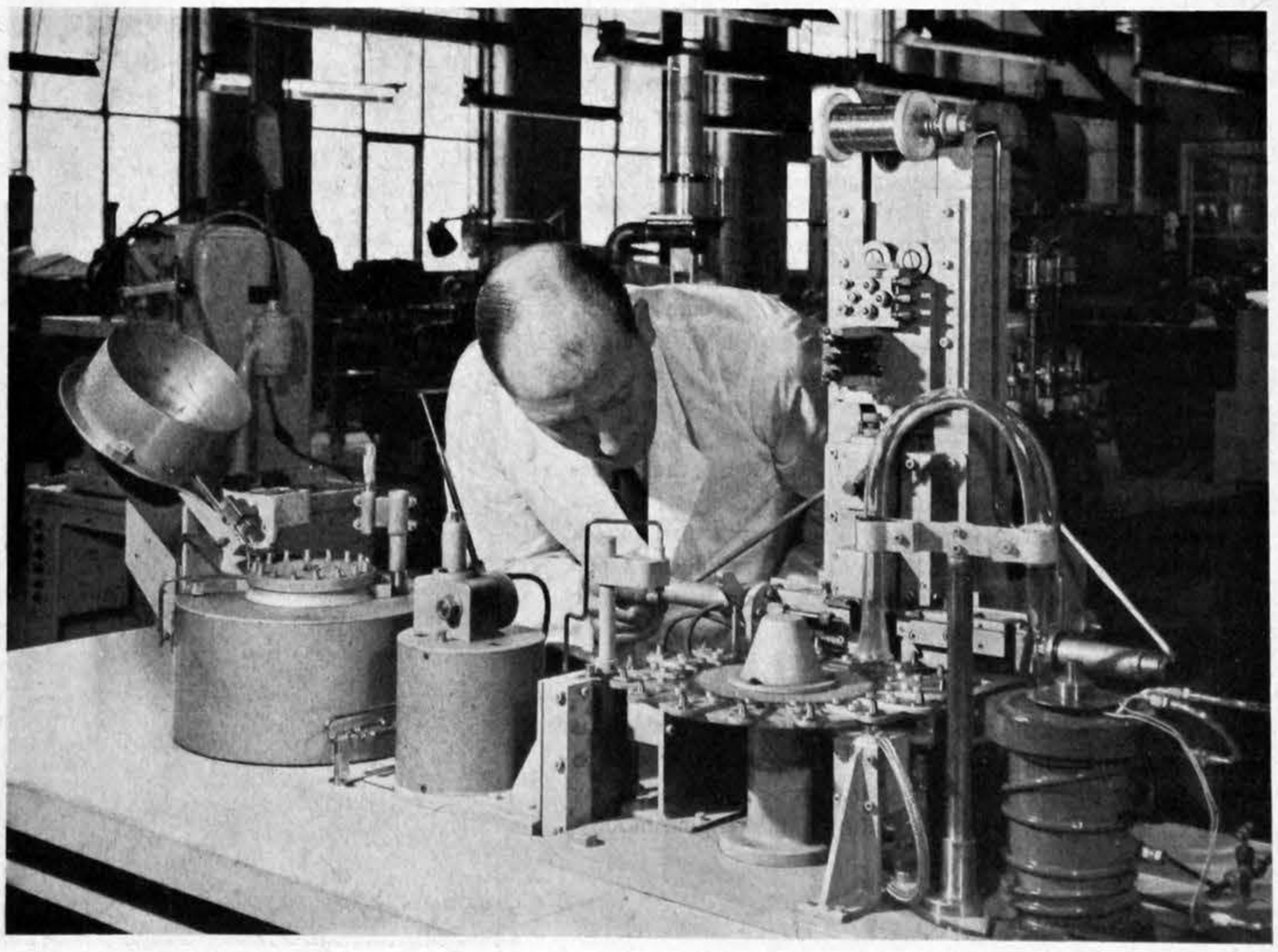
Post-etching treatment, which is the next stage of the process, is also carried out automatically in a specially designed plant, the use of which has already resulted in an increase in the efficiency of the diodes. A characteristic of this plant is that dangerous etching liquors (in this case, a mixture of hydrofluoric, acetic and nitric acids) are stored remotely in a ventilated cabinet outside the area where the operator is working.

A rotary indexing table passes the components through a series of etching, cleaning and drying stations before the final index position where automatic varnishing is carried out. The index position before varnishing is used for checking the polarity of the dice by means of a wire probe. The index figure of this mechanism is infinitely variable from five to ten seconds and the period in which the dice is exposed to the atmosphere is limited to seventeen seconds.

The etching liquor is constantly circulated throughout the system and on return to the sump is forced up to the header tank through a connecting pipe by a pressure of 3 lb per square inch applied to the surface of the liquor.

Before final encapsulation which is carried out by an automatic machine with an indexing time of fifteen seconds, a solder ring is placed on the header plinth and this assembly is located in a small ceramic chuck. The can, complete with glass seal through which the lead wire and compensator pass, is located directly above the plinth and the whole assembly is then placed in a vacuum chamber. The machine indexes round through a series of eddy-current heating positions until, after a predetermined period, a trip mechanism allows the can to drop on to the plinth, thereby locating the compensator on top of the dice which is positioned directly below it. The table continues to index while the assembly is allowed to cool to form the hermetically sealed encapsulation.

These diodes are rated at 500mA at 35 deg. Cent. and have a diameter of 3·8mm and a length of 8mm. They have a rectification efficiency of the order of 2,000,000 to 1, reverse currents lower than 0·2 microampere at 25 deg. Cent., stability from −70 deg. to +160 deg. Cent., and a maximum volt drop of 1·1V at 500mA. They are suitable for general rectification, magnetic amplifiers, radar systems, guided missiles and computers, &c.

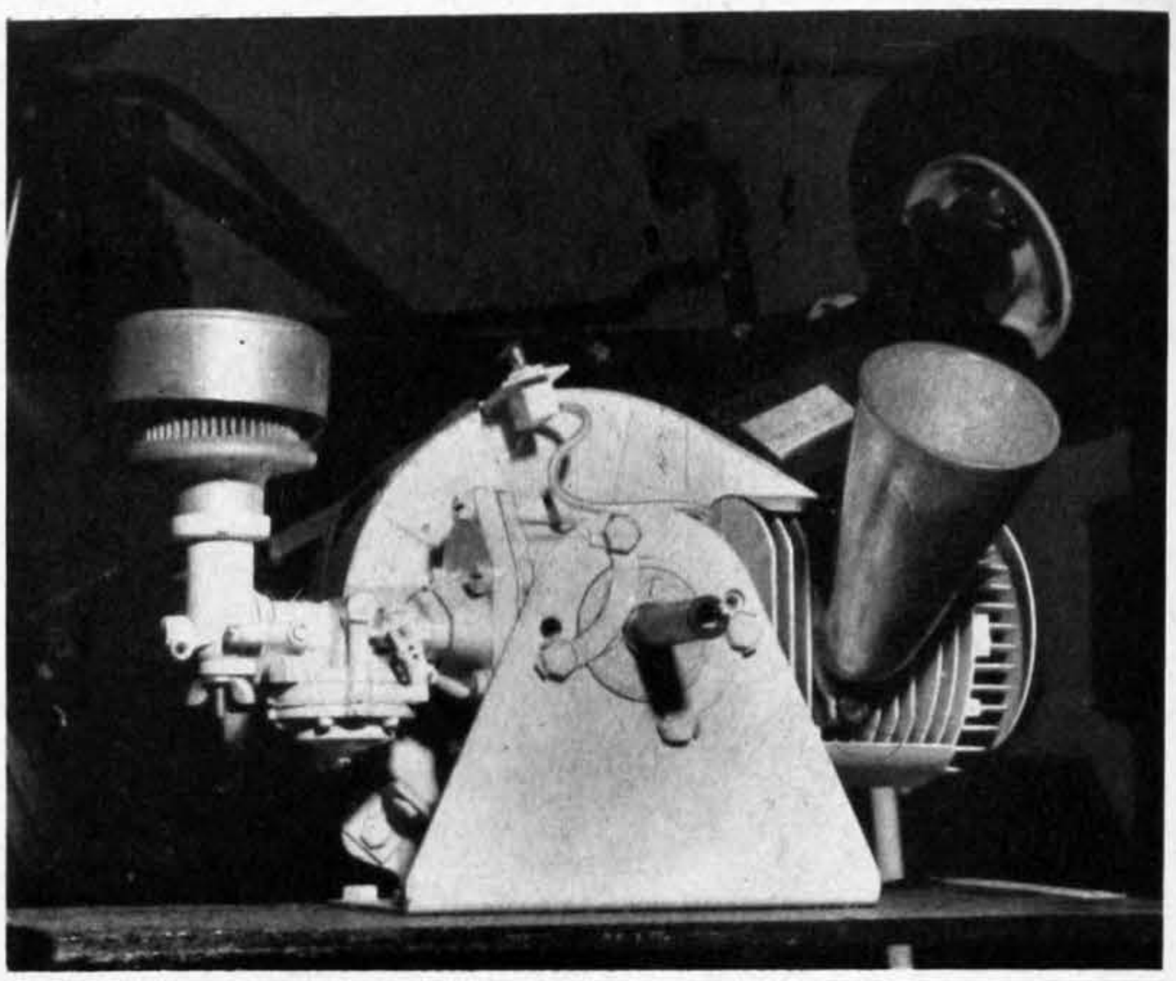


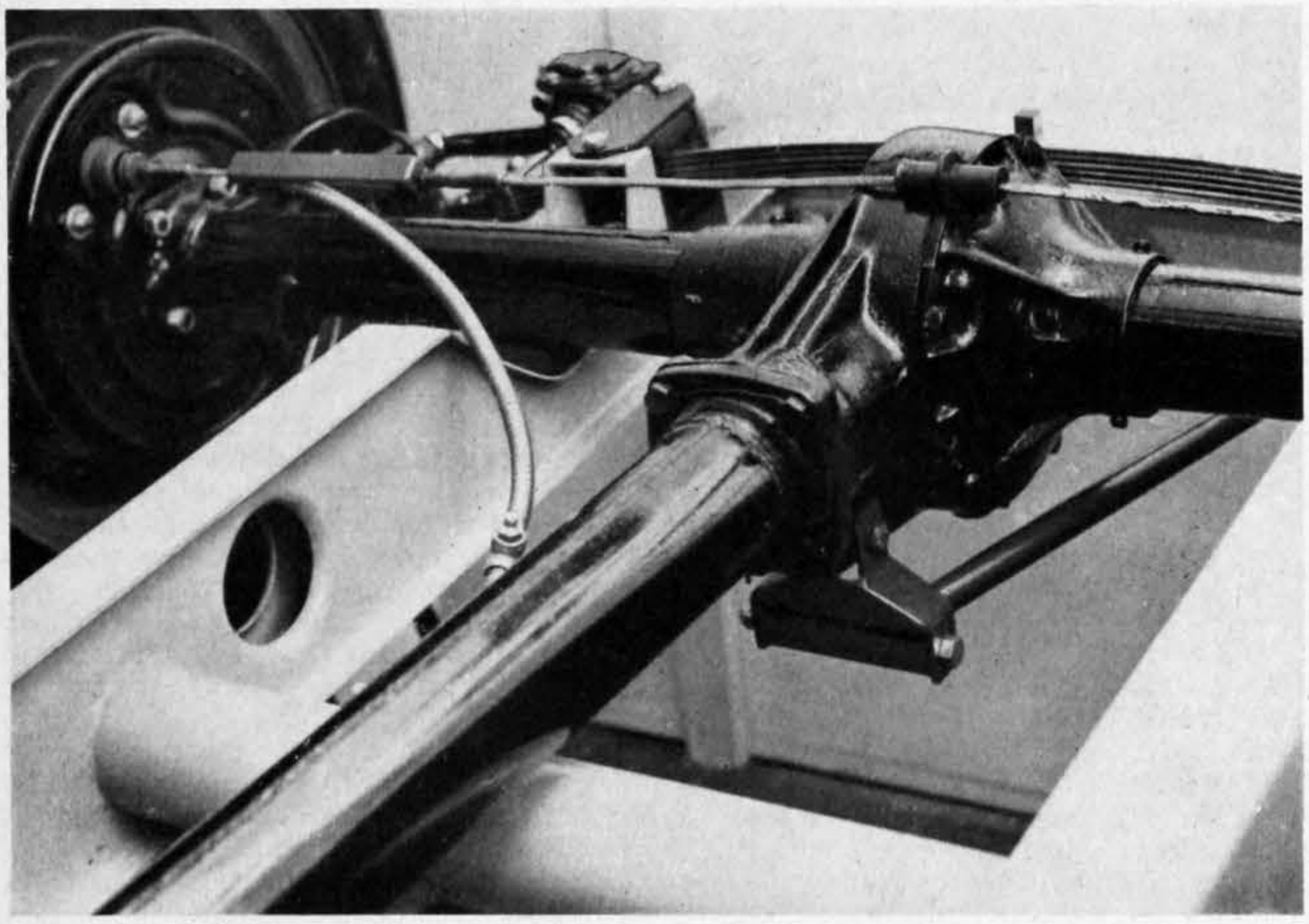
Automatic plant for assembly of ZS30 series, 500mA diodes at Gem Mill factory of Ferranti, Ltd., Oldham

Racing Car Show

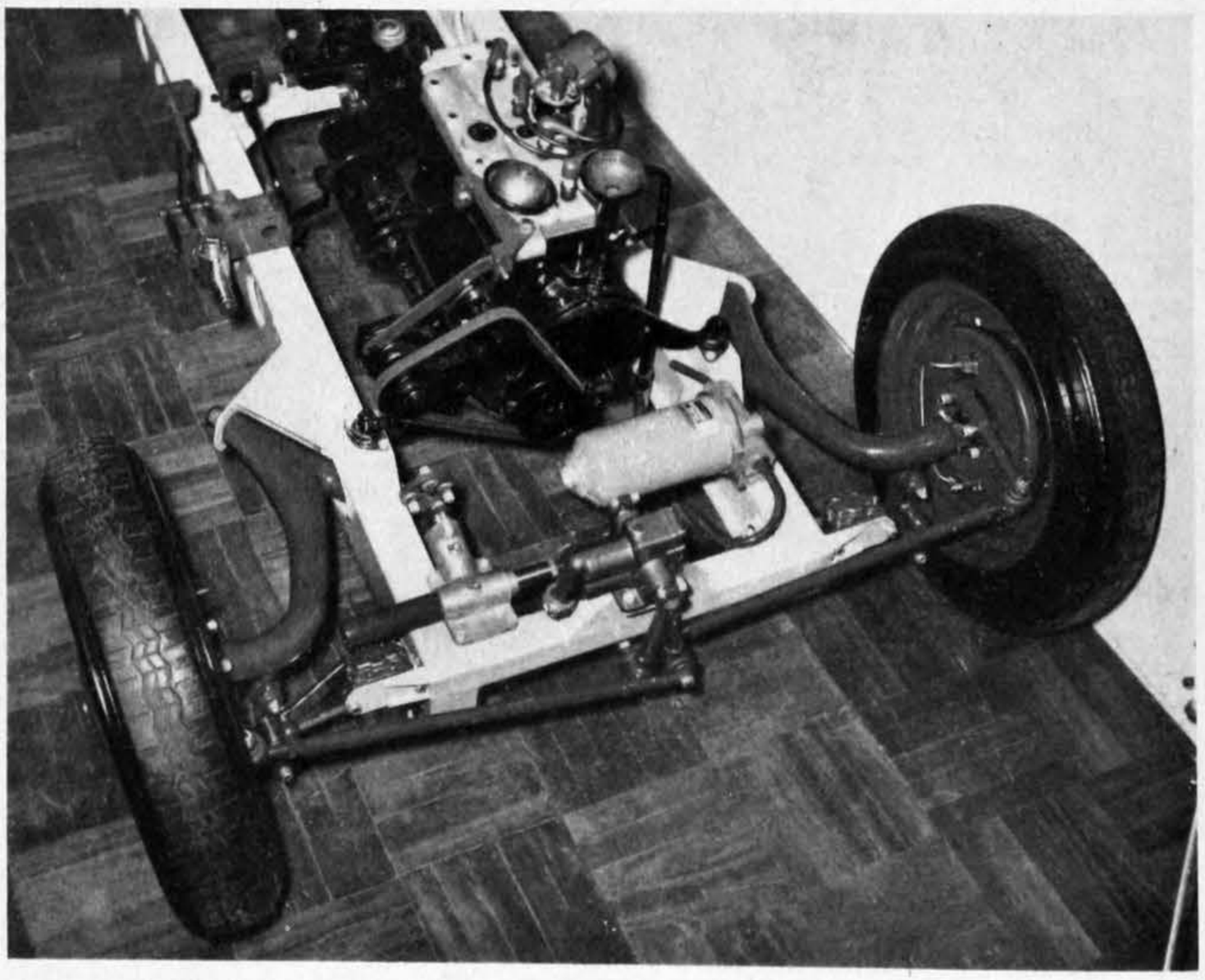
An annual Racing Car Show has been instituted by the British Racing and Sports Car Club, the first being held at the Royal Horticultural Old Hall and concluding tomorrow. There are exhibited not only competition cars of the past and present, but also many devices intended to refine the behaviour of even quantity-production contemporary cars.

A racing vehicle unfamiliar in this country is the "go-kart." Small two-stroke engines are used, and RIGHT is seen the most powerful version of the 95 c.c. Clinton, having an output of 4½ h.p. All these engines have automatic inlet valves and Tillotson pressure-balance carburetters ; dispensing with the float chamber allows the engines to run with faultless regularity under the extreme accelerations prevailing in racing. The engines are smoke-free on a 16 : 1 petroil mixture, and when a silencer is fitted access to the exhaust ports is available without removing it. The 2½ h.p. engines are unusual in having plain bearings, except for the drive side main. In the background can be seen a 'kart manufactured by Speedex Castings and Accessories, Ltd.

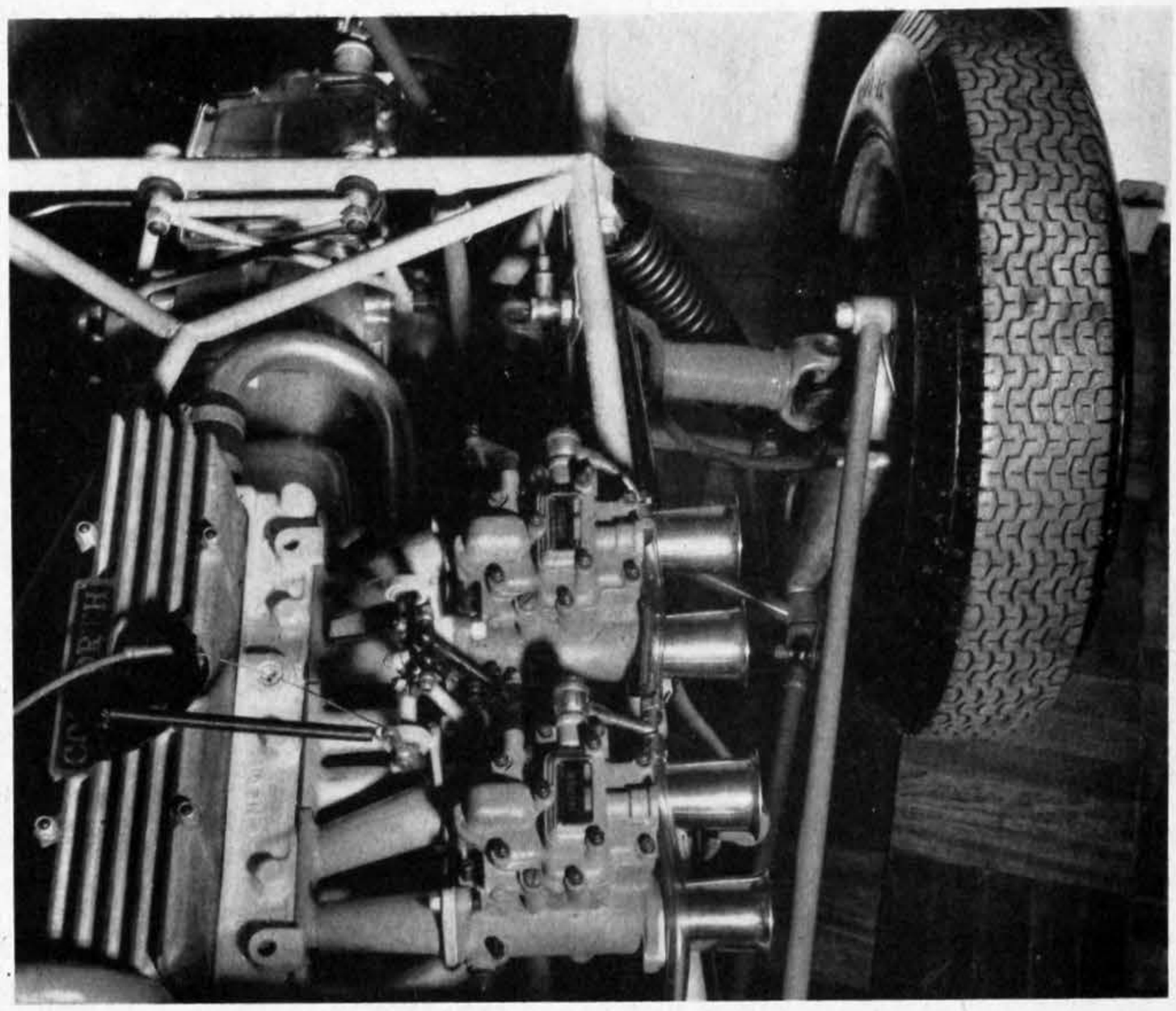


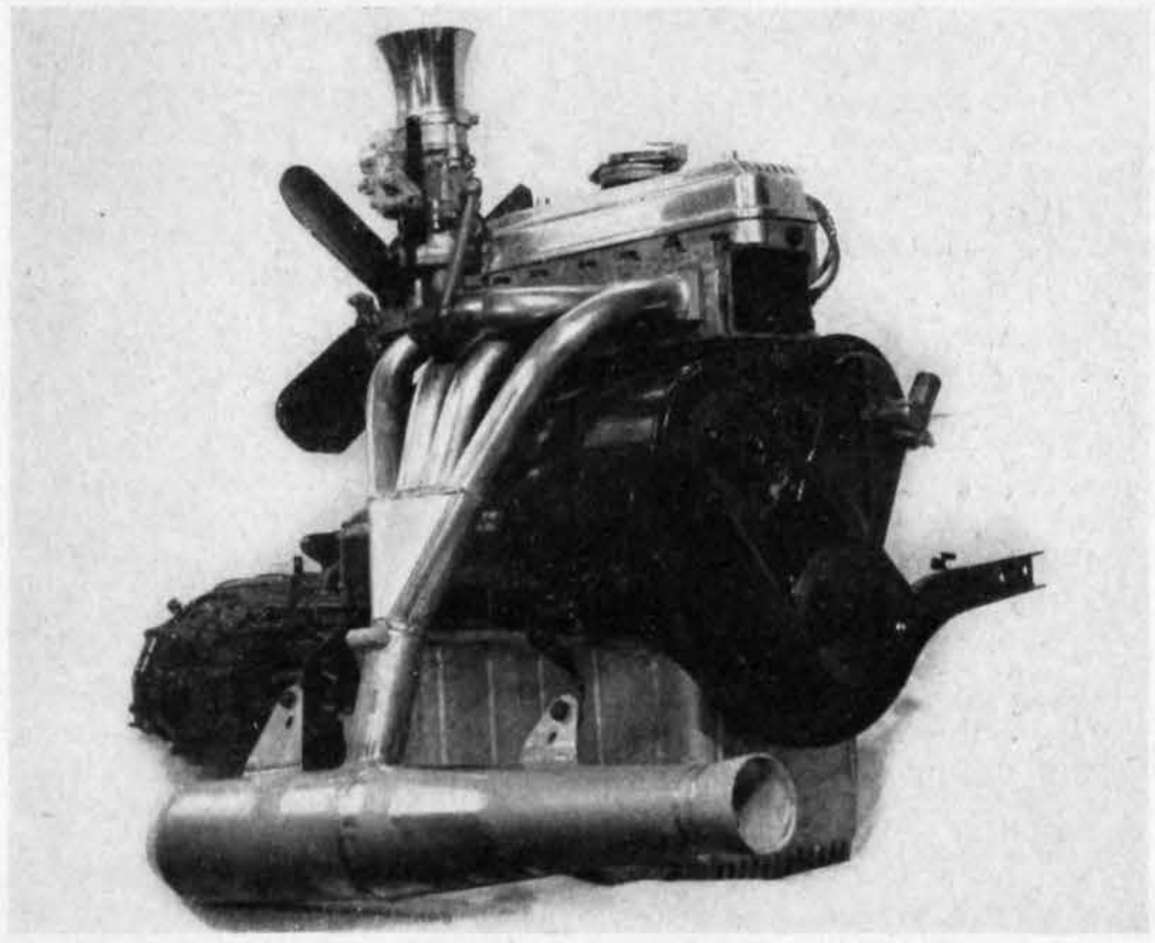


L.M.B. Components, Ltd., displayed a lightweight chassis for 1172 Formula racing. This formula suppresses variations in power loading and emphasises handling qualities, and in common with the bulk of cars designed for extreme adhesion this special is closely based upon the 90in wheelbase Ford. The most significant difference is front suspension by "semi-leading" arms ; the reason for this is that the design is based upon the use of rigid breaker tyres and hence it will corner with the steering turned into the bend, and with this suspension geometry the effect of roll is to increase favourably the camber of the outside wheel and diminish that of the inside wheel—on opposite lock the converse is true, so that the car becomes significantly more sensitive in a drift. The precession moments generated by the swing axle effect are dissipated by an adjustable double-piston damper, allowing rack and pinion steering that can be assembled for either left- or right-hand drive. To avoid changes in the static stability with imposed acceleration, both front and rear springs are clamped at two points to elicit roll stiffness ; thus symmetry forbids the axle being located sideways by the spring, as on the Ford, and to obtain the full tractive effort available with torque drive the extremely stiff scissors linkage is placed below the final drive—this displaces the simple and efficient brake linkage associated with torque tube designs, and the rear brakes are cable operated with manual reversion after hydraulic failure. (The standard Ford brakes are amply adequate for speeds up to 100 m.p.h. but hydraulic actuation simplifies conversion to i.f.s.—on the Ford chassis true hydro-mechanical operation is instituted.) The chassis itself is composed of box-section members, the longitudinals comprising two channels arranged face-to-back so that seam welding can be employed to unite them ; it has a torsional stiffness of 6500 in lb per degree and weighs (and costs) 85 pounds. Details worthy of attention in the photographs are the Spun Metals oil filler cap, which is retained by surface tension, the immensely deep Bosch distributor, cleared for operation to 8000 crankshaft revolutions per minute, and the exclusive use of lever dampers, in order that the heat generated in the fluid shall have an escape path to the frame. L. M. Ballamy is also active in engine tuning, and has attacked the problem of the very great variation in fuel utilisation of the 100 E Ford ; this has been found to be due to flooding of the carburetter due to vibration, and there is in course of preparation a fuel economy device consisting of a damper for the flexible engine mountings.



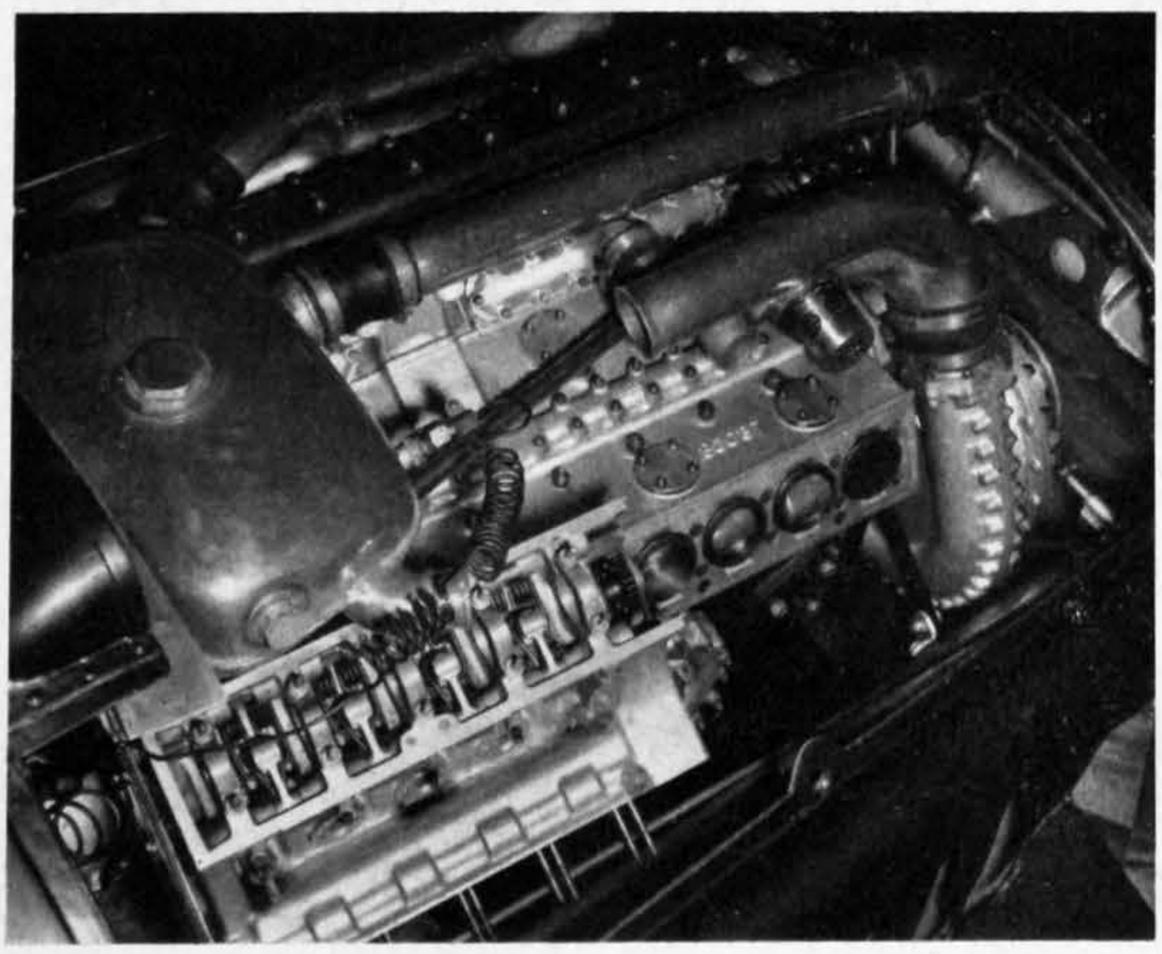
A number of cars for competition under the Junior Formula were on show, all using o.h.v. engines of under 1000 c.c. The British unit best matched to the formula is the Ford 105 E, seen here in a Lotus and also available in the "Gemini." Tuned by Cosworth Engineering, Ltd., the engine gives over 70 b.h.p. at 7000 r.p.m.; the changed rocker cover is necessitated by a cam grind increasing the rocker travel. The eight-port head is exploited by a pair of the Weber carburetters virtually universal in international racing. Gearboxes are, on rear-engine cars, invariably foreign, the Lotus having a Renault casing with either four- or five-speed Gordini clusters, and the Cooper, as originally, a Citroen box. Front suspensions employ the stub axles standard on the "Herald," the Elva using the Ford technique of taking the braking forces through the roll stiffness bar while the Lotus now has a separate anti-roll bar. As seen here, the Lotus has outboard rear brakes and employs two trailing arms to take the reactions, a wishbone and the drive shaft forming a parallelogram in the transverse plane; MacPherson geometry on such a low car would have entailed heavily canted struts and a high roll centre, which would both invite wheelspin and render the static stability undesirably negative. Inboard-braked transmissions such as the D.K.W. appear never to have been used, but the front-engined Elva has inboard brakes and uses a radius arm to take the braking and driving forces.

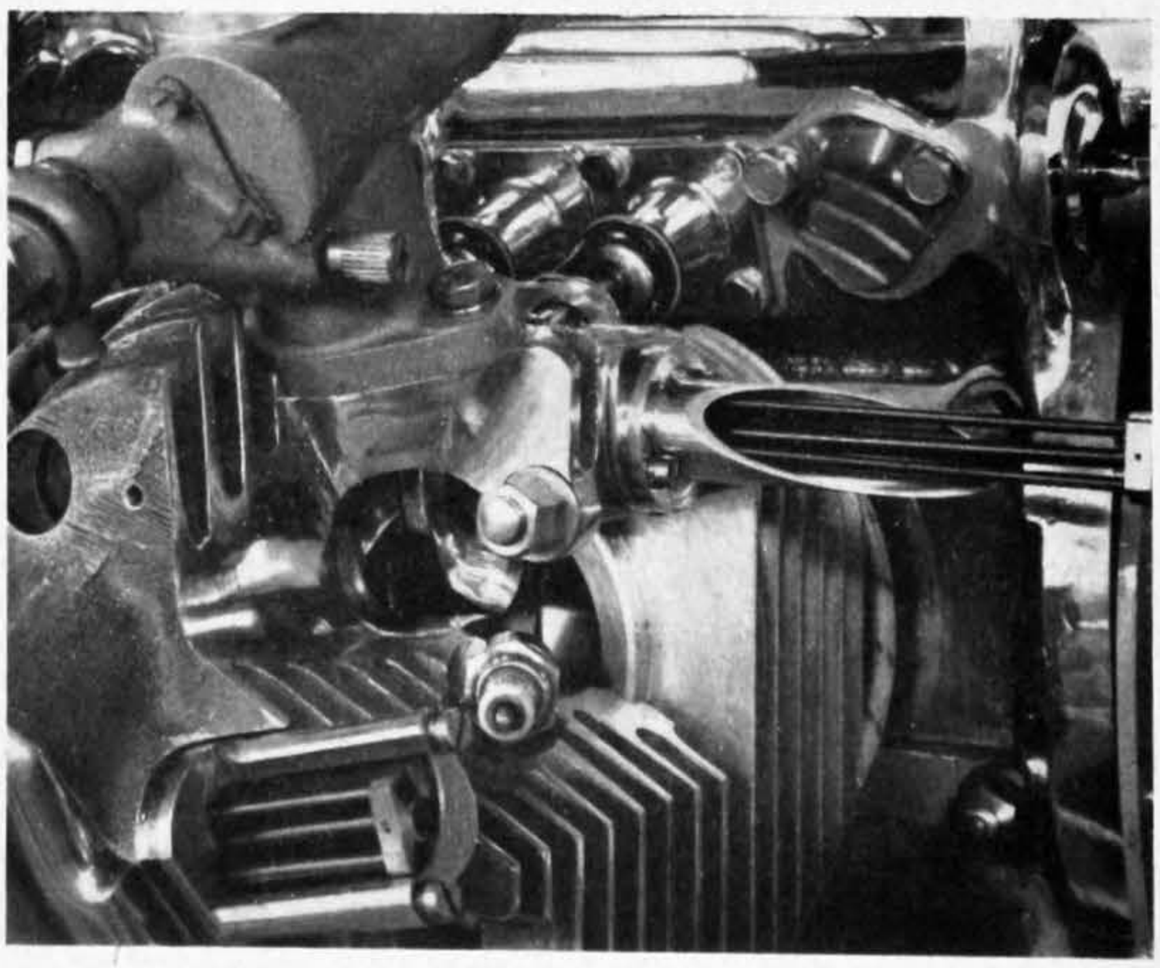




The great bulk of the exhibits were British, but France contributed a 1927 supercharged 1½-litre straight-eight Delage in chassis form, modified to hydraulic braking with a single master cylinder, and the Ferry silencer-ejector seen LEFT on a Renault "Dauphine" power unit fitted with a 1¼-gallon light alloy Butler sump. Another interesting fitting offered for the "Dauphine" by the Wilen Engineering Company was a steering "box" with a pinion having nine instead of six teeth and the centring spring eliminated, a modification intended to render safer driving at high speeds or on slippery surfaces.

The collection of cars of technical interest included a V-16 B.R.M. of approximately 430 h.p., probably the most powerful car raced under any but the 1000 kg formula. Below LEFT the engine is seen partly dismantled; at the front is the volute of the supercharger, with a nominal pressure ratio of 4, and above the engine the delivery duct and blow-off valve. In the foreground can be seen the valve gear, with rocking fingers to reduce the side thrust; the peak speed of 11,000 r.p.m. is probably as high as has ever been attained by a four-stroke without desmodromic valve gear. Another example of interesting valve gear was afforded by the 1½-litre A.J.B. engine with inlet through Butterworth swing valves; below RIGHT can be seen an open valve and, above to the right, the compound torsion bar spring. This plain-bearing push-rod engine achieved 150 h.p. at 7000 r.p.m. with dual ignition, an output comparable with that of the "Manx" Norton.





SHORTER REPORTS

Mumbles Railway Closed

AFTER the running of the last public passenger train over the Swansea and Mumbles Railway on January 5, this historic line (opened for goods traffic in 1806) is awaiting dismantling by the demolition contractor, Thos. W. Ward, Ltd., Albion Works, Sheffield. An unchecked decline in passenger traffic during recent years obliged the lessee of the line—the South Wales Transport Company, Ltd.,—to make a complete reappraisal of its prospects, and it was found that to put the undertaking in a sound mechanical condition would cost between £300,000 and £350,000. When the official decision to scrap the line was made some months ago, the lease agreement with the Swansea and Mumbles Railway Company and the Mumbles Railway and Pier Company still had some 939 years to run, but the opportunity arose to buy the shares of these companies for £200,000, representing approximately fourteen years' rental. Only the railway is affected by the closure decision, the pier and hotel undertakings at Mumbles continuing as before.

The history of the line dates from the incorporation on June 29, 1804, of the Oystermouth Railway or Tramroad Company to build a line from the Swansea Canal at Swansea to Castle Hill in Oystermouth. This company was empowered to " hale or draw " wagons or other carriages with " men, horses or otherwise," and began to carry goods in April, 1806. In 1807, the board gave permission to one Samuel French to run a " waggon or waggons on the Tram Road " for the conveyance of passengers. Thus, the Oystermouth line became the first passenger-carrying railway in the world. Horse-drawn passenger services were suspended about 1826, but were resumed in 1860. We illustrate a vehicle in use at this period.

Steam traction was introduced in 1877, and in 1898 the line was extended to its ultimate terminus at Mumbles by an associated company, the Mumbles Railway and Pier Company, being then 5¾ miles in length. Electrification followed in 1929, the railway being equipped with double-deck cars (illustrated) built by the Brush Electrical Company, Ltd., and each fitted with two B.T.H. 60 h.p. motors. Seating was provided for forty-eight inside and fifty-eight upper-deck passengers, and cars could run singly or coupled. Current was supplied to the overhead wire at 650V from a substation with two 500kW rotary converters, equipped by the Metropolitan-Vickers Electrical Company, Ltd. Electric traction made it necessary for the line to be signalled and an absolute block automatic system using illuminated electric disc signals at passing loops was put in by the W. R. Sykes Interlocking Signal Company as described in an article in THE ENGINEER of August 16, 1929.

Milestones in the history of the line have included the 150th anniversary celebrations in 1954, when the Swansea and Mumbles became the first railway to commemorate such an event while still working as an independent entity. It may also become the first railway to be buried under a modern seaside esplanade, for that is one use which has been suggested for the strip of land skirting Swansea Bay over which much of its track was laid.

Education and Training in Electricity Supply

THE Electrical Power Engineers' Association (E.P.E.A.) has issued a statement on education and training policy for technical staff in the electricity supply industry. This statement, a summary of which is given below, is not intended to be a detailed scheme but attempts to indicate the broad direction that a sound educational policy should take.

It may be recalled that the E.P.E.A. was founded in 1913 and reorganised in 1918 as a trade union for power engineers. To-day the E.P.E.A. is the representative organisation for technical staffs in the nationally-owned electricity supply industry.

Its membership includes sub-area managers and engineers, power station superintendents, distribution and transmission engineers, shift charge engineers, construction engineers, sales engineers, combustion engineers, control engineers and meter and testing engineers.

SUMMARY AND CONCLUSIONS

The industry's education and training consultative system has achieved nationally a semi-executive status but district educational consultation does not seem always to have made the same progress. In particular, relationships between local technical colleges and institutes and the educational work of the district advisory councils are probably not as close as they might be.

A feature of the graduate training scheme has been the fall off in the numbers entering the industry in recent years—particularly degree men. The new scheme for recruiting graduate material, from grammar and public schools, before the university stage and granting financial aid is the apparent solution but the risk is that the industry will spend a lot of money for a small ultimate return.

Figures show that the numbers of student entrants continue to grow steadily with the expansion of the work of the Electricity Boards ; this healthy growth goes some way to compensate for the falling off in the number of graduate trainees.

Outside industry still provides a natural reservoir from which staff flows to electricity supply. There is no objection to this provided the quality of the entrant is right. Mental inbreeding is bad for any industry.

The main pillar on which technical staff training must rest is student apprenticeship ; the student apprentice is the foundation material of the engineering staff. With his long practical training, he is able to make a close contact with all aspects of the industry, to absorb its traditions and aims and become a stable employee, looking on electricity supply as his chosen career and life work.

No sharp line should be drawn between engineering and managerial functions ; the successful engineer is bound to be a good manager or he will not achieve results. Management should be taught not as some external mystery, but as a normal, everyday outlook which sees every engineering problem in its commercial context and which judges the validity of commercial possibilities by their technical feasibility.

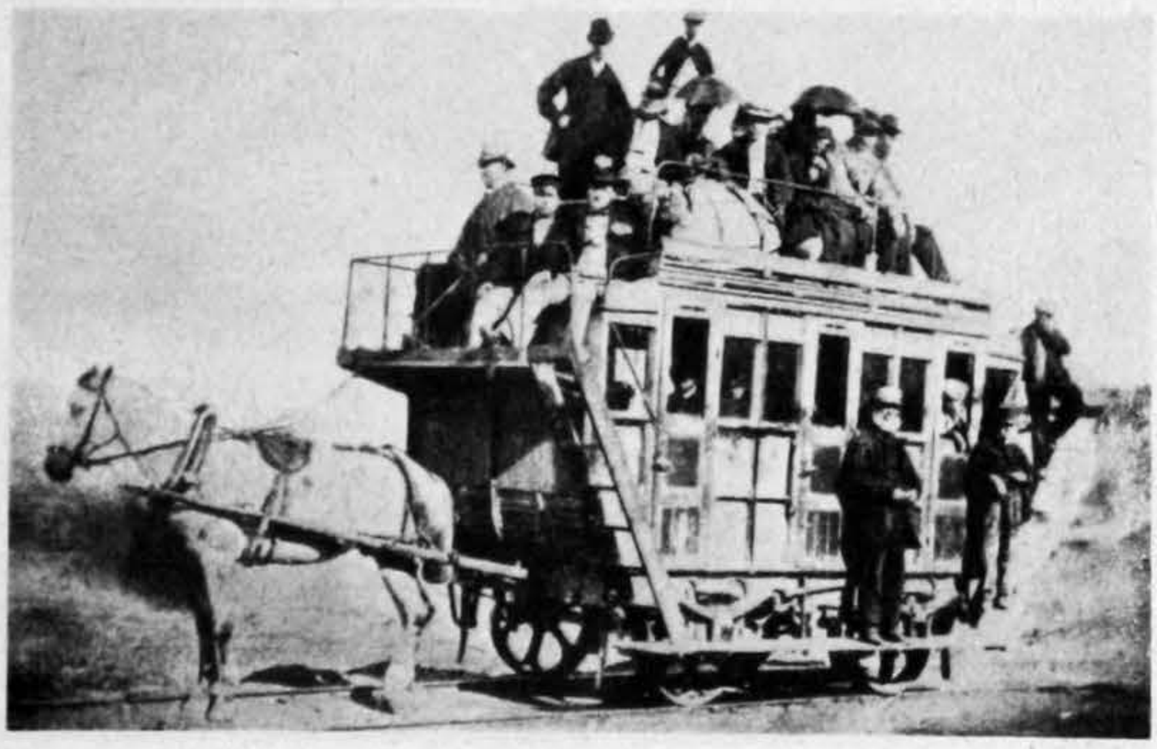
Ideally every student engineer should obtain the Dip. Tech. but since only a minority are likely to do so the Higher National Certificate will probably remain the qualification within the reach of many student apprentices. It is unfortunate that the Institution of Electrical Engineers should have so tightened its regulations that the way to corporate membership via the H.N.C. route is now very narrow. The Electricity Council should ask the I.E.E. to look again at its entry requirements with a view to making these less exacting until such time as the present shortage of professional engineers is gone.

For the future there should be three student training courses : (i) generation specialisation ; (ii) distribution specialisation ; (iii) general, without specialisation. The third would be a completely new departure for those who prefer to be trained broadly in the electricity supply business with special emphasis on trading and commercial relationships.

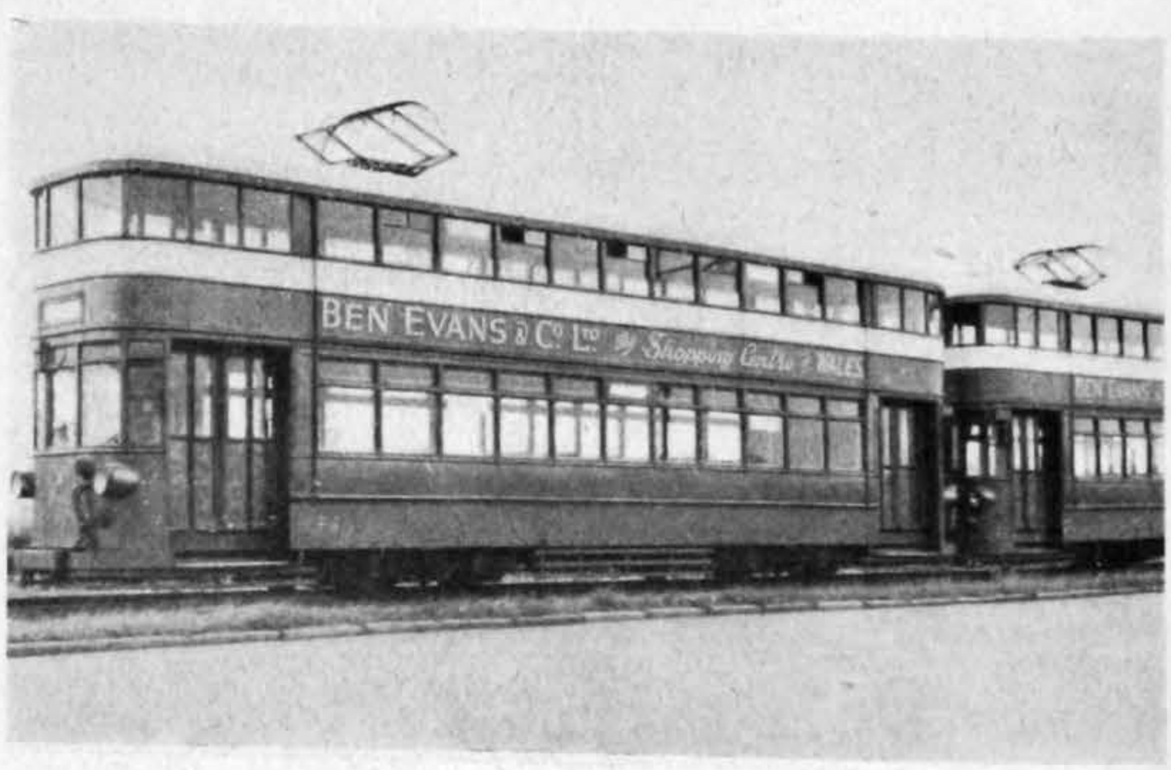
The talents of men with University training can be employed in every branch of the industry's work and graduates should be used to leaven the whole staff rather than form an undigested ingredient concentrated on research.

There is still need for an expansion of training for the established adult engineer although an open mind is thought desirable on so-called " appraisal " systems for personal development.

Adult training for engineers should be expanded by the introduction of more specialist correspondence courses ; by part-time day release as a right ; by residential course training in technical,



Horse-drawn coach used on the line from Swansea to Oystermouth in 1865



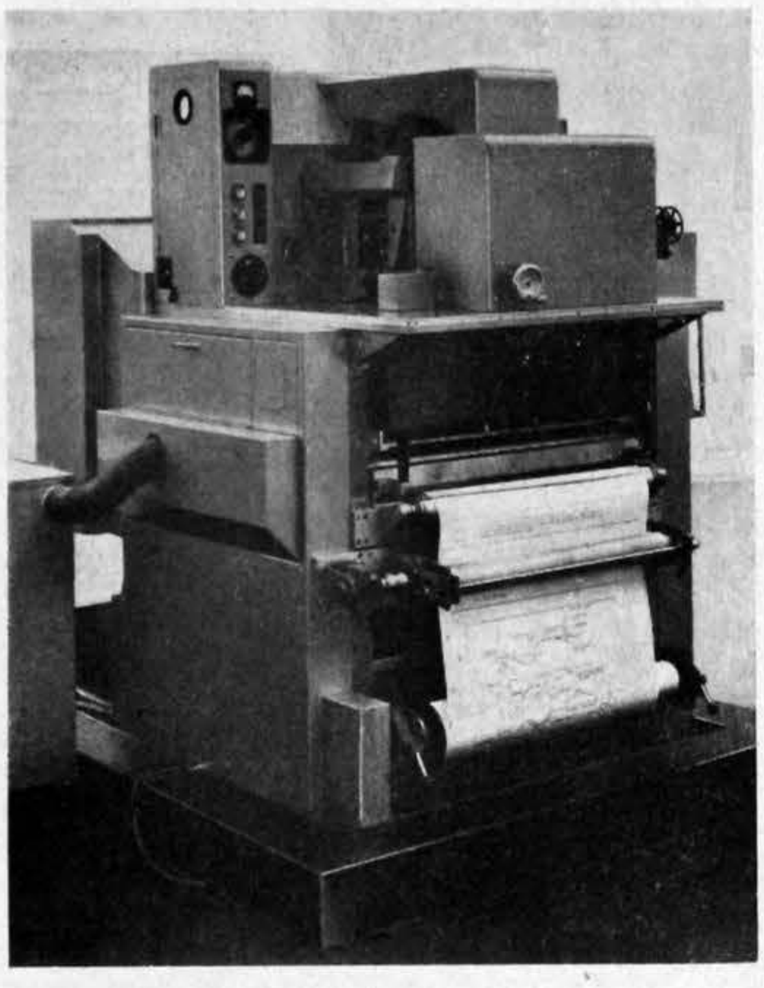
Electric coaches in operation at closing of the line

supervisory and managerial subjects ; by staff exchange arrangements ; and by making university scholarships as open as possible.

While money is not the sole attraction for would-be engineers they do in fact tend to choose employment which has a definite minimum salary prospect. There is need to establish very soon an improved salary progression for electricity supply entrants on the lines of that recently granted to teachers and in accordance with the standards of the best private manufacturing concerns.

Automatic Printer for Drawing Office

In the accompanying illustration we show an automatic xerographic enlarging machine as supplied to the engineering drawing office of Marconi's Wireless Telegraph Company, Ltd., by Rank-XeroX, Ltd., 33–41, Mortimer Street, London, W.1. This is the Rank-Xerox " Copyflo " Model 5 machine, of which the first production unit will be rented by Marconi's and installed at Chelmsford. Microfilms of drawings will be inserted in " Filmsort " aperture cards, which are coded by punching so that they may be rapidly selected and filed manually or mechanically. Copies of drawings will be made by stacking the selected cards in the machine, which will extract them one at a time from the magazine, scan each microfiilm frame and make the required number of enlarged copies from each (up to 400) as preset on a dial control. After copying, cards are returned to a hopper. Alternative degrees of enlargement—fifteen or twenty times—may be selected. The machine produces 20ft of prints per minute on ordinary, unsensitised paper.



Xerographic printer for producing drawings from microfilm negatives

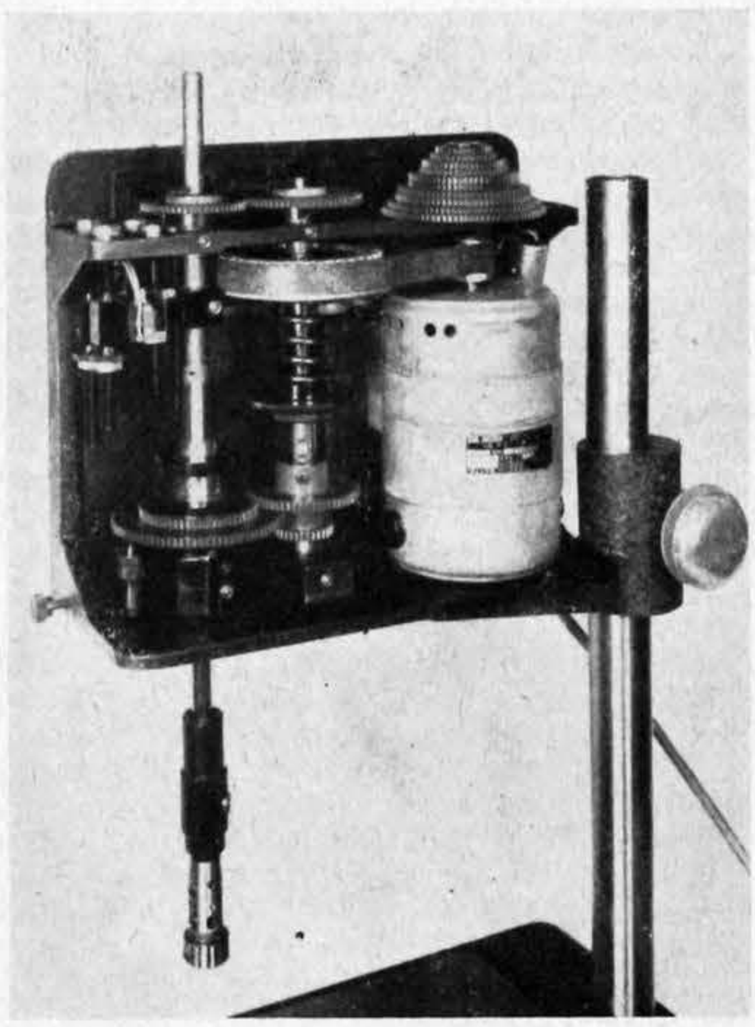
It is stated that the use of microfilm in conjunction with the " Copyflo " machine will substantially replace the dyeline methods which have formerly been in use. The system will be in operation early this year, and is expected to be productive of benefits in economy, speed and convenience both in the enlarging process itself and in the storing and finding of the microfilm cards.

[Reply Card No. E651]

Tapping Machine

A high-speed automatic tapping machine made by the Milman Engineering Company in the United States is now being sold in this country by the Rockwell Machine Tool Company, Ltd., Welsh Harp, Edgware Road, London, N.W.2. These machines using a single master lead screw are designed to tap all commonly-used B.A. threads and B.S.F. threads up to $\frac{3}{16}$in as well as a variety of other pitches by the fitting of standard and special change gears.

The tapping head, to be seen in our illustration with the cover removed, is assembled in an aluminium casting and its height is adjustable on the tubular column set into a cast iron base with a 10in by $6\frac{3}{4}$in ground working surface. A $\frac{1}{4}$ h.p. reversible motor drives the spindle through a 5 to 1 reduction toothed belt and an adjustable friction clutch. The feed rate of the tapping spindle is changed by altering the relative rates of rotation of the master lead screw and its matching nut through an arrangement of cluster gears and two change gears. When altering the feed rate the appropriate pair of change gears are fitted and the cluster gear moved to the required setting of its three positions.



Tapping head with cover removed to show drive, spindle and gearing arrangement

The length of spindle stroke is adjustable from $\frac{1}{8}$in to 2in and is controlled by the setting of limit switches. Either two foot switches or two push buttons on the control box are used in operating the machine. When the " down " switch is operated the tapping cycle is completed and the spindle reverses automatically at the preset depth to be braked at its uppermost position ready for the next cycle. In the event of a tap being arrested during down feed the spindle can be immediately reversed by operation of the " up " switch to prevent breakage of the tap.

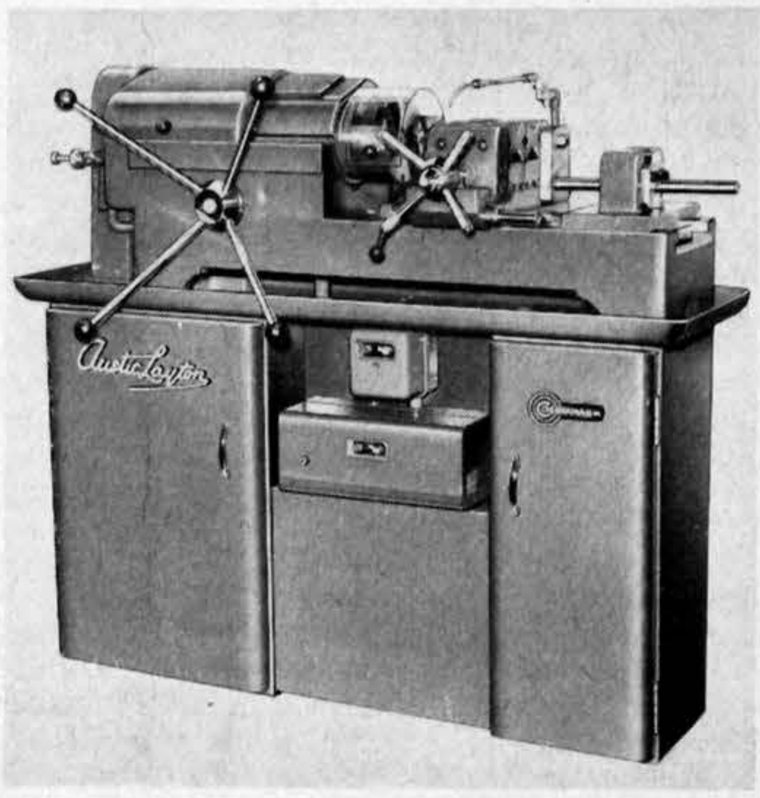
[Reply Card No. E652]

Centring and Facing Machine

A Centring and facing machine for workpieces from $\frac{3}{8}$in to $2\frac{1}{2}$in diameter now made by Austic-Layton Machine Tools, Ltd., Eaton, Norwich, Norfolk, is illustrated herewith. On this machine one end of a workpiece is faced and centred ; it is then reversed and located against a dead-length stop for its opposite end to be centred and face machined to length. The head of the machine carries a combined centre drill and facing cutter assembly by which the two operations of centring and facing are carried out in one traverse. During this traverse the fast spindle speed used for centring is automatically changed at a preset point to a slow speed for the facing operation.

The machine has a heavy cast cabinet base incorporating vee slides for the headstock which is traversed by a large star wheel through a rack and pinion. Its spindle is driven by a two-speed motor and an adjustable trip at the rear of the head slide is actuated to effect spindle speed changes. The spindle carries two tangential cutter blades designed to produce square, finish-turned, faces to the ends of a workpiece to eliminate the need for subsequent machining.

Workpieces are held in a quick-acting 5in jaw vice and a quarter turn of the vice star wheel is stated to be sufficient to release or rigidly clamp a workpiece. During machining a supply of cutting fluid is pumped on to the tools from a tank in the base. If required the cutter head can be fitted with a 6in chuck and the machine can be adapted for a variety of other operations including square or radiused recessing of bars or tubes, chamfering, pointing or hollow milling.



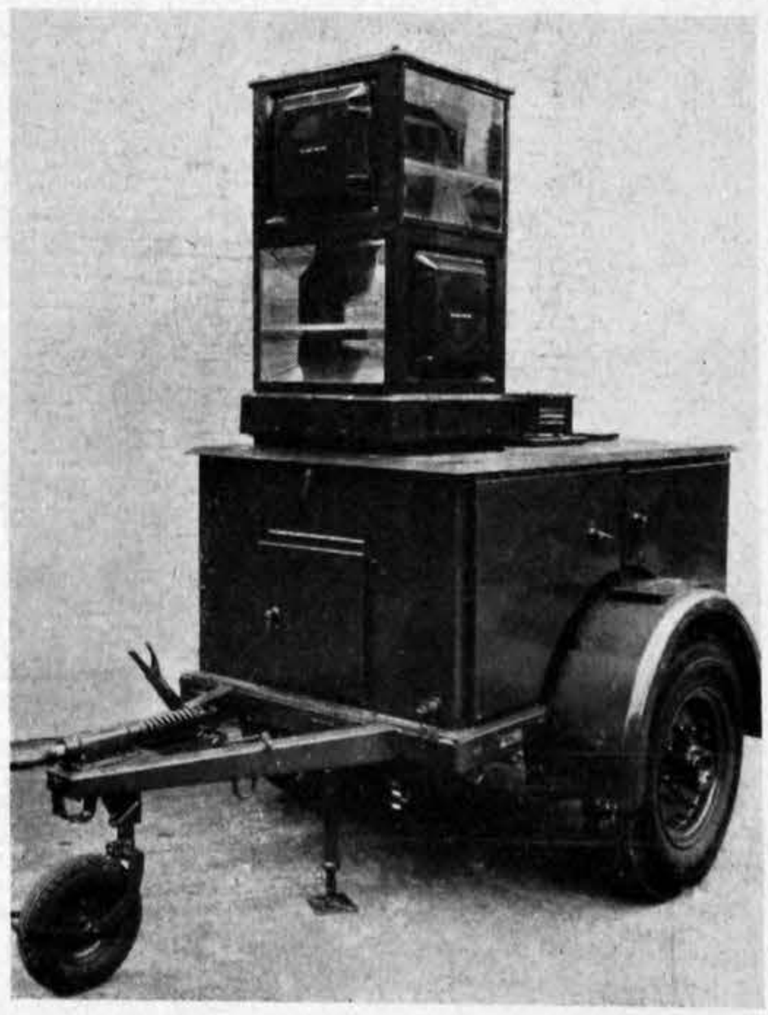
Centring and facing machine for workpieces from $\frac{3}{8}$in to $2\frac{1}{2}$in diameter

[Reply Card No. E653]

Mobile Landmark Beacon

Deliveries of forty-two mobile landmark beacons for the Royal Air Force have been completed by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. The beacons, one of which is illustrated, are of a design developed by the G.E.C. under a Ministry of Supply (now Ministry of Aviation) contract and employ a capacitor timing system instead of interchangeable cams for flashing morse characters identifying the airfields or other sites with which they are associated.

The signal can consist of any one or two letters in morse selected by switches in the master flashing unit. If required, the code can be changed while the beacon is operating. There are two rows of four switches, and each switch has three positions : dot, dash and off. Each row therefore enables any letter in the



Mobile beacon with capacitor-timed flasher controlling hot cathode tubes

SHORTER REPORTS *(Continued)*

Morse alphabet to be set up, since none of these exceeds four dots and dashes in length. The switches control telephone relays which in conjunction with capacitors form timing circuits giving the various intervals required for dots, dashes and spaces. Four single-pole changeover relays controlled by the master flashing unit cause four "Osram" 250W hot-cathode neon tubes to flash in accordance with the preselected signal. The tubes operate at a normal mains voltage and are similar to standard neon floodlighting tubes except for some structural modifications at the two cathode ends necessary to reduce the overall length. In "space" periods the changeover relays correct a dummy load across the input.

The optical system consists of two pairs of paraboloidal trough reflectors, placed back to back, each pair having two neon tubes arranged about the focal line. In addition, "Perspex" prismatic refractors and plain reflectors redirect into the beam light which would otherwise be lost downwards. The two reflector systems are set one above the other and at right angles in plan so that a continuous fan-shaped beam is produced all round the beacon.

Power is supplied by a 908 c.c. Coventry "Victor" AN.4 air-cooled petrol engine—governed to run at 2000 r.p.m. under load—driving through belts a 2½kVA single-phase 230V alternator. Provision of an auto-transformer enables the beacon to be operated from an outside single-phase supply of 200V–250V a.c. The beacon is mounted on a two-wheeled trailer chassis fitted with jacks for stability and levelling.

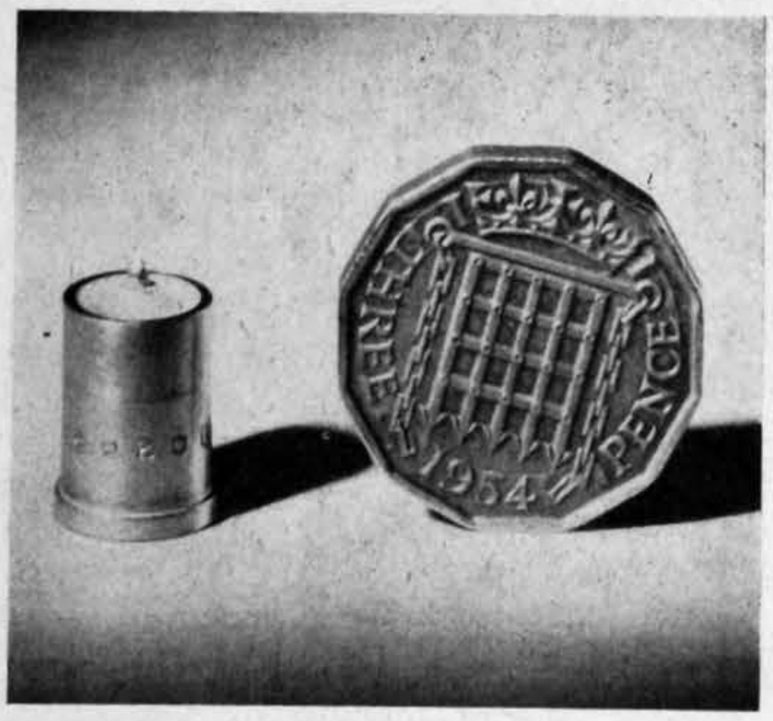
[Reply Card No. E654]

New Diode for Parametric Amplifiers

IN certain types of parametric amplifier for microwave signals, the equivalent of a variable capacitor is used as a means of increasing (or "pumping up") the signal voltage. This effect occurs because the charge on the capacitor varies with the applied signal, and if the capacity is decreased whenever the charge is relatively constant in one direction or the other, the voltage across the capacitor is increased, since $V=Q/C$. In practice the variation of capacity is obtained by biasing the junction of a semiconductor diode first in one direction and then in the other, when the consequent movement of electrons and holes causes alternate expansion and contraction of the layer across the junction, which is rendered temporarily devoid of mobile charge carriers. This layer may then be regarded as a dielectric of varying thickness between the plates of a capacitor. The bias voltages are derived from an oscillator known as the "pump."

We illustrate a silicon p-n junction diode of the kind described which is now in production by the Semiconductor Division of The General Electric Company, Ltd., Magnet House, Kingsway, London W.C.2. It is designed for use in parametric amplifiers at frequencies up to S-band and is claimed to be the first device with these qualities to be made available in the United Kingdom. The diode (EW97/1) is mounted in a coaxial structure for direct insertion into coaxial and waveguide circuits and has the low series inductance of 0·5mμH. A reverse polarity version (EW98/1) is also available. Other applications of the device are as a microwave switch or as a frequency multiplier, the latter having importance in the future design of microwave receivers based entirely on solid state devices. The inter-services prototype references of the diode are VX3314 (EW97/1), and VX3333 (EW98/1).

[Reply Card No. E661]

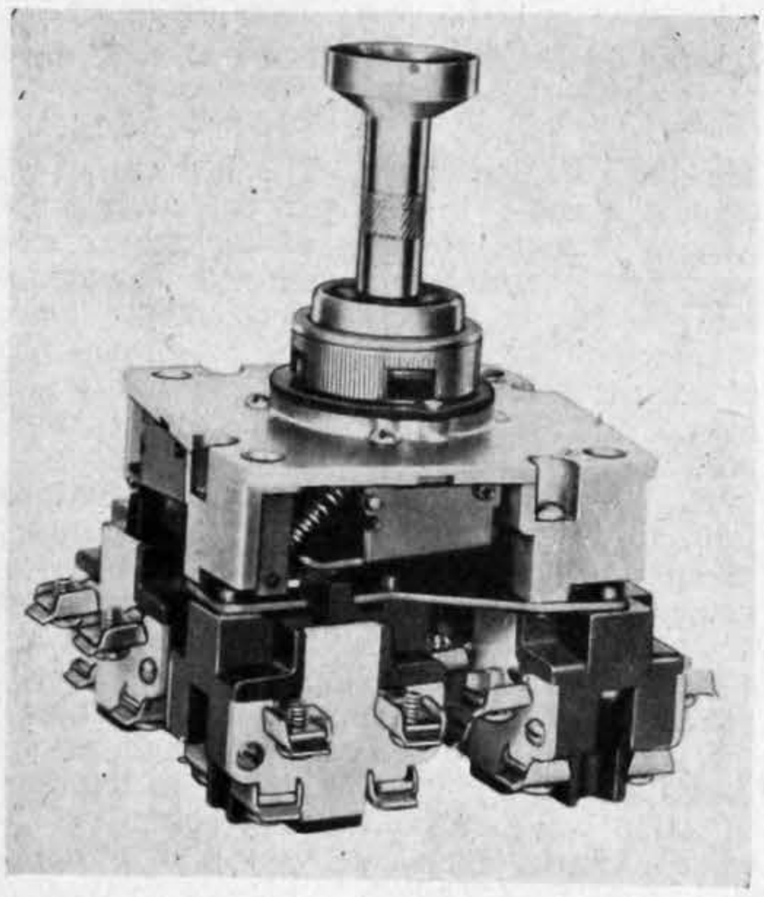


Silicon variable-capacitance diode

Joystick Controller

THE four-position controller illustrated is an addition to the range of oil-tight, heavy-duty control units manufactured by Square D, Ltd., Cheney Manor, Swindon, Wilts. It is designed for situations where it is essential that only one operation should be selected at a time, and the use of individual push-buttons would therefore introduce the possibility of faulty manipulation. With this Class 9001 joystick unit, a machine operator can perform four operations by movement of one lever which actuates a different switch in each of its positions. An "off" latch, released by depressing a trigger in the handle, can be fitted if required. This mechanism acts through removable latch bars associated with each operating position of the handle, so that it is possible to have permanently free access to certain positions by removing the corresponding bars, while others can only be reached from the central "off" position of the lever by depressing the latch release trigger. In any position of the operating lever the corresponding contacts may be closed momentarily or held in, according to the position of a pin in the lever.

[Reply Card No. E662]



Four-position joystick controlling push-button switches

Automatic Fixer System for Aircraft

IN connection with the recent installation by Marconi's Wireless Telegraph Company, Ltd., Chelmsford, Essex, of a 50kW, 50cm, Type S232 radar at the Hatfield aerodrome of the De Havilland Aircraft Company, Ltd., an automatic fixer system was provided to assist the identification of aircraft seen on the radar p.p.i. tube. The fixer shows the position of an aircraft which is using its v.h.f. transmitter to call Hatfield, by means of cross bearings on a cathode-ray tube display with a translucent map of the area superimposed on it.

The automatic fixer system at present employs two Marconi v.h.f. AD200 direction finders, one of which is sited at Hatfield and the other at Bedells End, near Chelmsford, the latter being remotely operated from the air traffic control tower at Hatfield over a v.h.f. radio link. When an aircraft calls Hatfield, bearings are derived from the transmission by the direction finders at Hatfield and Bedells End. At the Bedells End station the 25 c/s bearing information is used to modulate two sub-carriers of 1·6 kc/s and 3 kc/s respectively. These, together with speech signals, phase-modulate the main carrier of a 15W v.h.f. radio link; the modulator used is linear and capable of producing a deviation of 9 kc/s.

Only when the received d/f signal is of usable magnitude does the link transmitter pass the bearing data to Hatfield. Here the link receiver demodulates the carrier; its output is fed to the appropriate v.h.f./d.f. remote console, which produces from it a sine/cosine output for connection to the automatic fixer. The latter, which is also fed with similar information from the Hatfield AD200, provides on the cathode-ray tube display the crossed bearing lines required.

The radio-link receiver at Bedells End is permanently "on." When the services of the AD200 are required, a coded two-tone signal is transmitted over the link from Hatfield and picked up by this receiver to initiate the switching-on of the automatic direction finder. A second coded sequence serves to change the operating frequency of the d.f. set to another channel, while a third switches it off. Other coded tones are sent over the link to control the switching on and off of a field test oscillator at Bedells End. This equipment is sited a short distance from the AD200 installation and provides a signal on a known bearing as a check on the accuracy of the direction finding equipment.

[Reply Card No. E663]

Rail-to-Road Conversion Proposals in East Anglia

A SCHEME to buy six sections of disused track of the former Midland and Great Northern Joint Railway for conversion to roads was approved by a meeting of the Norfolk County Council on January 2. The longest of these is from Potter Heigham to Aylsham, approximately 18 miles, and it was stated at the meeting that the Ministry of Transport had been consulted and had said that there would be a grant for the 5·8 miles of this length between Potter Heigham and Stalham. It was estimated that the work here, including reconstruction of Potter Heigham Bridge, would cost £222,000 compared with £348,000 for improving the existing road on the line previously approved by the county council. The total length of track which it is proposed to purchase is about 30 miles, and the other sections concerned are short lengths at Caister, Hemsby, and Thursford (between Fakenham and Melton Constable). The Highways Committee considers that where using the railway would cost more than reconstructing existing roads, the additional cost would be justified by the better alignment obtainable.

Passenger traffic over the whole of the M. and G.N. line except for the 15 miles from Cromer to Melton Constable ceased at midnight on February 28, 1959. The Cromer-Melton Constable section is still open for passenger and freight traffic, and 77 miles remain open for freight only. The longest continuous section closed to all traffic extends from Gayton Road (near Kings Lynn) to Fakenham, Melton Constable, Aylsham, North Walsham, and Yarmouth.

Oil Mist Spray Equipment

AN oil mist spray equipment has been introduced by Wakefield-Dick Industrial Oils, Ltd., Castrol House, Marylebone Road, London, N.W.1, for the mist application of soluble or neat cutting oils in machining processes. These equipments are designed to operate at air pressures between 10 lb and 20 lb per square inch. Each consists of a porous bronze filter element from which the air passes through a reducing



Oil mist spray set for soluble or neat cutting oils

valve to an " Ayrlyne " lubricator fitted with a flow adjustment valve, as shown in the illustration.

The lubricator can be fitted with either a half or one pint capacity reservoir having a needle regulating valve through which the rates of oil to air can be adjusted. Neat cutting oils of a viscosity not exceeding 300 Redwood seconds at 70 deg. Fah., or soluble oil emulsions can be delivered in mist form from the spray sets.

[Reply Card No. E671]

Commercial Vehicle of Integral Construction

THERE has been announced by Commer Cars, Ltd., a range of 15 cwt forward control vehicles available with either petrol or oil engines. The range includes vans and passenger vehicles, and the underframe can be supplied to coach-builders with or without a cab. While the vehicle resembles other English designs in its appearance and leading particulars, the detailed design is unusual, in particular in that there is no separate chassis. The basis of the structure is a flat platform stiffened by two box-section elements running fore and aft, by transverse members of similar section welded to the longitudinals, and by sills at the sides. The platform is reinforced against local loading by being pressed into shallow corrugations, as can be discerned in our illustration. The semi-floating axle is located by leaf springs to form a Hotchkiss drive and these springs pick up on the longitudinal box members. The front suspension is assembled upon a large cross-member which also carries the greater part of the power unit, so that there are no concentrated loads to be taken at the front end : the output end of the gearbox is supported from the platform through a pair of rubber bushes. This construction clearly demands consistently good protection from corrosion, the structure being welded up from greasy steel sheet. The bare shells are degreased and dried and then dipped to just above floor level in an anti-corrosion bath : the liquid is agitated by submerged jets, and sectioning of treated shells has shown that the box sections, although very sparingly pierced, are protected adequately. In addition to spraying with primer, the exterior bottom is treated with " Underseal." Finish painting is optional.

The vehicles can have either hinged or sliding doors to the cab : in either case the doors latch into place only when shut, but a catch can be engaged manually to hold a sliding door fully back. In the hinged door the windows wind down, in the sliding door the rear third of the window slides forward, so that it is possible for a head to be passed through. On the passenger vehicles, or optionally on vans, there is a hinged door just aft of the nearside cab door, linked to a folding step, and in this case sliding doors cannot be chosen.

The mechanical design is found, on detailed examination, to be untrammelled by adherence to convention. As mentioned above Hotchkiss drive is employed, and a Hardy Spicer propeller shaft with universal joints sealed for life is fitted ; the spring anchors and shackles are rubber bushed, so there are no lubrication points on the rear suspension at all. The front suspension is of a design unusual to-day, employing a swivel-pin like that of a beam axle, so that the steering and suspension movements are all provided by cylindrical bushes : these are lubricated by sixteen grease nipples. The steering geometry is also unorthodox : even as on a normal control vehicle, the steering arms extend rearward from the stub axles, while instead of the track rods being the same length as the wishbones, they are long enough both to reach a swinging arm in the centre of the vehicle. This arm acts as a first order lever to bring the motion



Anti-corrosion treatment of a van shell : notice that the body is carried from the jacking points. The small size of the air intake is explained by its serving only the cabin ventilation system

from the back of the cross-member to the front : it is there jointed to a transverse link controlled by a bell crank and another link from the drop arm. This linkage is lubricated by ten grease nipples.

Under the bench that carries the seats for the crew is located a vertical water-cooled four-cylinder engine, together with its radiator : cooling air is brought up from under the floor of the cab. The petrol engine is that of a Hillman " Minx," and the overhead valve version of the current production model has been chosen—this engine has most of the auxiliaries located low down at the sides, and as only the cowling immediately above the engine is removable, accessibility is restricted : sparking plugs 1, 2 and 4 can, however, be reached readily. Since the petrol pump is accessible only from under the vehicle, a hand primer is not fitted. A starting handle is an optional extra. The alternative engine is the Perkins " Four 99 " : in this installation the injectors and the dip stick can be reached easily. The air cleaners are located under the right-hand seat for the oil engine and the left-hand seat for the petrol engine : the access panels are secured by screws slotted to accept a coin.

The gearbox has four forward speeds and is provided with Borg Warner synchromesh on the upper three ratios. It is remotely controlled by a lever mounted on the cab floor close to the pedals. The final drive may be either 5·125 or 5·625, and the tyres either 6·00/6·40 or 6·50/6·70×15 of 6-ply rating.

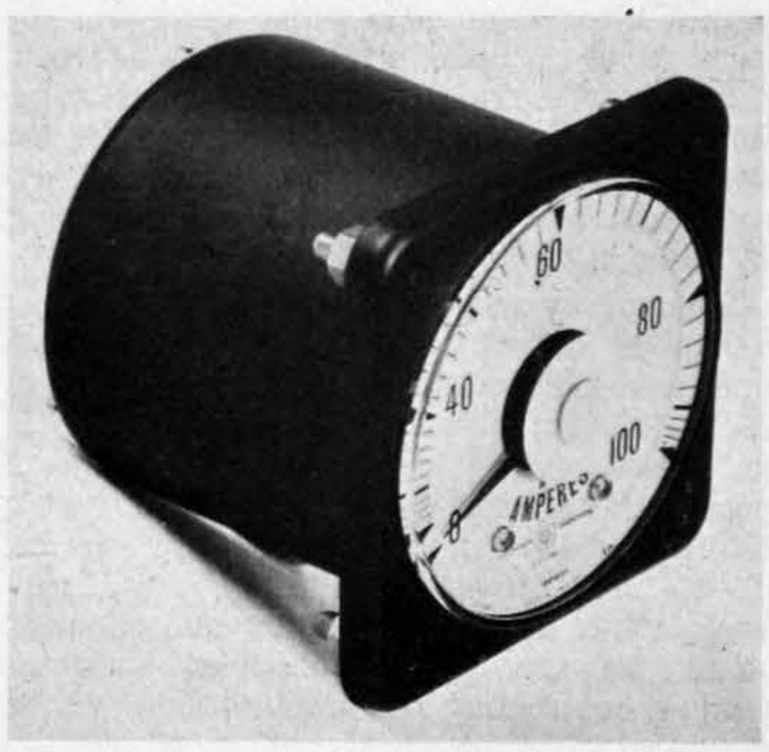
Leading particulars of the vehicles are given in the table.

Model	¾-ton forward control		
Gross vehicle weight :			
Van			41 cwt
Passenger			44½ cwt
Kerb weight:	Petrol		Oil
Hinged door van	23 cwt	...	24¼ cwt
Sliding door van	22½ cwt	...	23¾ cwt
12 seat bus	27 cwt	...	28¼ cwt
14 seat bus	27¼ cwt	...	28½ cwt
(Weights exclude options, i.e. side loading door, spare wheel and carrier.)			
Maximum power	49 b.h.p.	...	40·5 b.h.p.
Fuel capacity			9 gallons
Wheelbase			90in

[Reply Card No. E672]

Circular Scale Meters

A SERIES of flush circular scale instruments, designed and styled by Crompton Parkinson, Ltd., Crompton House, Aldwych, London, W.C.2, is now being made available in this country. One of the design features of this " New World " range is clear visibility over a wide viewing angle. The dial lies in the same plane as the front of the bezel, to ensure maximum light and elimination of shadows on the scale markings and pointer. Indications on the anti-parallax platform scale can be read accurately



One of a range of instruments designed to accord with North American practice and now available in this country

from acute angles. The illustration shows the slightly projecting moulded glass cover, which is contoured to avoid striations of light across the dial face.

Instruments available in this series include moving-iron and moving-coil ammeters and voltmeters, single- and double-element wattmeters, frequency, speed and power factor indicators, and rotary synchroscopes. All are of nominal 4in size with 3½in dials.

[Reply Card No. E673]

34-Ton Prestressed Concrete Beams

FIVE prestressed, post-tensioned concrete beams, each 95ft long and weighing 34 tons, were, in December, lifted on to 32ft high columns to form the main roof members of part of the new Izal factory of Newton Chambers and Co., Ltd., at Thorncliffe, near Sheffield. Two lorry-mounted cranes were used by Tarslag, Ltd., to lift the beams, each of which was lifted in twenty minutes and secured in position after another twenty minutes, despite unusually high winds. One of the cranes used was of 25 tons capacity but the other was a 50-tonner with a 70ft jib. The beams were supplied in 5ft long prestressed sections by Blakelay (Hope), Ltd., and were fabricated and post-tensioned on site. A spokesman for Husband and Co., the consulting engineers who designed the factory, said the construction of the beams could be compared with the Chiswick flyover. The main contractors for the building are George Longden and Son, Ltd., Sheffield.

INDUSTRIAL NEWS

Employment in the 1950s

According to a survey published in the Treasury's *Bulletin for Industry*, the number of people employed in Great Britain increased by just over 7½ per cent between mid-1948 and mid-1958. Growth was slowest in Wales, Scotland and Northern England and quickest in the eastern and southern region and in the south-west. The *Bulletin* says that about one-third of the total increase occurred in London and the south-east, although the rate of growth there was not much more than the national average. Another fifth was in the two Midland regions, where growth in the number employed was rather faster than the average. In six regions, where the rise was above the average, the labour force grew from 56 per cent of the country's total in 1948 to 58 per cent in 1958, which accounted for about four-fifths of the total gain. The growth inside each region was not uniform. Even within those regions in which there was the most rapid increase in the numbers at work, there are areas and towns where the expansion was markedly less than the average for the whole region and other areas where employment lost in declining trades was not offset by gains in expanding areas.

The survey shows that the net increase of 1,500,000 in employment between mid-1948 and mid-1958 was made up of a rise of 2,250,000 spread over a wide range of industries, partly offset by reductions of nearly 750,000 elsewhere. Most of these big reductions were in private domestic service, agriculture, Government service and railways, while there were smaller reductions in some old-established industries such as textiles, coalmining and shipbuilding. In the manufacturing industries as a whole, an increase of over 1,000,000 was shared by all the regions, the rates of increase being highest in the eastern and southern and south-western regions and lowest in Scotland and in the north-western region. The biggest increase in employment in manufacturing was in metals, engineering and vehicles. By mid-1958, it amounted to about 700,000, which was nearly one-sixth higher than in 1948. All the regions shared in this increase, though it was most marked in the south and the Midlands.

Treatment of Injuries in Factories

Changes in the contents of first-aid boxes, cases and cupboards for all workers in factories, at docks or on building sites throughout the country are necessitated by new regulations made by the Minister of Labour under the Factories Acts which came into operation on January 1. These changes have arisen from the advances made in medical and first-aid treatment of injuries during the last quarter of a century. For example, antiseptics, special burn dressings and cocaine eye drops are no longer required. A leaflet giving advice on treatment, which has been revised in the light of these advances, must be included in each first-aid box.

The Ministry of Labour points out that three scales of equipment are prescribed for first-aid boxes in factories or at the docks : one for establishments employing up to ten workers, another for those where from eleven to fifty workers are employed, and the third for those employing more than fifty workers. The same range of equipment has to be included in each box, but the minimum quantities are varied according to the number of employees. Workers on building sites have two scales of equipment, one for sites employing from ten to twenty-five persons, the other for sites on which more than twenty-five persons are employed. The scale of items for the first is similar to that for factories employing up to ten workers, and for the second is the same as that for factories employing more than fifty workers.

All the materials have to be of a grade and quality not lower than the standard specified by the British Pharmaceutical Codex, and specifications for adhesive dressings for wounds and for eye ointment, for which the regulations provide, are given in certificates of approval of the Chief Inspector of Factories.

Beet Sugar Factories for U.S.S.R.

British engineering firms are to supply two complete beet sugar factories to Russia. A contract was signed in London last week by representatives of Techmashimport of Moscow and by Vickers and Bookers, Ltd., the joint company recently formed for developing sales and supply of machinery for beet sugar factories to the U.S.S.R., China and other Eastern European and Far Eastern countries. The value of this order, which has been under negotiation for a year, is of the order of £8,000,000 ; it follows the contract secured last month by Vickers and Bookers for over £500,000 for beet sugar unit equipment to the Soviet Union. This new order calls for the supply of two factories, one in the Moscow region and the other in the Ukraine. Each of the two factories is to have a daily capacity of 5000 tons of sugar beet and will be designed to incorporate the latest ideas on process automation. Duncan Stewart and Co., Ltd., will be acting as the technical division of Vickers and Bookers, Ltd. Several works in the Vickers Group of Companies and George Fletcher and Co., Ltd., in the Bookers Group, will be engaged in considerable manufacture for the new contract.

British Construction Work Abroad

Overseas work by British constructional firms is now earning about £120,000,000 a year. The Treasury says, in the December issue of *Bulletin for Industry*, that statistics of contracts have been collected since 1954–55. Each year the value of work done has increased and, in the year ended March 31, 1959, it reached a total of £120,200,000, which was about 9 per cent of all new work done by British contractors. The contracts obtained and work outstanding have also shown a rising trend in the past five years, though there was a setback in 1956–57 (because of unfavourable conditions in the Middle East) and in 1958–59 (probably because few large contracts were put out to tender during a period of recession). The value of work outstanding on March 31 last is estimated at £123,600,000.

The *Bulletin* explains that the direct contribution of constructional work to this country's overseas earnings is less than the gross value of contracts, part of which is absorbed by expenditure in local currency on labour and materials. But, it is emphasised, there is also a wider contribution. Most large constructional projects take shape in three stages, namely, a first stage of engineering consultancy, a second stage of building and civil engineering, and a third stage of supply and installation of any necessary plant and machinery. Traditionally, each stage is put out to tender separately, though, in " turnkey " offers for the execution of complete projects, contractors often form a consortium with consulting engineers and manufacturers of plant and machinery. Orders won in the first two stages introduce British personnel and techniques and frequently lead to orders for capital goods in the third stage. Moreover, the *Bulletin* adds, " construction can be a lasting advertisement for British products generally."

Wages and Hours

There was another meeting on Tuesday of the Engineering and Allied Employers National Federation and the Confederation of Shipbuilding and Engineering Unions on wages and hours in the engineering industry. The union representatives had been directed by their executive to seek further talks with the employers, following the offer, made in November, of a reduction of the working week from forty-four to forty-two-and-a-half hours. This offer, the employers then said, must be regarded as a settlement of the unions' claim for a wage increase of £1 a week (for adult male workers) and a forty-hour week without loss of pay.

At the resumed discussions last Tuesday, the unions virtually resubmitted their original claim. The employers' spokesman said that an offer of a pay increase was unlikely but possibly the question of hours could be further considered. The employers' federation has undertaken to put the matter again before its member-firms and to give its reply to the unions on January 26.

Trade Union Membership

During 1958, membership of trade unions with their headquarters in the United Kingdom declined by about 1·9 per cent ; at the end of the year it totalled 9,616,000 (7,773,000 men and 1,843,000 women). The total number of trade unions in existence in this country in 1958 was 657, or nine less than in the preceding year. This resulted from ten small unions being absorbed by larger unions or otherwise ceasing to function, and from the formation of one new union. In some comments on the figures, the Ministry of Labour says that the trend towards amalgamation continued during 1958. Nevertheless, at the end of the year, 366 unions had fewer than 1000 members each and 304 of them had under 500 members each. The 366 smaller unions, therefore, accounted for only 1 per cent of the total membership of all unions. By contrast, the seventeen largest unions, each with more than 100,000 members, together accounted for two-thirds of the total membership of all unions.

PERSONAL AND BUSINESS

Appointments

MR. A. J. W. GREEN has been appointed joint managing director for the Frederick Braby Group of Companies.

MR. J. J. FINLAYSON has been appointed chief mechanical and electrical engineer, Scottish Region, British Railways.

MR. CHARLES M. COCK, M.I.Mech.E., M.I.E.E., has joined the board of directors of Brooke Marine, Ltd., as a deputy chairman.

ELCONTROL, Ltd., announces that Mr. B. A. Worswick has been appointed to the post of technical director, with a seat on the board.

WHITLOCK BROS., Ltd., has appointed Mr. K. A. Perkin as senior area representative for the Counties of Somerset, Dorset, Devon and Cornwall.

MR. W. H. C. PILLING, M.I.E.E., has been appointed chief project engineer of the northern project group of the Central Electricity Generating Board.

GEORGE WIMPEY AND CO., Ltd., states that Mr. T. A. Mitchell has resigned from the board of the company, and that The Viscount Marchwood has been appointed a director.

MR. E. T. JUDGE has been appointed joint managing director of Dorman Long (Steel), Ltd., and an executive director of the parent company, Dorman Long and Co., Ltd.

FRED MYERS, Ltd., states that Mr. Peter Hamilton has joined the company as managing director. Mr. R. D. Bowers has been appointed sales manager of the Caterpillar earthmoving division.

GLENFIELD AND KENNEDY, Ltd., announces the following appointments to the board of the company: Mr. John H. Lawrence, Mr. Donald A. S. Maclellan, Mr. James C. Robertson and Mr. James G. Workman.

THE BRITISH TRANSPORT COMMISSION announces the following appointments to the research department: Mr. T. Baldwin and Mr. D. L. Bartlett have been appointed assistant directors, engineering division, Derby.

THE MINISTRY OF LABOUR has announced that the Rt. Hon. Lord Crook has been reappointed chairman, and Mr. J. C. Poole vice-chairman, of the National Dock Labour Board for the period January 1 to December 31, 1960.

MR. A. E. BATES, M.I.E.E., has taken up an appointment as manager of The English Electric Company's office in Edinburgh. He succeeds Mr. W. M. Todd who has been transferred from Edinburgh to manage the company's Bristol office.

LONDON TRANSPORT announces that Mr. R. T. Gladwin and Mr. J. B. L. Hoban, both senior executive assistants in the office of the new works engineer, department of the chief civil engineer, have been appointed principal new works assistants.

THE BRITISH ELECTRICAL AND ALLIED MANUFACTURERS' ASSOCIATION EXPORT PANEL states that Mr. D. Maxwell Buist has retired from the chairmanship and has been succeeded by Mr. E. V. Small. Mr. L. H. Short has been elected vice-chairman.

THE ELECTRICITY COUNCIL announces that Professor Ronald E. Lane has been appointed part-time medical adviser. Mr. C. F. Kearton has been appointed chairman of the Electricity Supply Research Council, in succession to Sir David Brunt, who has been appointed vice-chairman.

MR. G. A. D. SMITH has been appointed commercial managing director of Imperial Chemical Industries, Ltd., Metals Division. Dr. Maurice Cook, chairman of I.C.I. Metals Division for the past two years, has retired, and has been succeeded by Mr. Michael Clapham, a joint managing director.

BRIGHTSIDE ENGINEERING HOLDINGS, Ltd., announces that Mr. R. Ivor Slater has resigned from the position of secretary, on his appointment as managing director of Moorwoods, Ltd. He has been succeeded as secretary by Mr. James R. Nuttall. Mr. W. S. Richards has been appointed managing director of Brightside Heating and Engineering Company, Ltd.

THE HADFIELDS GROUP OF COMPANIES announces that Mr. T. H. Arnold has relinquished his appointments as local director and controller of the research department and also as a director of the subsidiary companies, Hadfields Steels, Ltd., and Hadfields Forgings, Ltd. Mr. L. G. Finch has succeeded Mr. Arnold as local director and controller, research department, and Mr. J. A. Grainger has been appointed deputy research controller.

Business Announcements

CRANE, Ltd., has opened a new branch at Sweet Street, Leeds, 11 (telephone, Leeds 3-5026).

LAURENCE, SCOTT AND ELECTROMOTORS, Ltd., announces that Mr. H. M. Medhurst, sales engineer, has retired.

ELECTROPOL PROCESSING, Ltd., Trading Estate, Farnham, Surrey, has changed its telephone number to Farnham 3355.

BRITISH WELDING RESEARCH ASSOCIATION states that its London office has been moved to 19, Fitzroy Square, W.1 (telephone, Euston 9595/6).

CRAVEN BROTHERS (MANCHESTER), Ltd., states that the address of its London office is now 139, Park Lane, W.1. (telephone, Mayfair 6783).

LANCING MACHINE TOOLS, Ltd., Commerce Way, Lancing, Sussex, has been appointed sole agent in the United Kingdom for Boldrini, S.p.A., of Milan.

THE J. I. CASE COMPANY OF AMERICA has formed a British subsidiary, registered as J. I. Case Company, Ltd., Horton Parade, West Drayton, Middlesex.

THE GLOBE PNEUMATIC ENGINEERING COMPANY, Ltd., has announced the retirement of Mr. Frank Hills, A.M.I.Mech.E., after fifty-three years' service with the company.

TRUSCON, Ltd., has moved its Birmingham reinforced concrete design office from Edmund Street to George House, George Road, Birmingham, 15 (telephone, Edgbaston 4391/2/3).

MR. F. P. LAURENS, M.I.Mech.E., assistant managing director, production, of International Computers and Tabulators, Ltd., has resigned from the board of directors of Vickers-Armstrongs, Ltd.

POWELL DUFFRYN TECHNICAL SERVICES, Ltd., 19, Berkeley Street, London, W.1, states that as from January 11, its address will be Boundary House, 7/17, Jewry Street, London, E.C.3 (telephone, Royal 0141).

MR. H. KERR, director-in-charge of the operating department of Woodall-Duckham Construction Company, Ltd., retired on December 31, 1959, from which date he resigned from the board of the company.

FIRTH CLEVELAND FINANCE, Ltd., has opened a branch office in the Scottish Widows' Fund Building, 28, Baldwin Street, Bristol, 1 (telephone, Bristol 25013). Mr. M. L. Midgley has been appointed branch manager.

A.E.C., Ltd., 49, Berkeley Square, London, W.1, and Etablissments Spitals, of Antwerp, announce that they have formed a company, A.E.C. Continental, S.A., to manufacture and market A.E.C. vehicles in Belgium for the Continent.

G. AND J. WEIR HOLDINGS, Ltd., Cathcart, Glasgow, S.4, announces that Wm. Simons and Co., Ltd., and Lobnitz and Co., Ltd., have merged their interests and will in future trade together as one company to be known as Simons-Lobnitz, Ltd.

THE CANADIAN GENERAL ELECTRIC COMPANY, Ltd., and E.M.I. ELECTRONICS, Ltd., state that E.M.I. broadcast equipment will be distributed and serviced in Canada by Canadian General Electric to supplement its existing line of equipment.

VENESTA, Ltd., Vintry House, Queen Street Place, London, E.C.4, is now a holding company and its operating activities have been transferred to the following subsidiary companies: Venesta Foils, Ltd.; Venesta Plywood, Ltd.; Venesta Tea Chest Company, Ltd.; Venesta Metal Containers, Ltd.

THE BRITISH VACUUM CLEANER AND ENGINEERING COMPANY, Ltd., Goblin Works, Leatherhead, Surrey, states that the name of the company has been changed to Goblin (B.V.C.), Ltd. The name of the British Vacuum Cleaner and Engineering Company, Ltd., has been retained as a subsidiary company to market all industrial vacuum cleaners.

STONE-PLATT INDUSTRIES, Ltd., announces the formation of a wholly-owned subsidiary company, J. Stone and Co. (Propellers), Ltd., Woolwich Road, Charlton, London, S.E.7, to undertake from January 1, 1960, the business of the manufacture and sale of ship's propellers and other marine products previously undertaken by J. Stone and Co. (Charlton), Ltd.

LLOYD'S REGISTER OF SHIPPING has re-established an exclusive office at Pearl Assurance House, Royal Parade, Plymouth, Devon (telephone Plymouth 67006). The new office will be operated by Mr. R. E. Pritchard, and will also embrace Appledore and Dartmouth. Mr. D. L. H. Collinson has retired from his appointment as a non-exclusive surveyor of the port.

Contracts

THE CEMENTATION GROUP OF COMPANIES announces that the contract for the construction of the first part of a new shipyard at Jacnacanja, near Rio de Janeiro, has been awarded by The Verolme Dock and Shipbuilding Company to a member company. This is the Cementation Brasil S.A.-Engelharia Civil em Geral of San Paulo and it will sponsor the contract jointly with Perini, Ltd., of Canada.

E. G. IRWIN AND PARTNERS, Ltd., has been awarded the initial part of a £100,000 contract for a materials handling plant, to be built in Northern Spain. The Spanish steel concern, Ferroaleaciones Y Electrometales S.A., of Santander, placed this contract for the conveyors, bunkers, elevators and transportation system of a ferromanganese and ferrochrome plant which will be commissioned by the end of 1960. The contract does not include the building and civil engineering work, and the main contractor for the plant is Mecanica de la Pena S.A., of Bilbao.

THE CENTRAL ELECTRICITY GENERATING BOARD has placed contracts recently for power stations, transmission lines and transforming stations amounting in the aggregate to approximately £13,020,000. The principal contracts include: West Thurrock power station, two 300MW reheat boilers, Nos. 3 and 4 (Babcock and Wilcox, Ltd.); one 210MVA, 275kV generator transformer, No. 2 (C. A. Parsons and Co., Ltd.); Thorpe Marsh power station, two 310MVA, 275kV generator transformers (English Electric Company, Ltd.); Fleet-Alton/Portsmouth (extension), 275kV double circuit overhead line (Balfour Beatty and Co., Ltd.); Stafford-Rugeley, 275kV double-circuit overhead line (Riley and Neate, Ltd.).

WOODALL-DUCKHAM CONSTRUCTION COMPANY, Ltd., has received a contract valued at £6,500,000 from the West Midlands Gas Board, for the installation of a high-pressure coal gasification plant on a new site at Coleshill, Warwickshire. The installation will include tonnage oxygen plants, Lurgi complete gasification generators and extensive ancillary plants for gas treatment and enrichment, by-product recovery, effluent treatment and coal and ash handling. The gas manufacturing capacity will be 40,000,000 cubic feet daily and provision made for future extension in two stages to 80,000,000 cubic feet and 120 million cubic feet daily. The generators are designed to gasify low rank, small coals, from the Midlands coalfields.

STRACHAN AND HENSHAW, Ltd., Steelhoist Works, St. Philips, Bristol, has been awarded a contract to the value of rather more than £500,000 for the design, manufacture and erection of the wagon marshalling and unloading equipment for ore, coke and coal, by Richard Thomas and Baldwins, Ltd. The equipment, which will be installed at the new Spencer Works at Newport, Mon, will comprise four 50-ton wagon tipplers with automatic weighbridges and dust suppression equipment, together with beetles and hydrabrakes for remote control of marshalling operations necessary to handle all incoming raw materials. The first stage will be put into operation by June, 1960, and the remainder of the system ready by July, 1961.

HEENAN AND FROUDE, Ltd., Worcester, has secured an order from Machinoimport, the official Russian Purchasing Department in Moscow, for two large Froude hydraulic dynamometers. Another order, for a machine identical with the smaller of the two for Russia, has been placed with the same company through the Polish Embassy in London. The dynamometers, used for absorbing and measuring the brake horsepower of engines undergoing test, will be the most powerful of their kind ever supplied to Russia. The first machine will have a capacity of 17,000 b.h.p. at speeds ranging between 115 and 300 r.p.m.; the second, identical with that ordered by Poland, will be capable of absorbing up to 10,000 b.h.p. at speeds between 132 and 300 r.p.m.

SOLARTRON ELECTRONIC BUSINESS MACHINES, Ltd., a subsidiary of the Solartron Electronic Group, Ltd., has received an order for an Electronic Reading Automaton ("ERA") from Domestic Electric Rentals, Ltd., by whom it will be used for rental and credit-sales accounting. The machine will read directly information recorded by National Cash Register machines at each branch of Domestic Electrical Rental's radio-TV rental organisation. This information, which will include the customer's account number and rental payment amount, will then be automatically punched on to eighty-column I.C.T. cards for subsequent use in a standard punched-card installation. Reading and information inversion in the Solartron "ERA" can take place at a speed of 200 to 300 characters per second.

CONTINENTAL AFFAIRS

by Our Continental Editor

Oil Developments

Centenary of the Oil Industry

LAST year, petroleum mining celebrated its centenary. On August 27, 1859, Col. Edwin Laurentine Drake's borehole at Titusville, Pennsylvania, struck oil at a depth of 21m. This was not the first time that systematic drilling had been undertaken with a view to obtaining petroleum, a substance known from outcropping deposits in many parts of the world. Five drillings had been brought down in 1858 in the region of Celle-Velzen, near Hannover, under the direction of Konrad Hunäus, professor of geological science at Hannover Polytechnic, but although some oil was found near Wietze, the quantity was too small to make its exploitation profitable.

In Pennsylvania, petroleum had been obtained commercially as a by-product of drilling for brine, and the chemist Benjamin Silliman had in 1855 given a very favourable technical report on this substance to the Pennsylvania Rock Oil Company (later Seneca Oil Company) which employed Drake on the Titusville site. The cable-drilling methods which Drake used were similar to those applied at the brine drillings at the neighbouring town of Tarentum. The only novelty introduced by Drake was the use of an iron casing to prevent the borehole caving in. It may be of interest to note that cable-drilling was already known in China, certainly *ca.* 200 B.C. but possibly even 800 years earlier. These Chinese wells were sunk for obtaining brine and reached depths of up to 1000m.

Ten years after the first "strike" (which yielded 2–3 tons of oil per day, worth about 150 dollars per ton) the production from the Pennsylvania field had risen to about 1,000,000 tons per year.

The first commercial pipeline went into operation in the U.S.A. in 1865. With a diameter of 50mm, it was 7km long and operated by four steam-driven pumps. Its cost, 150,000 dollars, was recovered within three months.

TABLE I—*Oil Statistics for* 1958 *and* (*in parentheses*) *for* 1950 (*Millions of Tonnes*)

	Reserves	Production	Refinery capacity	Consumption
World total :	37,811 (10,887)	887 (526)	1,126 (589)	949* (536)
North America :	5,340 (3,697)	352 (287)	564 (369)	498 (342)
South America :	2,771 (1,507)	154 (89)	118 (60)	63 (34)
Far East :	1,304 (226)	24 (13)	64 (14)	65 (25)
Near East :	23,900 (4,714)	210 (89)	71 (44)	24 (13)
Africa :	548 (29)	5 (2)	5 (3)	23 (13)
U.S.S.R., China, Eastern Europe :	3,723 (674)	129 (43)	113 (45)	123 (45)
Western Europe :	225 (40)	13 (3)	191 (54)	153 (64)

* This figure includes petrols from natural gas and coal products, and thus exceeds the petroleum tonnage.

* See THE ENGINEER, September 4 and 11, 1959.

World Oil Production

Table I shows some of the principal statistical data of the world's oil industry for 1958, the last year for which complete figures are available, and, for comparison, the figures for 1950.

Pipelines

In our issue of February 27, 1959, we described the 390km-long, 28in North West Oil Pipeline from Wilhelmshaven to Cologne which came into service at the end of December, 1958, and which is designed to supply ultimately 20,000,000 tons per annum to the refineries and petrochemical works of the Cologne and Ruhr areas. This pipeline is jointly operated by Esso A.G. and other companies, while a second major pipeline of 24in diameter and 300km long, was completed between Rotterdam and the Shell refinery at Cologne-Godorf.

As is known, the Shell Group and Compagnie Française des Petroles are the principal protagonists of the Marseilles–Strasbourg pipeline project which was recently officially approved by the French Government. This concerns a 750km-long line from the oil port of Lavera near Marseilles to Strasbourg, with the possibility of extending it northwards to Cologne and eastwards to Bavaria. Tentative plans envisage the beginning of construction in 1960 and the completion of the first stage by the end of 1962. In this first stage, there would be only two pumping stations, giving a throughput of 12,000,000 tons per annum, which could be doubled by adding pumping capacity. The cost of construction may amount to DM.470 million to DM.510 million. Additional refinery capacity will be built at Karlsruhe to process the oil delivered through the new pipeline.

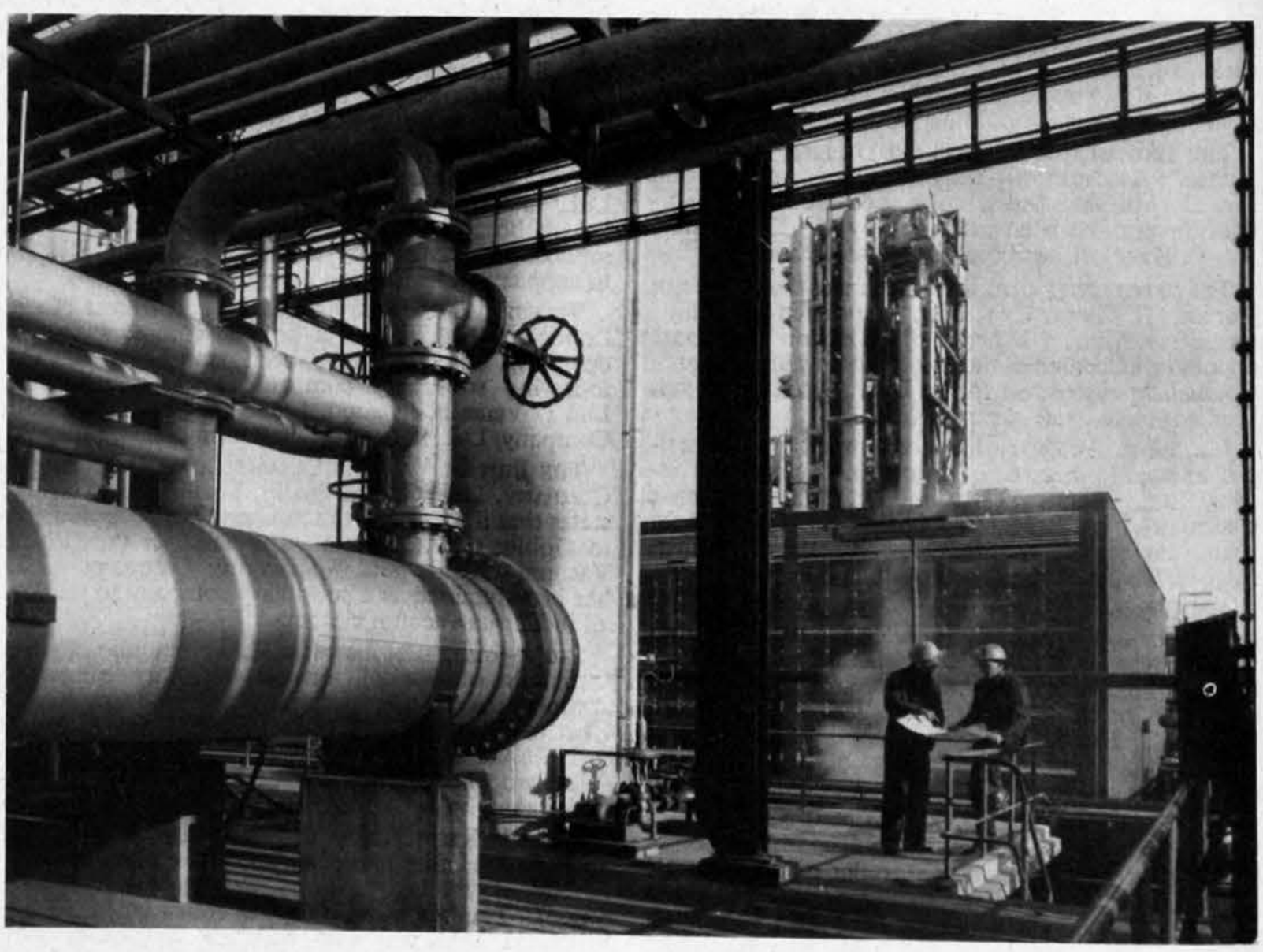
The pipeline from Lavera to Strasbourg and beyond will be of particular interest in view of the fact that the Sahara oilfield has now been connected by pipeline to the Mediterranean, so that both Middle East and Sahara oil destined for Western Europe could be shipped to Marseilles.

On December 5, the 660km-long 24in pipeline from Hassi-Messaoud in the Sahara to the Algerian port of Bougie was officially opened. The initial capacity of the new pipeline is reported to be approximately 4,000,000 tons per annum, but this is to be stepped up as soon as possible to 10,000,000 tons by installing more pumps and a second pipeline is to be completed through Tunisian territory. Because of the Algerian war, the pipeline to Bougie has been laid entirely underground.

Alpine Pipeline Project

For supplying Bavaria, the eastern parts of Baden-Württemberg and Hesse, a pipeline is being projected to extend the Genoa-Aigle pipeline to the West German frontier and thence to Munich, with a branch serving the regions of Stuttgart and Offenbach. In September it was announced that a company, the "Südöl Aktiengesellschaft für Erdölwirtschaft" had been formed for constructing and operating this pipeline by a group of German banks and the Italian state holding company ENI (Ente Nazionale Idrocarboni). Of the DM.1,000,000 initial share capital, 50 per cent is to be held by the German group and 50 per cent by the ENI subsidiary, Oleodotti Internazionali, Rome. The pipeline is to constitute a "free road" and will not be tied to any particular company.

The decision to go ahead with the Genoa-Aigle–Munich project at first seemed to imply that plans for a pipeline from Venice to Munich



No. II ethylene plant of Rheinische Olefinwerke G.m.b.H., Wesseling. In the background, the 45m high "cold" distillation tower for recovering ethylene from light petroleum fractions

were to be abandoned. The reasons which make Venice appear the less favourable starting point are partly the fact that its port can at present accept only 18,000-ton tankers (although unloading from deep water discharge points would seem a simple matter), while at Genoa the largest tankers of up to 100,000 tons can unload. In addition, for a pipeline to compete with other means of transport means that a minimum annual throughput must be reached. While along the 350km Genoa–Turin–Milan–Aigle there is already an existing demand for 6,000,000 tons per annum, on the Venice–Munich pipeline the first worthwhile centre of oil consumption would be Innsbruck where only some 500,000 tons per annum would be required. It has, however, been reported that a group of Greek shipowners, as well as certain oil companies, show continued interest in the Venice project.

The two projects are to be submitted to the study group " Transalpin, Verein zum Studium des Baus alpenüberquerender Ölleitungen nach Bayern e.V." which has been formed at the instance of the Bavarian Government.

If fully exploited it is considered that the Genoa–Munich pipeline and its branches will save 50,000,000 dollars in transport costs annually.

The 66cm pipeline from Genoa to Aigle (near Geneva) is already under construction since May, 1959. Its capacity will be 10,000,000 to 12,000,000 tons per annum, and its cost is estimated at 20 milliard lire. The section from Aigle to the German frontier will have a diameter of 61cm and will continue to Munich as a 40cm pipe while the Stuttgart–Offenbach branch will be of 46cm diameter. This second part of the project will cost about 16 milliard lire, and is to be completed in two and a half years. The whole system will have a length of 1400km.

It is intended to build a refinery in the Munich region at a cost of 30,000,000 to 40,000,000 dollars Bavarian consumption of petroleum products, which last year stood at 2,800,000 tons, may well be double by 1965.

No details of the proposed route have become known, except that the Great St. Bernhard will be crossed either by using the road tunnel now under construction at a sea level of 1800m, or by constructing a separate tunnel at an additional cost of 1·5 milliard to 2 milliard lire.

Russian Developments

In the nine months until the end of September, 1959, Soviet oil production amounted to 95,300,000 tons, an increase of 11,900,000 tons over the corresponding period of 1958. This implies a rate of production only slightly less than that of Venezuela, the second largest oil country after the U.S.A. In the course of the present Seven-Year Plan (1959–65) the output of oil is to be expanded from 113 million tons in 1958 to 230 or 240 million tons, representing an average annual increase of 17,000,000 tons as compared with 6,600,000 tons in the period 1951–55 and 14,200,000 tons in 1956–58.

Deposits of natural gas now under exploitation in European Russia are situated mainly in the Eastern and Western Ukraine, in the Caucasus and on the Volga, but strikes have been made all over the country, e.g. near Buchara. Proven deposits are estimated to amount to 1×10^{12} cubic metres, with a calorific value of about 8400 kcal per cubic metre.

Natural gas production is intended to cover one-quarter of the total energy consumption by 1972, compared with 4 per cent in 1957. Actual production in 1958 was 31,000 million cubic metres, which by 1965 is to rise to 150,000 million cubic metres. This may be compared with a current annual consumption in the U.S.A. of about 300,000 million cubic metres. Last year some 1500km of gas pipelines were built, and about 4000km are to be laid within the next few years. At present, 10,500km are in use ; by 1965 it is intended to add another 26,500km. The sections Dashava (Ukraine)–Kiev–Briansk–Moscow, Stavropol–Rostov–Voronesh–Moscow, Saratov–Riazan–Moscow, Achida–Moscow, Ufa–Gorki, Kuibyshev–Stalingrad, Buchara–Samarkand–Tashkent, are said to be already in operation.

Pipe sections are chosen to permit a speed of flow of 10m per second, most diameters being in the region of 500mm to 800mm. Up to 400mm diameter, the pipes are seamless, between 400mm and 800mm they are longitudinally welded, and from 800mm to 1000mm spirally welded. Nominal pressures, between 500mm and 800mm diameter, are up to 55 atmospheres ; safety factors of 1·5–1·9 are employed depending on whether the line is in open country or in built-up areas. The largest pipes of 1000mm are operated at only 10 atmospheres, but new welding methods, it is hoped, will permit higher working pressures of up to 55 atmospheres.

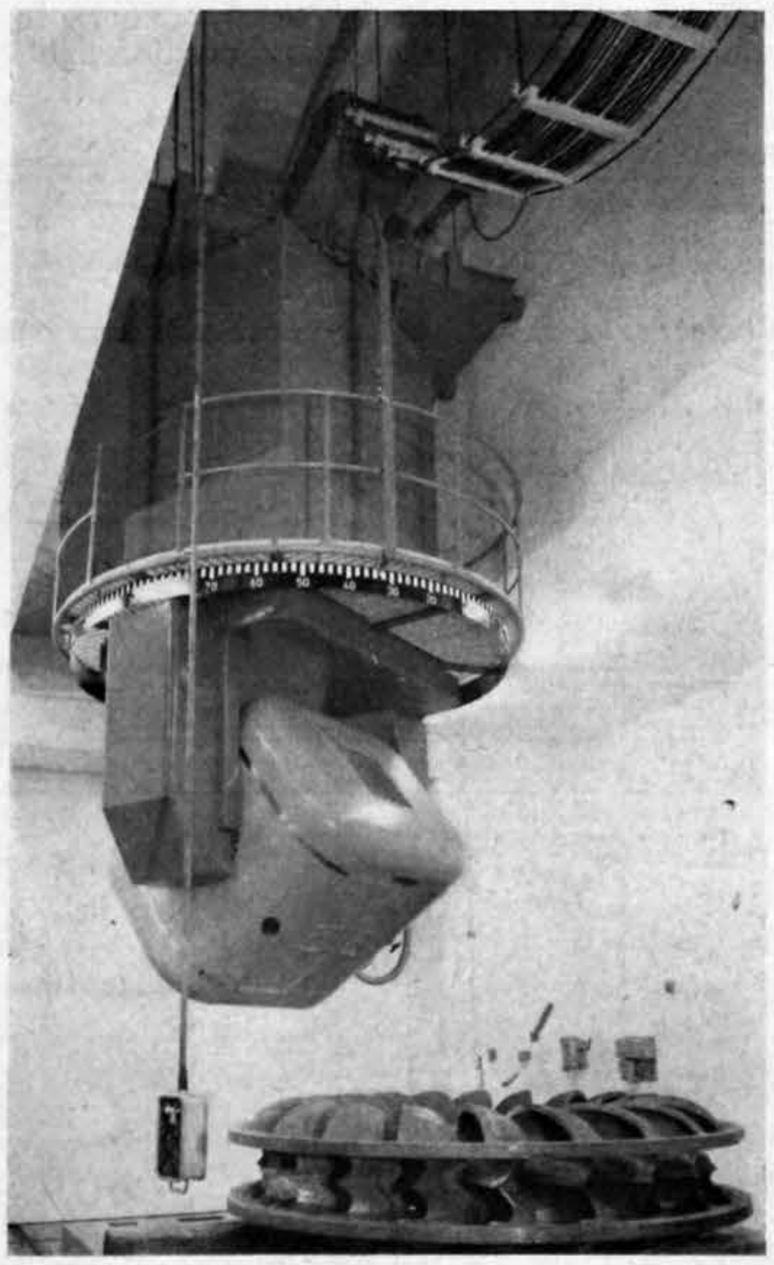
Pipes are automatically butt-welded at the site into lengths of 70m, cleaned, primed, and wound with asbestos-bitumen insulation, then lowered into the machine-excavated trench. The sections are then joined by automatic welding.

Booster stations are about 120km apart and are designed to step up the pressure from 20 to 45 atmospheres (Buchara–Tashkent : 65 atmospheres). The compressors are piston designs with three or four cylinders, driven by gas engines, mostly multi-cylinder " Vee " engines of 100 h.p. per cylinder and a consumption of about 2450 kcal per brake horsepower per hour. Before compression the gas is washed with oil in order to free it from dust, and is afterwards dried with glycol before being returned to the pipeline. The possibility of using larger compressor units of up to 2000 h.p. is being investigated, as is the question of installing free-piston compressors, and gas turbine driven turbo-compressors of 4000kW to 6000kW. Such machines would have a capacity of 10 to 15×10^6 cubic metres per day. Larger turbines up to 16,000kW at 7900 r.p.m. and 800 deg. Cent. are also being studied.

31 MeV Betatron

We illustrate a 31 MeV betatron intended for the non-destructive testing of very thick materials and for research work with high energy X-rays and electrons. This instrument is made by Brown Boveri and Co., Ltd., Baden, Switzerland, and is marketed in Great Britain by Watson and Sons (Electromedical), Ltd., East Lane, North Wembley, Middlesex.

It is stated that steel can be radiographed up to a thickness of 20in. At full output and focus to film distance of 2m, radiographs of 8in of steel can be obtained in four minutes with a density of 2in., and in thirty minutes with 12in of steel. The instrument has two focal spots, each 0·1mm by 0·3mm. The wire penetrameter (DIN) sensitivity over a thickness range of 6in to 14in of steel is almost constant at 0·3 per cent. At 10in steel a 0·03in diameter wire can still be seen. The very small focus size allows X-ray magnification to be used, and thus further improvement in sensitivity can be obtained. The instrument is also used for nuclear physics studies, including photo-nuclear reactions and generation of Cerenkov radiation. It has also been used to study biological processes induced by high energy X-rays and electrons, as occur for example in therapy and genetic changes. A betatron producing electrons and X-rays up to 35 MeV is available for cancer therapy.



Industrial 31 MeV betatron installation

A detachable beam equaliser may be used ; it provides a beam of intensity constant to within ±5 per cent over a circle of 8in diameter at 1m from the target. The dose rate measured with a thimble chamber surrounded by 3mm of lead is at least 62 r/min. at 1m distance. Shutters in each beam control the beam height.

For setting-up the betatron, two light beams are projected along the centres of the X-ray beams. The targets are 531mm apart and produce X-ray beams converging to a point at 2·4m distance. They may be used separately or simultaneously. In the latter case, two parts of the specimen are radiographed producing a double field ; alternatively stereo radiographs may be made.

A control desk contains sequence switches and a delay timer for controlling the magnet field, electron injection and orbit expansion. Ion chambers are fitted in the betatron head in each beam, and the dose rate and dose are indicated for each on separate meters on the control desk. The exposure may be terminated by the dosemeter (0r to 10,000r) or a timer (0 to 55 minutes).

The power consumption is 16kW and cooling is by a built-in fan. The basic X-ray head can be rotated by motor drive about horizontal and vertical axes, and mounted on a crane or gantry. Auxiliary equipment includes a condenser bank and cabinets containing electrical equipment for electron injection and orbit expansion.

Demag Aktiengesellschaft, Duisburg

An ordinary general meeting of Demag Aktiengesellschaft, Duisburg, was held on June 18, last year. In the year 1958 economic expansion in the German Republic continued on the whole according to the report submitted to the meeting, which also states that the need for capital investments continues on a very large scale. Although steel consumption again rose in 1958, the production of coal and steel suffered a setback owing to the running down of stocks by manufacturers.

In the West German engineering industry, employment remained at the level reached at the end of 1957 ; turnover rose by 5·4 per cent ; the volume of incoming orders remained unchanged, but foreign orders dropped by 12·4 per cent. The ratio of export deliveries to export orders thus deteriorated from 100 : 117 in 1956 to 100 : 79 in 1958, while the percentage of projects worth over DM.1,000,000 decreased from 27·4 per cent in 1956 to 20·4 per cent in 1958.

As regards the Group's own trading position, the volume of incoming orders fell short of the previous year's figures by more than 20 per cent, thus continuing the downward tendency noticeable since 1956. The inflow of orders from the home market was the lowest since 1952 and reached only two-thirds of the average figure for the preceding five years. Orders for iron and steel plant were particularly badly affected by the recession in the steel industry. The volume of export orders was 9 per cent below the previous year. The export turnover, which represented 46 per cent of the turnover as a whole, decreased by 19 per cent as compared with 1957 ; the total turnover reached no more than 89 per cent of the figure for that year.

Demag's gross turnover in 1958 reached DM.746 million (−9 per cent), the labour force remaining approximately constant at an average of about 23,000 persons. Production costs rose as the result of the introduction of the 44-hour week, with wage adjustments, on January 1, 1958.

CONTINENTAL AFFAIRS *(Continued)*

Prestressed Concrete Dock Gate

ON June 2 last, the largest dry-dock on the European continent, "Elbe 17," at Hamburg-Steinwerder, was re-commissioned after having been largely destroyed in the war and subsequently dismantled. The dock, which is about 350m long, 60m wide, and 9m deep at mean high tide, is being operated by the Schlieker Werft (Ottensener Eisenwerke A.G.). An interesting innovation in the reconstruction of this dry-dock is the floating dock gate, which was constructed in prestressed concrete. The gate was the responsibility of the firm Dyckerhoff and Widmann K.G., Rud. Otto Meyer (ROM) and Siemens-Schuckertwerke A.G. (SSW).

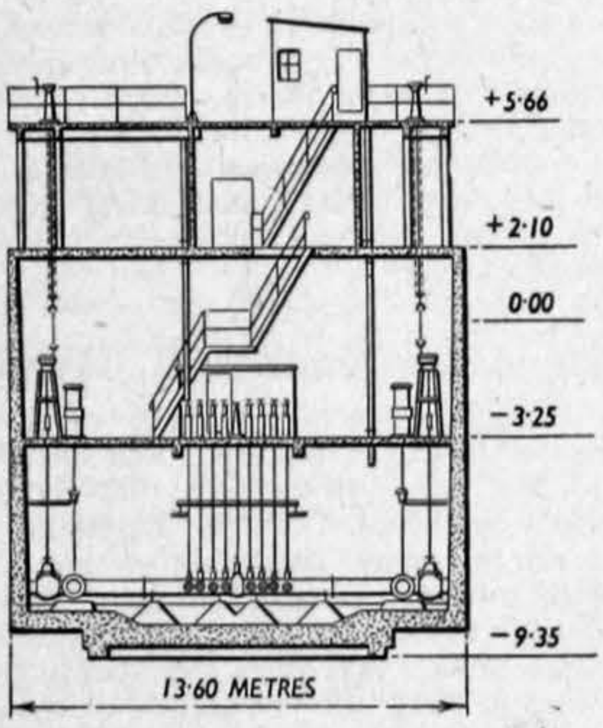
Our accompanying illustration shows the gate, which has an overall length of 62·60m, a beam of 13·60m, and height (keel to gangway) of 15·01m. The interior is subdivided into fifteen compartments of which the central compartment (No. 8) contains the pumping machinery.

This comprises two vertical ballast pumps, each capable of delivering 500 cubic metres per hour against a head of 8m, installed on either side on the bottom deck, and driven through shafting by 36·8kW, three-phase, 380V, 50 c/s motors arranged on the intermediate deck. The 965 r.p.m. motors are squirrel cage designs for direct-on-line starting; the pumps have double-sided impellers. Both suctions are connected to a common manifold which can be divided into two symmetrical halves by a central shut-off valve. Pipes for flooding and pumping out are connected to this manifold which itself communicates with the outside by way of shut-off valves. Similar valves control the delivery side of the pumps.

The floating gate is manœuvred into and out of position by tugs during slack tide. Its empty weight is 4500 tonnes, and its displacement when fully ballasted at 11m draught and 0·5m freeboard is 6000 cubic metres. Without ballast, the draught is 8·2m, and at mean low tide 300 tonnes of water ballast are required to sink it to the sill, an operation which occupies six minutes. The mean level at high tide being 2·3m above low tide, an additional 950 tonnes of ballast are required at high tide, but in actual fact, 2066 tonnes are admitted so as to obtain sufficient sill pressure. All flooding is carried out under the difference in natural head between the inside and outside.

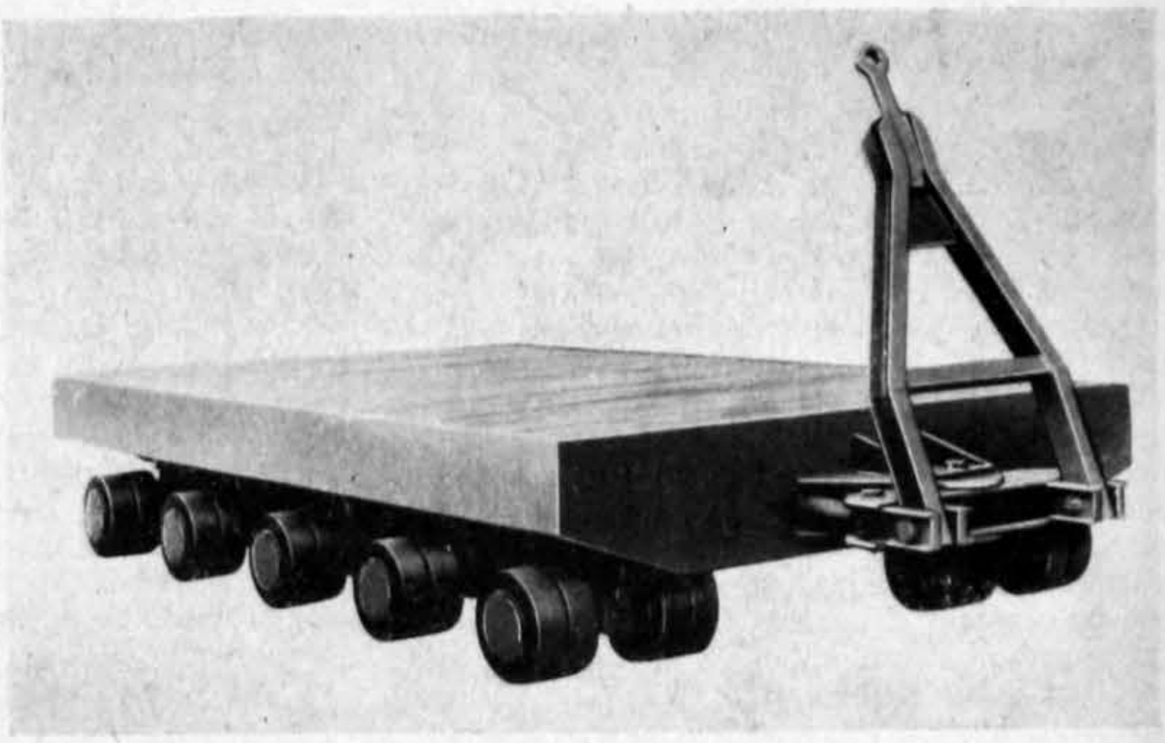
The 2066 tonnes of ballast correspond to 4m depth in all compartments except No. 8, where the level is limited to 2·8m by a float valve, in order to prevent any danger of the motors being drowned.

All machinery and valves are controlled from a central position on the top deck where an illuminated panel indicates the state of the ballast compartments and of the valves, as well as any failure in operation. The valves can be operated either electrically or by hand. In addition to general illumination, position lights are provided at the ends of the dock. Water levels, trim, and structural deflections can be measured, the latter by sighting an illuminated scale through a telescope. The electrical installation receives its current from the shore through a 380V, three-phase cable.

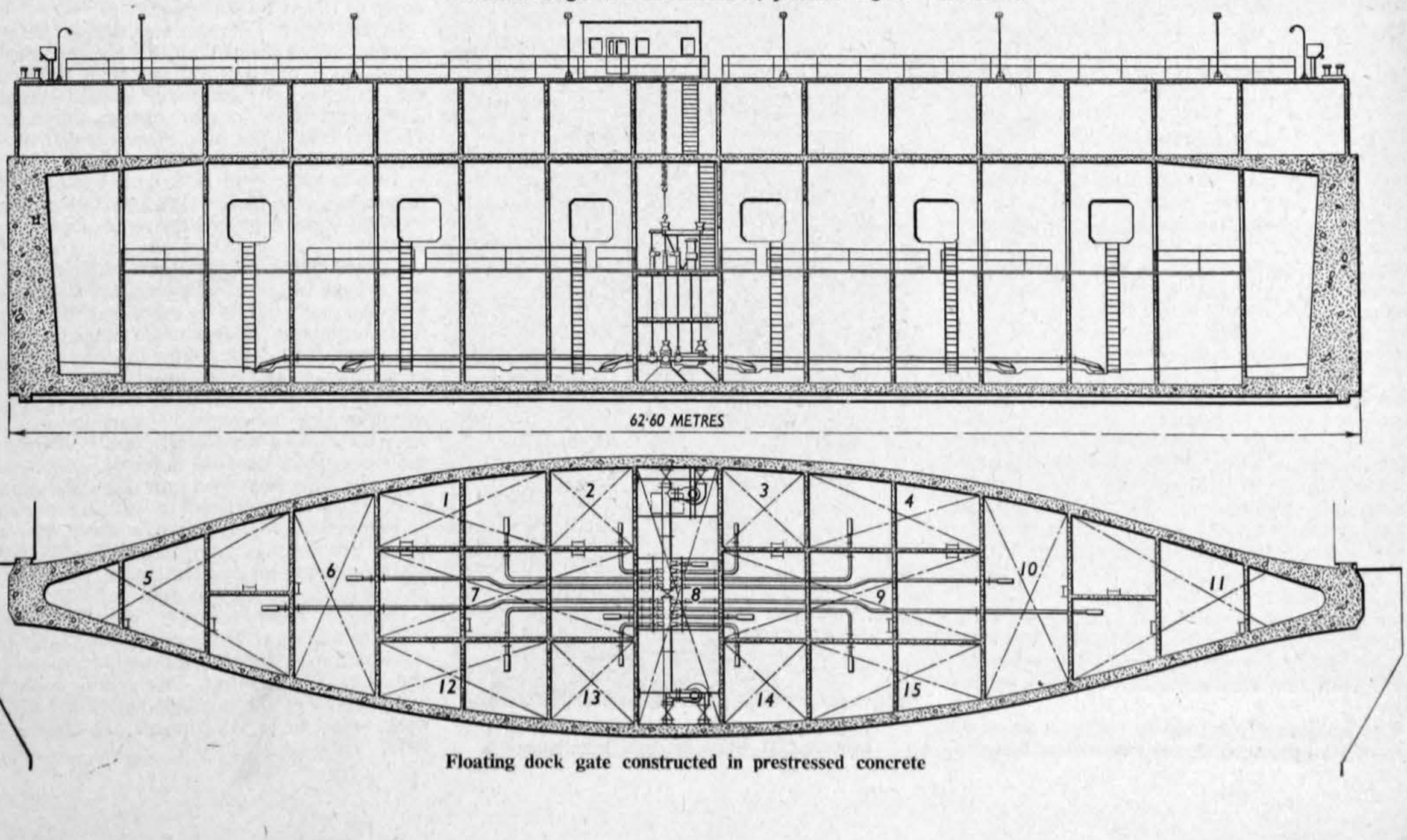


Heavy Trailer

In the accompanying illustration we show a heavy transporter trailer, one of a range covering useful loads from 12 to 60 tons, made by Martin Fiala K.G., Stuttgart-Korntal. The trailer here shown is the model "Mafi 1065," with a carrying capacity of 40 tons. It is intended for the transport of heavy workpieces, castings, and machines, and possesses ten helically sprung balance beam axles. These axles are connected to a common steering gear, maintaining their alignment to a common centre. The equal distribution of the load over a large number of wheels gives a low loading height and even ground pressure, while the axles adjust themselves to uneven ground. The wheels are fitted with double ball or roller bearings, and have solid rubber tyres. The shaft can be attached at either end of the trailer. Platforms are available in three standard sizes, up to 5000mm by 2500mm.



40-ton trailer with ten steered balance beam axles



Floating dock gate constructed in prestressed concrete

Russian Space Rockets

THE first Russian moon rocket (" Lunik I ") was fired on January 2, 1959, and missed its target by some 7500km, the rocket going into orbit round the sun. The second attempt was successful, and " Lunik II " hit the moon on September 13 at 20.02.24 hours, a matter of a minute or so behind schedule. In view of the extraordinary accuracy required in the absence of any control during flight, this constituted a remarkable feat. The final-stage rocket of 1500 kg, containing an instrument capsule weighing 389 kg, had to have its speed controlled very closely indeed—an accuracy of 1m per second is being quoted—if it was to hit the moon which travels in its orbit round the earth at a speed of over 3500km per hour. The firing had to take place within a few seconds of the calculated time, and the angular accuracy had to be " better than 1 deg. of arc."

The third moon rocket was launched on October 4 in a manner calculated to make it pass behind the moon, at that time in its new phase, and take a series of photographs of the illuminated rear surface. The photographs were developed on board and subsequently transmitted to earth by wireless. The final stage of the multi-stage rocket, without fuel, weighed 1553 kg. The instrument capsule, which after burn-out separated from the final stage, has been described as an automatic interplanetary station; its weight is said to be some 278 kg. The shape of the station is stated to be cylindrical with spherical ends, its length without aerials 130cm, its maximum diameter, 120cm. The thin-walled shell houses a framework on which the instruments are mounted. A porthole at the upper end is automatically uncovered when photographing is about to begin, while small portholes are provided in both end plates for the solar pick-ups of the orientation system, the guide engines for which are mounted on the lower end plate. Power for the instruments is supplied from chemical batteries replenished by a solar battery ; external shutters regulating the radiation loss maintain the internal temperature at 25 deg. Cent.

For taking photographs, the entire station is turned in the required direction by a special guidance system. This system first suppressed the tumbling motion caused when the station separated from the final rocket stage, and then locked on to the sun. This caused the opposite end of the station to face the moon, the earth being to one side at the time. A fine adjustment then came into play to bring the moon into accurate focus, and photographing began. Afterwards, before being switched off, the guidance system was used to impart a slow rotation to the vehicle which is stated to have been imposed in order to improve the thermal regime.

The flight trajectory of " Lunik III " passed the moon at a minimum distance of 7900km from its centre on its southern side. It thus deviated behind the moon towards the north and returned towards the northern hemisphere of the earth, thereby making possible its observation from the Soviet Union. A more distant trajectory, besides making close observations of the moon impossible, would have meant that the station would return towards the southern hemisphere. Moreover, the rocket would re-enter the atmosphere and burn up, after only one loop. The nearly elliptical trajectory extended some 480,000km from the earth, with a perigee within 47,500km. Due to solar perturbation, the height of the perigee is constantly decreasing, so that the station is bound eventually to burn up in the earth's atmosphere unless, owing to the influence of the moon, the orbit is deformed to such an extent that it actually strikes the earth.

No corrections were made to the rocket's speed and direction during flight ; the greatest accuracy had, therefore, to be maintained during the launching ; this accuracy was, in fact, greater than that required for obtaining a direct hit.

Careful measurement of the orbit parameters was carried out subsequent to launching and after circling the moon, so as to enable the station's transmitters to be switched on at the right time. These data also enabled a forecast to be made of the probable life of the station ; early indications were that it would survive until April, 1960, making eleven to twelve revolutions round the earth.

Because it was desired to photograph as much as possible of the reverse side of the moon, pictures had to be taken at a time when the disc was fully illuminated, which considerably reduces contrast. In order to ensure high-quality transmission of low-contrast pictures, the television apparatus was provided with automatic adjustment of the brightness of the scanning tube. The photo-television equipment comprised a camera with two lenses, of 200mm and 500mm focal length respectively, which operated simultaneously, the image of the disc taken by the 200mm lens completely covering the frame, while the long-focus lens showed details. During a period of about forty minutes, while the station was 60,000km to 70,000km from the moon, photographs were taken on special 35mm film capable of being processed at higher temperatures. Shielding was employed to prevent the film being fogged by cosmic radiation. A special method was used for developing and fixing the film under conditions of weightlessness, using reagents which have but small sensitiveness to temperature. After drying, the film was prepared for transmission. Reference marks, some put on in advance and some recorded at the time of taking the photographs, allowed the processes of photographic treatment and transmission to be controlled.

Transmission was carried out in the same way as films are transmitted by television stations, but much more slowly, using a small scanning tube with a high resolving capacity, and a stable photo-electronic multiplier, in conjunction with low frequency scanning devices. Amplification and sending of the pictures was effected by a narrow-band stabilised transmitter which automatically compensated for changes in the average density of different negatives. Two speeds of transmission were employed, a slow speed for the largest distances and a faster speed for when the station approached the earth. The number of lines per picture could be changed in accordance with the speed, the maximum being 1000 lines. Two radio channels, both operating with continuous transmission, were employed, one from the earth to the station (command channel) and one in the reverse direction (telemetering and picture transmission ; this is stated to have been the first time such a combination of functions has been attempted in a single channel with continuous emission).

The entire electronic system, both on the earth and in the station, was duplicated. A faulty section in the station could be replaced by a standby by means of a command from the ground. Electronic equipment in the station was almost wholly transistorised. The station's transmitter had only a few watts output and because of its own rotation had to radiate uniformly in all directions, so that the power received at maximum distance—the television system has functioned over up to 470,000km—was of the order of 1×10^{-8} that received by the normal television set. Special steps had therefore to be taken to minimise the noise caused by cosmic radiation and in the receivers themselves. Recordings of the pictures were made simultaneously on photographic film, magnetic tape, " skytron " tubes (i.e. cathode ray tubes with image delay), and electro-chemical paper.

Owing to the libration (precessional motion) of the moon's axis, some 59 per cent of its surface is visible from the earth. The photographs taken, some of which have appeared in the daily press in this country, are stated to have covered about 70 per cent of the invisible side and a certain proportion of edges of the visible disc which allows the co-ordinates of the features of the reverse side to be established.

British Radar for Arlanda Airport

According to a recent announcement by Decca Radar, Ltd., Albert Embankment, London, S.E.11, the new Stockholm international airport at Arlanda will be served by an advanced design of " D.A.S.R.1 " air surveillance radar, specially developed for use in areas of medium and high traffic density. The equipment is already in working order and is being used in an intensive programme of flight trials and operator training. The reflectors are mounted back to back at the top of a 90ft-high cylindrical concrete tower standing approximately one-quarter mile to the south of the airfield, while displays and control equipment are situated in the approach control room on the main airfield.

A description of a similar type of equipment installed in this country, at Wisley airfield, will be found in our issue of May 29 last, on page 859. The " D.A.S.R.1 " is stated to provide gap-free coverage to ranges in excess of 100 miles, at heights above 40,000ft, with a high degree of discrimination, and can be used for long-range aircraft control as well as for the monitoring of other approach aids at close range.

The use of the 10cm wave band makes possible an improved degree of discrimination, gap-free high and low cover, and a high information renewal rate of twelve times per minute. Although these advantages have been known for some time the use of such short wavelengths in civil air surveillance has only become feasible since it was found possible to suppress the interference by rain or snow to which it is specially liable. Joint research by Decca Radar, Ltd., and Société Nouvelle d'Electronique, Paris, showed how by employing circular polarisation this difficulty could successfully be overcome.

Another aspect of the " D.A.S.R.1 " is the elimination of ground returns which might otherwise mask echoes from aircraft ; this is done by using what is described as air target indication (A.T.I.) and consists of the planned exploitation of the twin beam aerial radiation pattern in conjunction with special receiver circuits. It is stated that a superior performance is achieved in this way without the use of blind speeds, radial course limitations, or additional complex electronics.

The two radar displays fitted with the " D.A.S.R.1 " at Arlanda are of the Decca " Interscan " series, with two main traces each, in order to display echoes from each of the back-to-back aerials. An electronic method measures range and bearing between any two points by means of an electronic line variable in length and direction. By offsetting the origin of this line, course to steer and distance to go to any fixed point can be determined rapidly and accurately and passed on to an aircraft. This electronic line may also be switched to indicate D/F bearings.

Luminous Traffic Policemen

Although it has become customary to provide traffic police on night duty with white uniforms, experience has shown that accidents, nevertheless, do occur on crossings where lighting is insufficient or where no traffic island can be placed, e.g. because of tramlines. In such situations in particular, where the policeman on point duty has to move within a certain area—in order, say, to allow a tram to pass—it is frequently found that the ordinary street lighting does not make him sufficiently conspicuous.

With a view to finding a solution to this problem, experiments were carried out recently in Hanover by the local police in conjunction with Siemens-Schuckertwerke A.G. The policeman's overall, jacket, cap, and signalling disc were treated with a fluorescent paint. Four ultra-violet searchlights of 125W each were positioned at a height of 8m above the crossing so as to illuminate a circle of 4m diameter. The searchlight's ultra-violet radiation causes the fluorescent uniform to light up vividly and make its wearer much more conspicuous to drivers than ordinary illumination could do. Tests are stated to have shown that neither the paint, nor the comparatively weak ultra-violet radiation are a source of danger to health. A broad cap peak protects the policeman's eyes from the direct downward radiation.

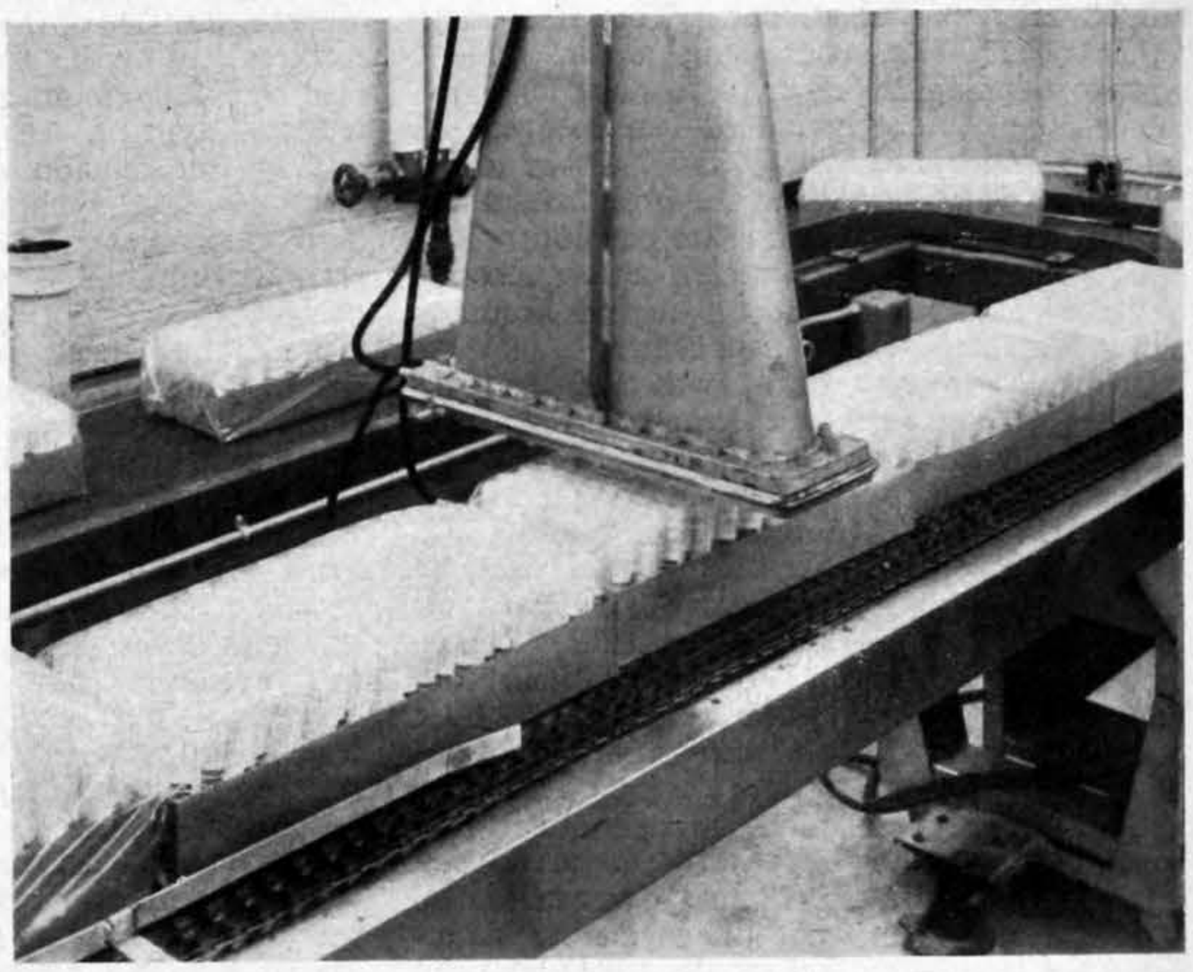
THE AMERICAN SCENE

by Our American Editor

Industrial Processing Applications of Electron-Beam Radiation

No. I

Penetrating high voltage electron-beam radiation has, within the past few years, drawn widespread industrial attention as a promising processing tool, and many American companies and institutions are now engaged in intensive programmes of research and application. The efforts of these groups extend from fundamental studies on the basic interaction of radiation with matter to the actual operation of radiation processing facilities. While many types of radiation sources have been proposed and investigated over the past few years, the Van de Graaff and microwave linear particle accelerators are now generally recognised as the principal sources of radiation for industrial use.



AS the principal manufacturer of particle accelerators in the United States, the High Voltage Engineering Corporation, of Burlington, Massachusetts, is now actively engaged in the development of industrial processing applications of electron-beam radiation. The basic Van de Graaff as well as other designs of particle accelerators since the last war have become remarkably useful instruments in many fields beyond the original one of nuclear physics, from super-voltage X-ray therapy to non-destructive testing in industry. During the last few years, the particle accelerator has also found a growing use in the field of electron-beam, or radiation, processing. The industrial promise of this technique is recognised in the food, drug, surgical supply and petrochemical industries. Because radiation is essentially a new form of available energy, its future applications appear to be very broad indeed.

The following processing applications of radiation energy are representative of current practice : (*a*) the preservation of foods, either to obtain extended shelf-life or indefinite storage, the deinfestation of cereals and grains, and the inhibition of sprouting in fruits and vegetables ; (*b*) the sterilisation of drugs, such as anti-biotics and hormones, of vaccines, of surgical supplies, such as sutures, intravenous sets and plastic tubing, and of human tissues for surgical transplant ; (*c*) the cross-linking of plastics to improve such characteristics as strength, temperature resistance and insulating properties—thus providing extended usefulness in packaging, electrical and fabricated product applications ; (*d*) the polymerisation of monomers to yield polymers with unique properties, including new films, and graft polymerisation to obtain special surface characteristics ; (*e*) the initiation of chemical reactions, such as catalysis, isomerisation, halogenation and oxidation.

Radiation Sources

For industrial processing purposes the two principal forms of radiation employed to-day are gamma and electron-beam radiation. Gamma rays are fundamentally the same as X-rays except that the name gamma has been given to photons, emitted from radioactive materials. The gamma rays now available are more penetrating than the X-rays produced by conventional X-ray machines, which operate at up to 250kV. Formerly, radium was considered to be a valuable and powerful source of energetic gamma radiation. Now, gamma sources exceeding the world's entire supply of radium can be prepared in nuclear reactors or from their waste products. Although these by-products of the atomic energy programme are the most intense gamma sources known, few sources of this type have so far been developed with enough output for processing or even for practical applied research at high radiation dosage rates.

While few of the existing gamma or fission-product sources have adequate output for processing, several low-output laboratory installations are in use and the possibilities of eventual large-scale facilities are being investigated, particularly in connection with the utilisation of by-product radiation from future atomic power plants. The penetrating ability of gamma radiation appears attractive for process applications where considerable thicknesses of solids or liquids are involved. It should be noted, however, that for treating certain other systems, such as gases or thin materials, this same characteristic seriously limits the amount of radiation that can be absorbed.

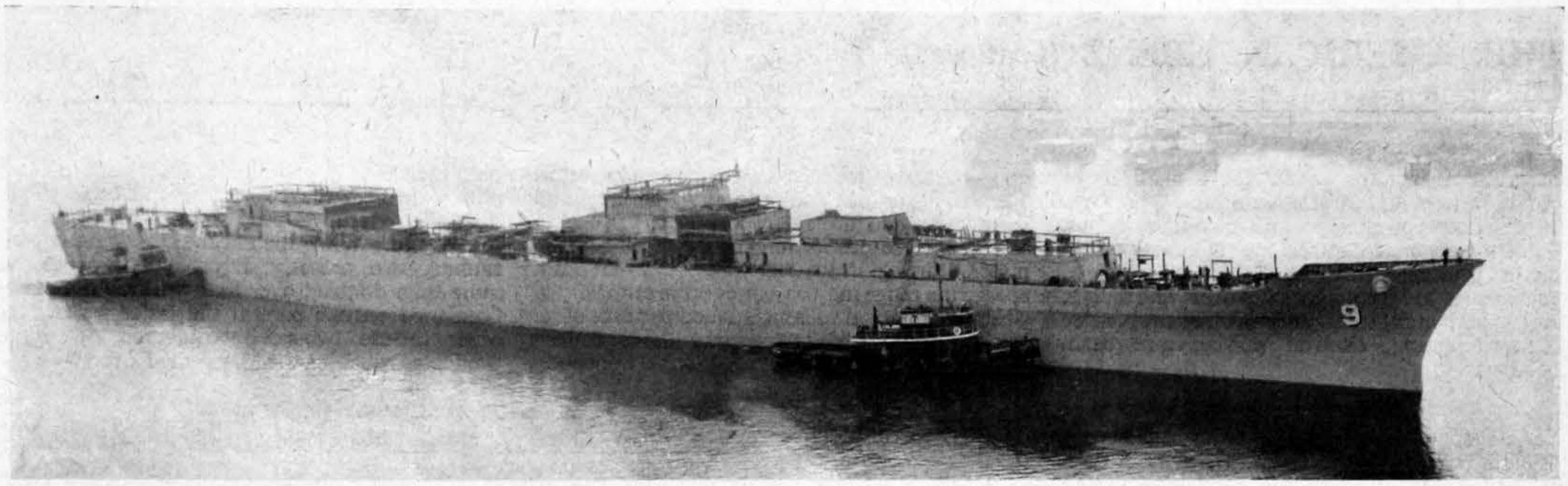
When high-velocity electrons collide with matter, the chemical changes brought about are essentially the same as those induced by X-rays or beta or gamma radiation. The great advantage of the electron beam is the very high-intensity radiation that can be produced. Very intense beams of high-velocity electrons can be produced by particle accelerators, which convert conventional electric power to electron power with good efficiency. The radiation intensity and output available from some of these accelerators exceeds, by orders of magnitude, that from any other sources of radiation that might otherwise be considered for processing. An impressive number of accelerators specifically developed as electron-beam radiation sources are now in use in this country and abroad.

It has often been said that the major limitation to the general usefulness of electron-beam radiation is its relative lack of penetration. But accelerator technology has now progressed to the point where penetration has been so increased that there appear to be few, if any, important applications that cannot be handled with machine produced electrons. In the United States to-day it appears that powerful electron accelerators will continue to be the principal sources of radiation for processing use. Although radioactive gamma sources will undoubtedly become available in much more powerful forms than exist to-day, sound predictions about the practicality of the gamma sources of the future cannot yet be made. Their eventual nature and cost will depend on new developments in reactor design and in nuclear fuel and waste processing.

Radiation of high power output has been available for only a few years and it is still an expensive form of energy. The best prospects for its early use are in those applications where the effects produced are unique and valuable. Intensive research on other applications is under way, and it is being done by men who believe that electron-beam radiation will be available at greatly reduced cost in the future.

Radiation Process Research

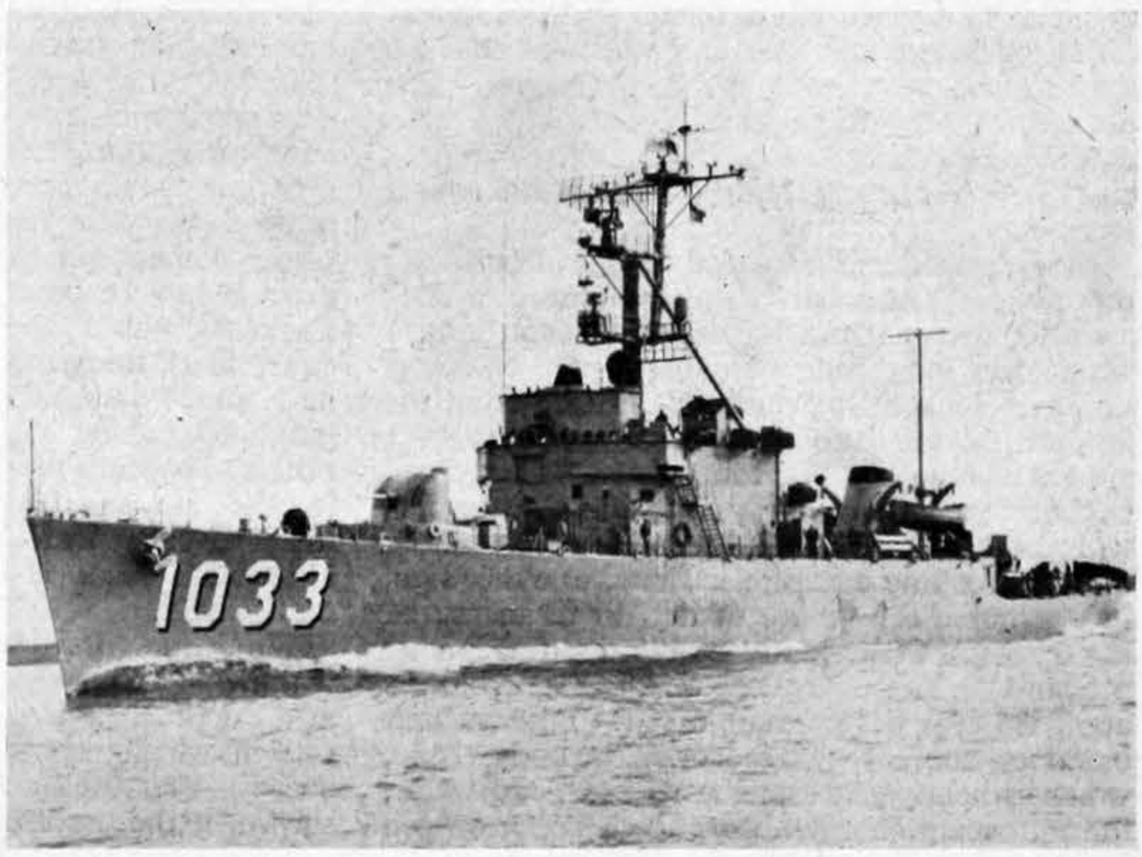
Fundamental research into the reaction mechanisms and kinetics of ionising radiation is as essential to the establishment of a useful radiation processing technology as it is for any other chemical process in which a wide variety of reactions can be initiated. While the minimum effective dosages are now reasonably well known, both in the applications for microbiological control and for the initiation of the more common organic chemical reactions, other variables are also important in many specific cases. For example, in the preservation of food and the sterilisation of drugs, much effort is being directed toward the control of the "side" effects on product quality. Similarly, in chemical process applications, work aimed toward the reduction in dosage needed for a given effect involves the study of changes in other process variables, such as temperature, pressure and atmosphere. Dose rate, or the time taken to deliver a given dose, is another factor that is important in a large group of reactions. Thus, flexibility of reaction conditions, of power control, and even of type of radiation is needed for such research and development studies. A single radiation source that will give this flexibility in one's own laboratory is preferable. The Van de Graaff accelerator fulfils all these requirements. Electrons and penetrating X-radiation can be produced from



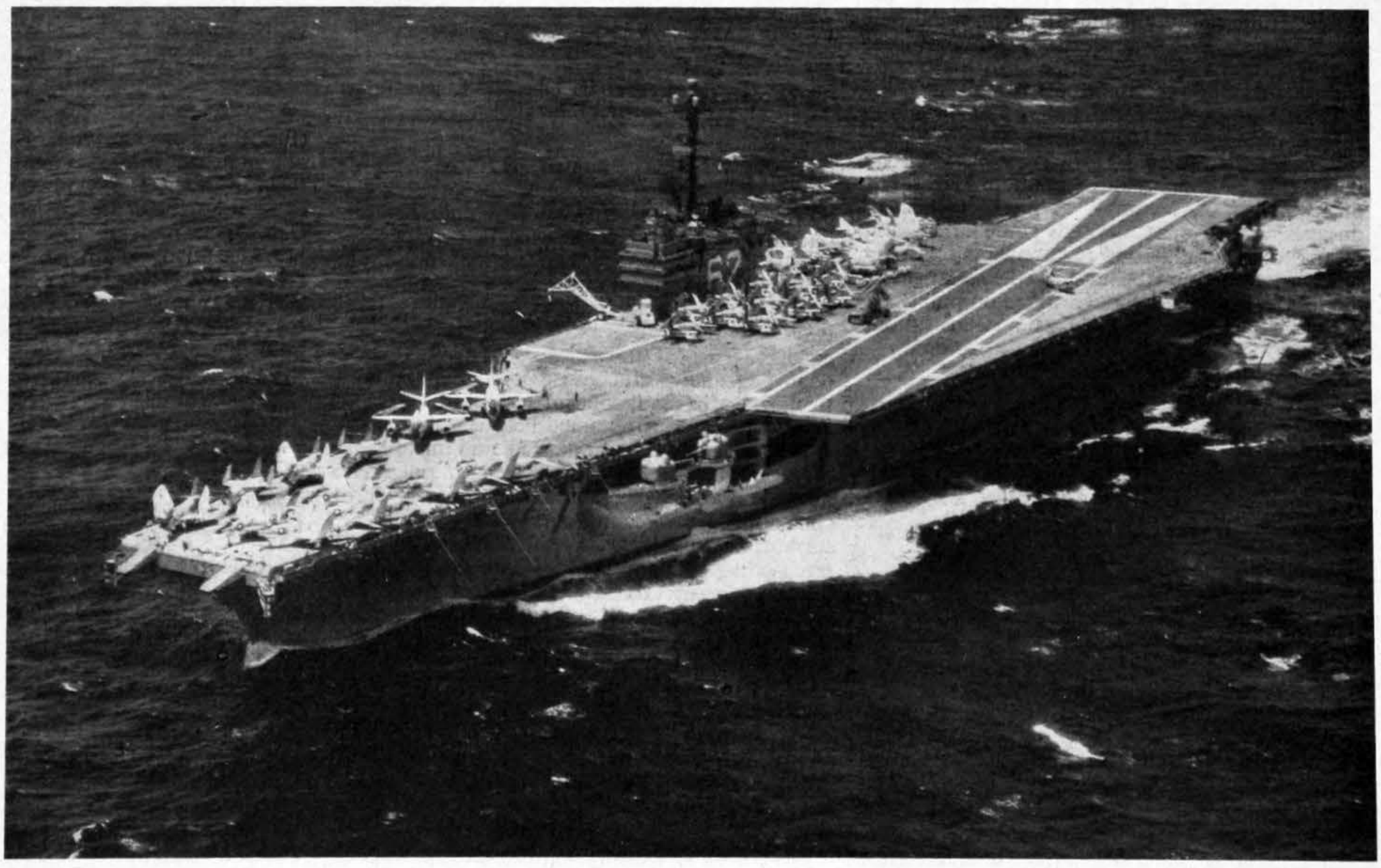
U.S. Warships

The U.S.S. "Long Beach" (ABOVE) is the first nuclear-powered surface fighting ship to be launched in the world, and the first surface ship to be armed with a main battery of guided missiles. She has a displacement of 14,000 tons, an overall length of 721ft, and a beam of 73ft. Her armament will consist almost entirely of guided missiles. She will also carry electronic devices and weapons for destroying submarines. Her main machinery comprises two Westinghouse Electric Corporation pressurised water-cooled nuclear reactors and a two-shaft arrangement of General Electric Company geared turbines.

The "Claud Jones" (RIGHT) is a diesel-propelled destroyer escort. These vessels embody a unique upper deck arrangement, aluminium masts and deck houses. Her displacement is 1450 tons standard, 1930 tons full load, with an overall length of 312ft and beam of 39ft. Armament includes two 3in dual-purpose guns, two hedgehogs and a depth-charge thrower. Main propelling machinery consists of four diesels with reduction drive to one shaft.



The U.S.S. "Independence," the world's largest conventionally powered aircraft carrier, was built by the New York Naval Shipyard; she has a displacement of 60,000 tons standard and 76,000 tons full load with an overall length of 1047ft, a waterline beam of 129ft 6in, and an extreme width of 252ft. She is capable of carrying 100 of the latest jet aircraft. Her propelling machinery comprises eight Babcock and Wilcox boilers and four sets of cross-compound double-reduction geared turbines turning four screws and developing 260,000 s.h.p., equal to a speed of 35 knots. She has a fully angled deck, four steam catapults, four deck edge elevators—three on the starboard side and one on the port—and three launching areas for aircraft. She has eight 5in dual-purpose guns and can launch guided missiles.



THE AMERICAN SCENE *(Continued)*

the same accelerator. Also, for other fields of radiation research, this design of accelerator can be modified to produce positive ions and neutrons. Standard machine controls and laboratory techniques provide regulation of dose rate, energy, current and beam configuration over wide ranges. Additional equipment is available to provide X-ray scanning, electron pulsing and beam bending.

Radiation Dosage

As a consequence of the variety of potential applications for radiation energy, a wide range of dosage levels must be considered. The irradiation of grain to retard storage losses, through the destruction of insect larvæ, for instance, may need only 1/10,000 of the radiation dosage needed for the improvement of the temperature resistance of polyethylene. The dosage required for a given process, then, is a major determinant in establishing processing costs and in selecting the type of radiation source to be used.

In the published literature, radiation doses are reported in a number of different units. They are often derived from, or related to, the röntgen, which has long been used as a unit of X-ray dosage. This is frequently determined from the amount of ionisation produced in a gas in a special chamber. The röntgen has been defined as " that quantity of X-rays or gamma rays which will produce, as a consequence of ionisation, one electrostatic unit of electricity, of either sign, in one cubic centimetre of dry air as measured at 0 deg. Cent. and standard atmospheric pressure." The equivalent energy absorption is about 84 ergs per gramme of air. Later, a unit based on the energy absorption in body tissue, which is nearly like water, was used. In water, the equivalent energy absorption of one röntgen is about 93 ergs per gramme. This unit is called a " rep."

More recently, the use of still another unit—the " rad "—has become accepted widely in radiation processing applications. The rad is arbitrarily defined as the absorption of 100 ergs per gramme, independent of the nature of the irradiated substance. These units can be readily transposed into the more common industrial terms associated with electrical energy. Radiation dosage can be reported, for instance, in watt-seconds per gramme. In reviewing the published literature, one must bear in mind that the dosages cited, regardless of the units used, must be viewed critically in terms of the experimental irradiation procedure for each case. Frequently, for example, one finds average radiation dosages reported for a given irradiated sample, without regard for possible variations between maximum and minimum levels at different parts of the sample. While the published dosages can serve as a rough guide in making estimates of the radiation requirements for some of the processes now being studied, the ranges in the following table, although based on published work, are presented merely as an illustration. Most applications are only partially explored.

	Dose in Megarads	Power in lb per kWh
Deinfestation	0·025–0·1	10,000–30,000
Food preservation	0·1–5·0	200–8,000
Graft polymerisation	1–2	400–800
Drug and medical supply sterilisation	2–3	250–400
Polyester curing	5–10	80–160
Silicone vulcanisation ...	5–15	50–160
Colouring of plastics	15–20	40–50
Rubber vulcanisation	10–40	20–80
Polyethylene cross-linking ...	20–60	10–40

Beam Penetration

The electron-beam energies of particular concern for processing applications are between about 0·5 MeV and 15 MeV. One MeV is the energy carried by an electron accelerated across a voltage difference of 1,000,000V. The practical size limit for a direct accelerator like the Van de Graaff is about 4 MeV ; above this energy, the most suitable acceleration method is an indirect one—the use of the microwave linear accelerator. The range, or penetrating ability, of the beam varies nearly in direct proportion to its energy and in inverse proportion to the density of the material being irradiated. For a given beam energy the range may be expressed in terms of the weight of material to be irradiated per unit of its area, which takes into account both density and thickness. Thus, penetration is frequently expressed in grammes per square centimetre, which is the product of the thickness, in centimetres, and the density, in grammes per cubic centimetre. For water or other unit specific gravity material, the thickness in centimetres equals the number of grammes per square centimetre. It has thus become common practice to express thickness as " the equivalent thickness at unit specific gravity," which is obtained by multiplying the thickness by the specific gravity of the material being irradiated. Therefore, a 0·005in aluminium sheet is equivalent to 0·0135in at unit gravity.

While the total beam energy is all delivered within the above range, the dose is not uniform at all depths. For a mono-energetic beam—i.e. one in which all the electrons carry the same energy—the radiation dose varies in depth as shown in the accompanying graph. This curve

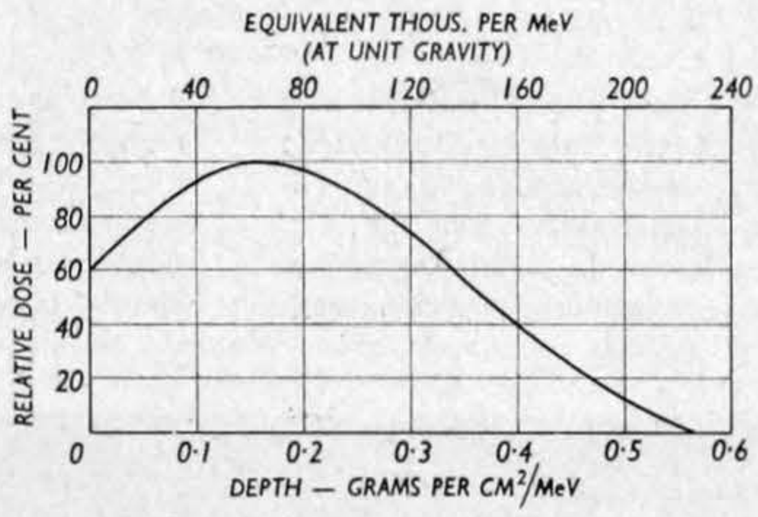


Fig. 1—Graph of ionisation intensity v. penetration for one-sided irradiation

is typical of that obtained with the Van de Graaff accelerator. The same general shape is produced by the microwave linear accelerator, but the relative entrance dose is considerably greater. Dosage, measured as ionisation, increases to a maximum at a point about one-third along the total range. At a depth about two-thirds of the total range, the relative dose is equal to that at the surface. This particular depth is significant because it is the optimum thickness of a rigid, solid material to use. Here the best balance is obtained between minimising over-dosage beyond that desired, and maximising the total use of the beam penetration. The above curve and the discussion thus far have considered the directing of a beam at only one surface of a material. When irradiation is done on both sides of a product—a technique called " double bombardment "—a mirror image of the penetration curve is obtained from the other side (Fig. 2).

Because the dosages in the last third of the range of each of the opposed beams are additive, the most useful thickness for double bombardment is more than twice that obtained with single-side irradiation. As shown in accompanying graph, the most useful product thickness for irradiation from two sides is 2·4 times that for single bombardment from one side.

In the case of a solid material, the product can be turned over after irradiation on one side and passed through the beam a second time. This does not reduce the processing rate but, rather, increases it. While the linear speed is halved by running two passes, the product thickness is more than doubled over that which would have been used on one pass at the faster speed. In order to use two-sided irradiation of liquid products, which cannot be turned over without

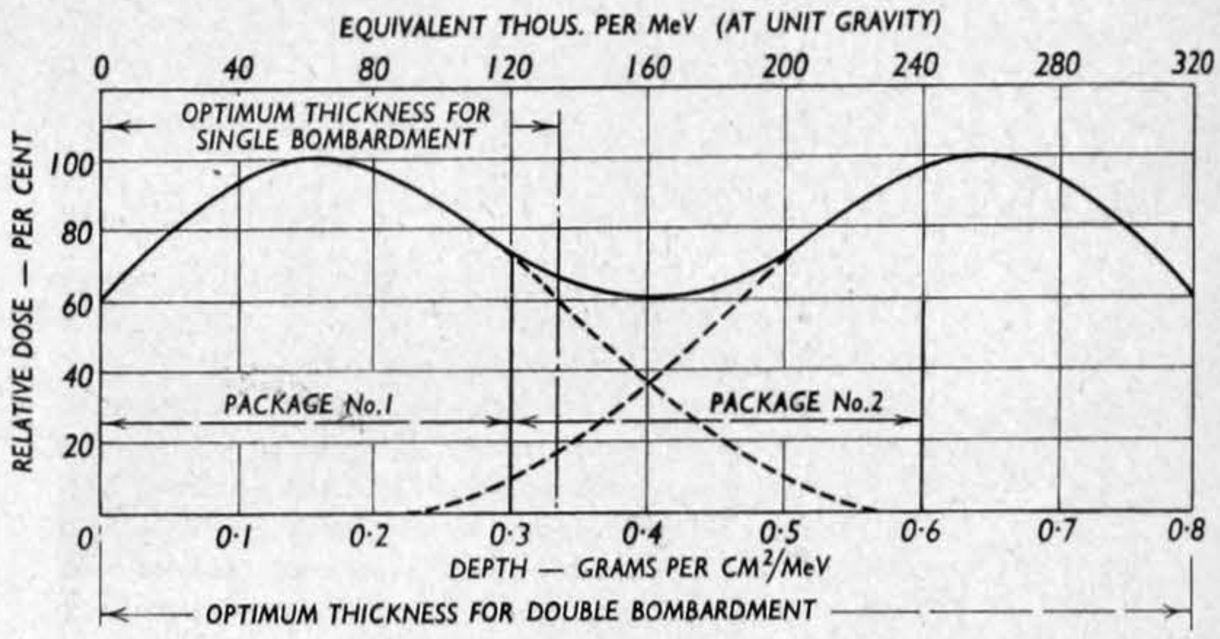


Fig. 2—Depth profile plot for a fixed package thickness at a given voltage

internal mixing, simultaneous bombardment from both sides is required. This can be provided by a " cross-fire " from two accelerators or by the inversion of a portion of a beam from one accelerator. This may be a valuable technique in those cases where it is desired to avoid the use of a higher-energy accelerator.

Since flexible packages of plastic or aluminium are now used industrially for all types of materials, including powders, liquids and gels, it is usually most economical to design the product thickness and its container for optimum use of one of the beam energies available. If the product thickness cannot be altered to suit the energy for optimum use, special positioning on the conveyor line can often be designed. An example is shown

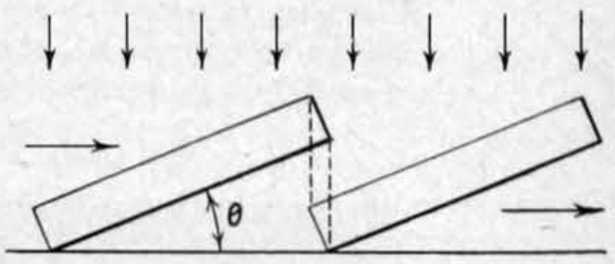


Fig. 3—Package inclination to obtain maximum radiation

(Fig. 3) of a product which is slightly too thin for optimum use in a single-sided process, but too thick to permit use of three flat layers on top of each other for a double irradiation. However, if the packages are inclined at an angle that presents an optimum path in thickness to the beam, the production rate will be increased. The optimum angle of inclination, θ, is related to product thickness and beam energy by the following expression :

For single-side irradiation : $\cos\theta = \frac{t}{0{\cdot}13 \times \text{MeV}}$.

For double-side irradiation : $\cos\theta = \frac{t}{0{\cdot}31 \times \text{MeV}}$

where t = product thickness in inches equivalent to unit gravity.

Many materials considered for electron processing do not present a uniform thickness to the beam. In that case, the thickest portion must be considered in deciding what beam energy is needed for penetration. Sometimes stacking arrangements can be designed to offset an uneven depth profile.

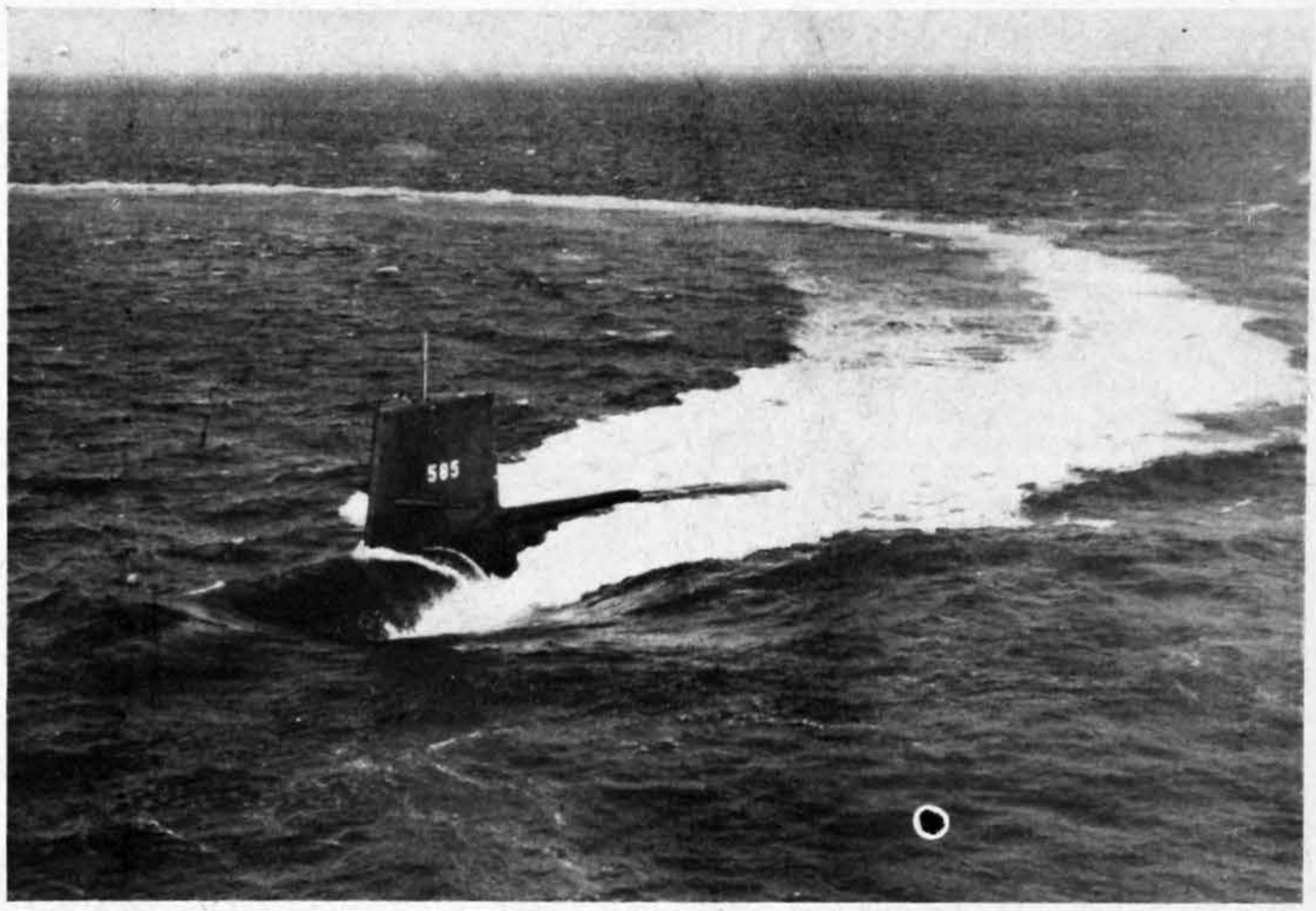
Efficiency of Beam Utilisation

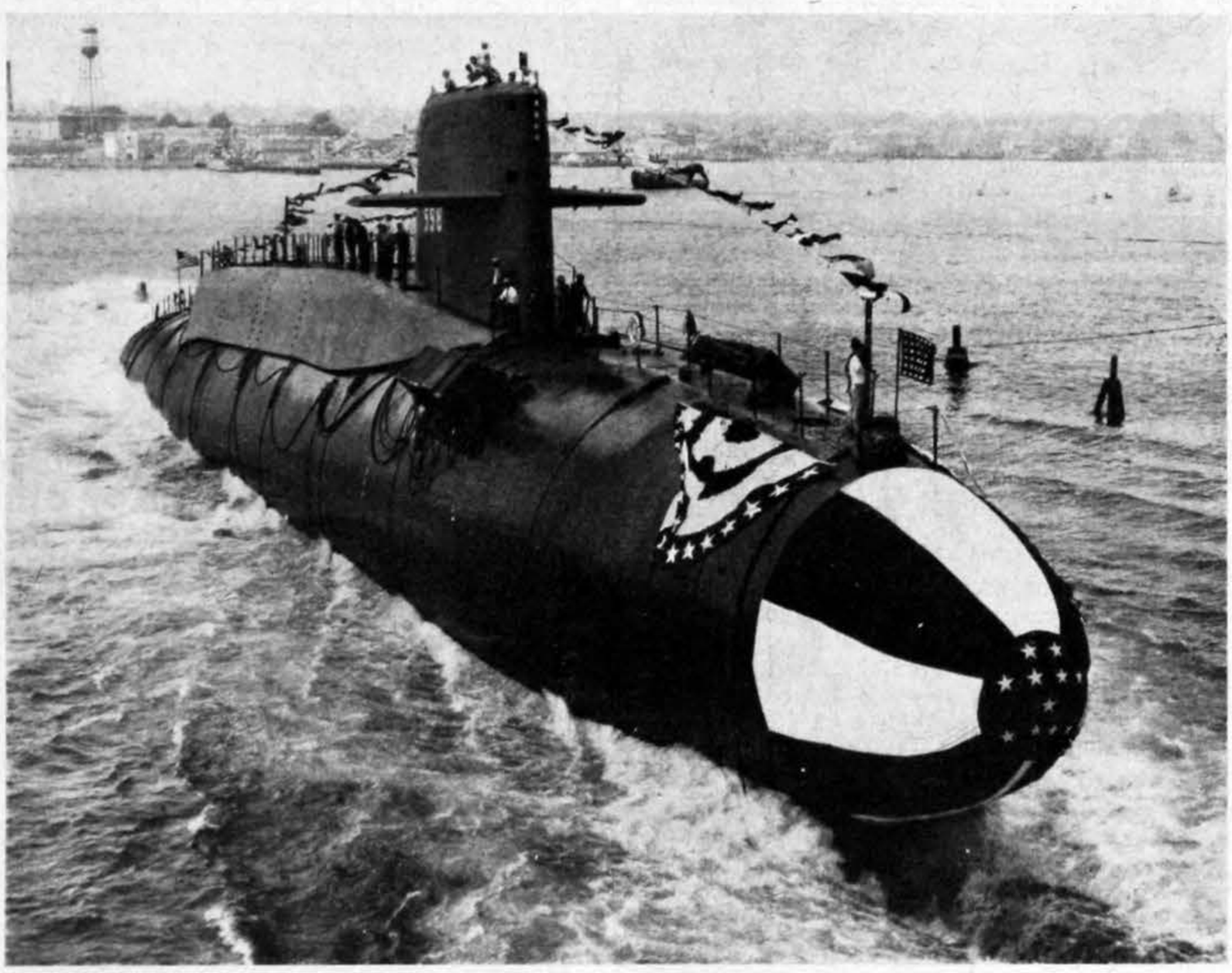
To obtain maximum efficiency and minimum cost in a radiation process, it is necessary : (*a*) that the maximum possible fraction of the electron-beam power be absorbed in the product,

U.S. Submarines

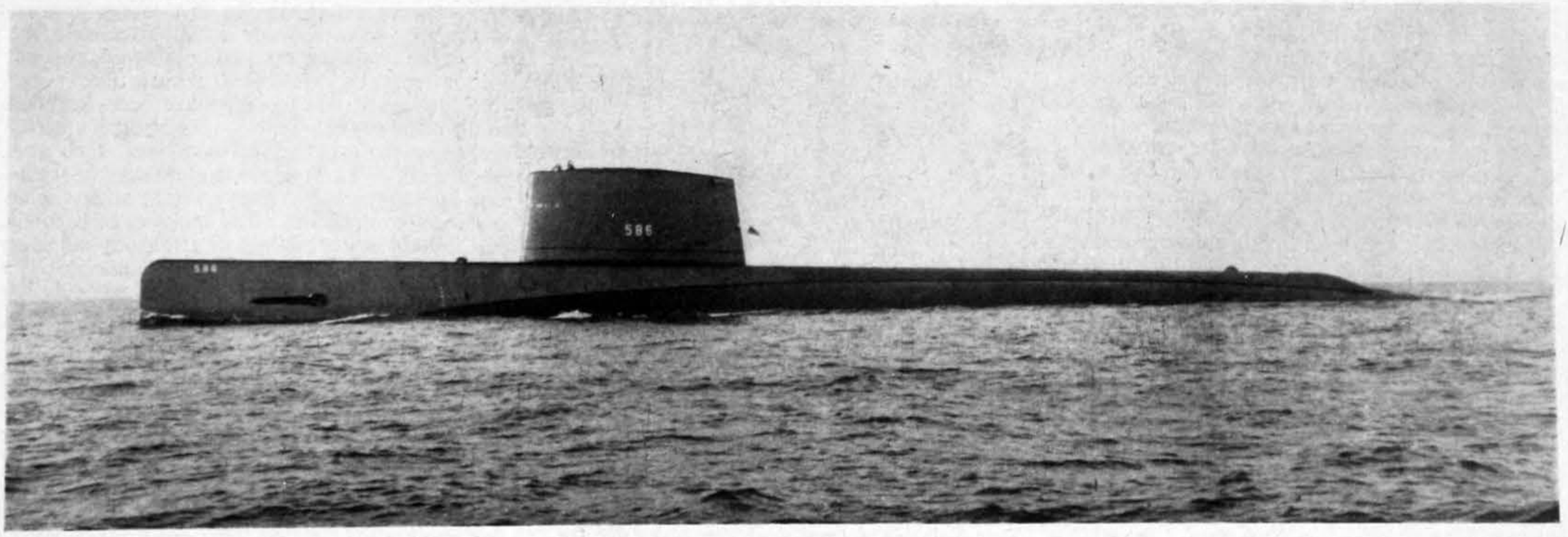
U.S.S. "Skipjack" (RIGHT), one of a total of thirty-three nuclear-powered submarines known to be in various stages of construction in the U.S.A., is here shown at speed on the surface, after successful completion of the first of her builder's trials last March. She is considered to be the fastest of the nuclear-powered submarines, and was built by the Electric Boat division of the General Dynamics Corporation.

The "George Washington," illustrated BELOW at her launching at Groton, Connecticut, last June, has a displacement of 5600 tons standard and 6700 tons submerged, a length of 380ft and a beam of 32ft. Her armament comprises fourteen "Polaris" missiles (30ft long, 50in diameter, with nuclear warheads and a range of 1500 miles), as well as four 21in torpedo tubes forward. The main propelling machinery consists of a Westinghouse water-cooled nuclear reactor and General Electric geared turbines, but there is also an auxiliary diesel engine and batteries, both of which can be used for emergency propulsion.





Also completed in 1959 was the U.S.S. "Triton" (BELOW), the world's largest and most powerful submarine, on September 28, 1959. Built by the Electric Boat division of the General Dynamics Corporation, Groton, Connecticut, and engined by The General Electric Company, she is the United States Navy's first submarine to be powered with two nuclear reactors. As the first nuclear-powered radar picket submarine, she is designed to serve as an early warning station for U.S. Navy task forces, and to keep up with the fastest aircraft carriers and destroyers. With a displacement of 5900 tons standard and 8000 tons submerged, she has an overall length of 447ft and a beam of 37ft. Her two water-cooled reactors and geared turbines turning two shafts give her a speed of 30 knots. She is armed with six 21in torpedo tubes. She cost 100,000,000 dollars.



THE AMERICAN SCENE *(Continued)*

and (*b*) that the radiation dosage level in all parts of the product be as nearly uniform as possible, i.e. that the required minimum level be achieved throughout, with as little over-dosage or wasted energy as is practical. Any portion of the electron beam that does not hit the product is, of course, wasted—as is any portion of the beam that passes completely through the product and is not absorbed. Radiation is also wasted when any part of the product receives a higher dosage than necessary. In selecting irradiation techniques for greater efficiency, therefore, two factors must be considered: (*a*) the distribution of the beam energy over the product area, and (*b*) the absorption of the beam through the product thickness. The overall beam utilisation efficiency is the product of these two factors: the efficiency of area irradiation and the thickness efficiency of absorption.

The methods by which the efficiency of beam use is calculated are related to the geometry of the beam and to a time factor called dose rate. The dose rate is important in comparing the relative effectiveness of radiation sources for use with chain reactions. The net effect produced by radiation in a chain-reaction process, such as free-radical polymerisation or graft polymerisation, depends not only on the dose used but also on the rate at which the dose is applied. This rate is a characteristic of the radiation source. Gamma sources and X-ray generators produce very low dose rates. Electron accelerators, particularly those with pulsed beams, produce extremely high intensities. The approximate intensities are shown in the table below.

Source	Dose rate	Remarks
250kV X-ray generator, 10 ma	180,000 r. per hour	In air at 10cm
10,000 curies Cobalt^{60}	1·3 megaröntgens per hour	In air at centre of 8in diameter cylindrical source
Van de Graaff accelerator, 1·0ma	250 megarads per second	Volume average for 1cm diameter beam
Resonant transformer 1·0ma	1250 megarads per second during pulse	Volume average for 1cm diameter beam: assumes 72 deg. phase-conduction angle
Linear accelerator, 1·0ma	125,000 megarads per second during pulse	Volume average for 1cm diameter beam; assumes duty cycle of 0·002

With a gamma or X-ray source, the intensity is inversely proportional to the square of the distance. The peak-point intensities of accelerator beams are about three times the volume-average intensities. Various methods of beam diffusion can be used with accelerators to reduce peak intensities, as desired for those chain polymerisation reactions that are more effective at lower dose rates.

The electron beam produced by a particle accelerator is brought out of the machine through a thin metal window. The beam passing through this window is approximately circular in cross-section and may vary in diameter from a fraction of a millimetre to several centimetres. Regardless of exact size or shape, it is most intense at the centre, and its intensity falls off sharply towards the circumference.

For processing purposes, this lack of uniformity in lateral intensity leads to two forms of radiation wastage in cases where a minimum dosage level must be maintained across the product. Both are illustrated in the accompanying graph which shows, in cross-section, that a

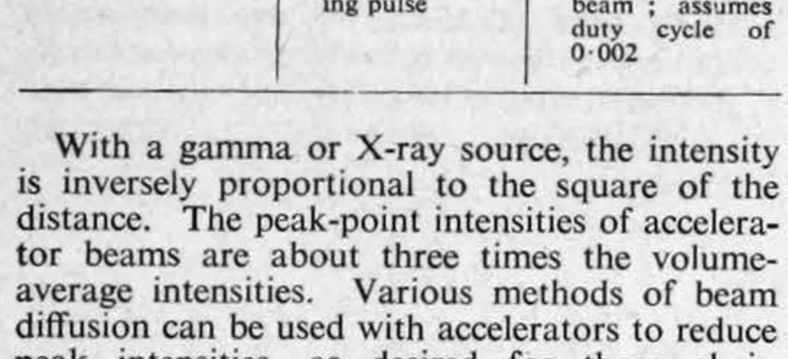


Fig. 4—Lateral intensity distribution of an unscanned electron beam

product of rectangular shape receives an over-dosage at the centre, while a substantial portion of the beam, of necessity, misses the product edges completely. When products are passed through such a beam on a moving conveyor, the best attainable area efficiency of irradiation is about 50 per cent. This efficiency can be greatly increased if the electron beam is scanned. In scanning, the beam is rapidly deflected back and forth inside the vacuum of the acceleration tube extension, emerging through a thin, slot-shaped metal window. Although this technique is most effective with the mono-energetic electron beams produced by Van de Graaff accelerators, similar scanning methods are also applicable to microwave linear accelerators.

The dosage distribution across a product moving through such a beam is shown in the

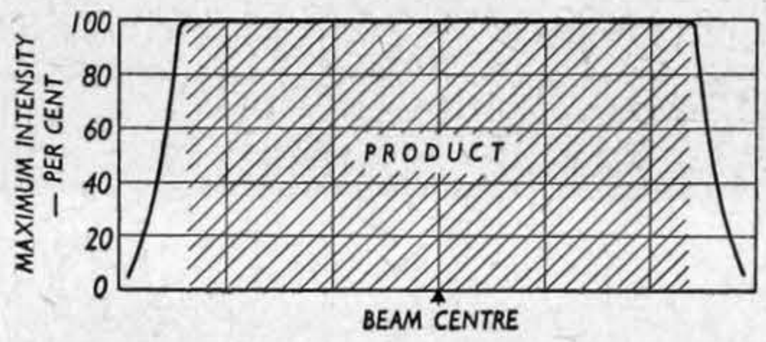


Fig. 5—Lateral intensity distribution of scanned electron beam

accompanying graph. The lateral dose distribution is now uniform except for slight edge losses. The radiation intensity delivered in the other dimension of the product area is made uniform by continuously conveying the product under the beam at constant speed. With rectangular objects, a conservative over-scan is used to ensure proper dosage at the edges. Even with over-scan, area efficiencies exceeding 90 per cent are attained if the product flow is uninterrupted. However, there will necessarily be some efficiency loss whenever the conveyor area is not completely covered with the product.

The dosage variation in depth, inherent in the absorption of electrons, must be taken into account in estimating the thickness efficiency of absorption. The thickness efficiency is approximately 60 per cent for single-side irradiation and between 65 and 70 per cent for double bombardment. Double bombardment, then, not only increases penetration about 2·4 times but also increases this thickness efficiency. The efficiency of double-sided irradiation can be further improved, at some sacrifice of product thickness, by a refinement of technique in which thin absorbing filters are interposed between the product and the beam. These filters might be the product-container walls. In this case, a suitable combination of product thickness and beam energy is chosen so that the dosage halfway through the product is equal to about 80 per cent of the maximum dosage in the product.

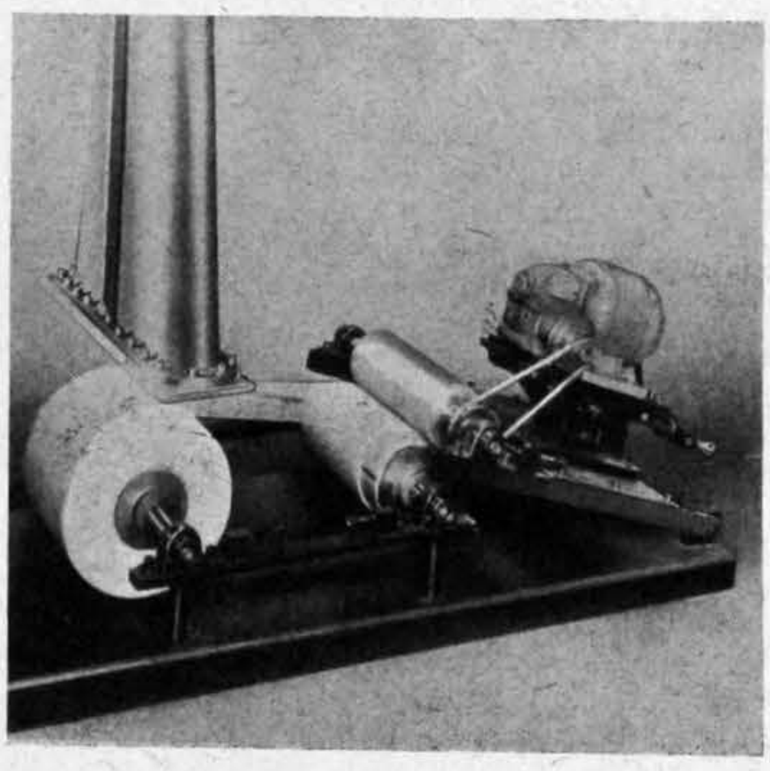


Fig. 6—Unwinding and rewinding device for the continuous irradiation of film rolls

Thickness efficiencies up to 75 per cent can be realised in this way.

Continuous flexible sheets or filaments of material whose thickness is substantially smaller than the range of the beam can be irradiated with thickness efficiencies close to 100 per cent. In the irradiation of a roll of film (Fig. 6) the film thickness is very small compared with the beam range, and the roll thickness is much greater than the beam range. The film is wound or unwound at constant linear speed while the roll is irradiated. Once a small initial amount is irradiated, all parts of the film receive the same integrated dosage, and all of the available radiation in depth is used until the end of the roll is reached.

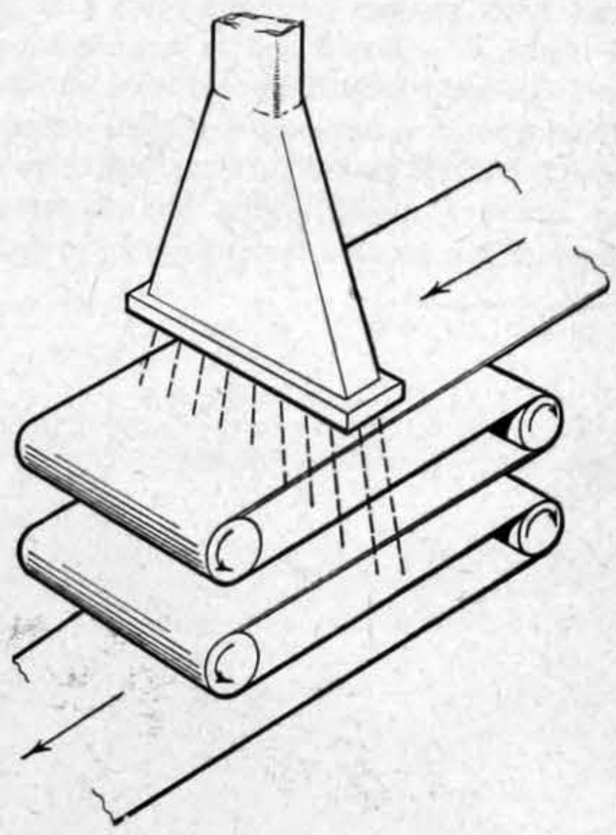


Fig. 7—Diagram of multiple-layer film processing technique

The diagram (Fig. 7) shows an alternative method for the efficient processing of film—a roller system that passes the film under the beam several times. Similar systems may be designed for fibres, insulated wires and tubing. With irregularly-shaped objects, it is necessary to consider their specific geometry to select the best processing method. For example, a cylinder might best be rotated while it is passing through the beam in the direction of scanning. This also applies to the treatment of wire insulation if the wall thickness is about equal to that which is optimum for the particular beam energy used. If the wall thickness is much less, both the diameter of the metal conductor and the wall thickness of insulation must be considered. If double bombardment is required, a continuous method for turning the wire through 180 deg. over pulleys can be used.

Whenever a product is contained in a package, some of the incident beam will be absorbed in the container walls; this loss must be deducted from the beam energy in calculating product efficiency. In single-side irradiation, only the top of the container need be considered, and the bottom may be discounted because the energy loss through it will already have been included in the efficiency calculation. Rotation is a useful technique for a cylindrical container, such as a large glass phial, in order to eliminate the variation in wall thickness which would otherwise be presented to the beam. The spinning of partially full containers is a method of artificially reducing the thickness of a product being irradiated.

There are some applications in which only the exterior surfaces of the product need be irradiated—to a depth, for example, of a few millimetres. This type of treatment appears promising for certain food preservation applications, such as the extension of storage life of packaged meats and cheese, or for surface effects on fabrics or films. In these cases, a relatively low-energy electron beam is generally indicated because the radiation dosage is required only near the product surface, leaving most of the volume untreated.

(*To be continued*)

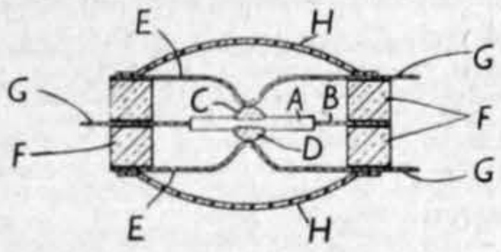
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

ELECTRONICS

824,255. September 12, 1955.—TRANSISTORS, Pye, Ltd., Radio Works, St. Andrews Road, Cambridge. (*Inventor : Dennis Quintrell Fuller.*)

It is an object of this invention to provide a simple construction of transistor in which efficient dissipation of the heat generated in the device, when in operation, is obtained. Referring to the drawing a

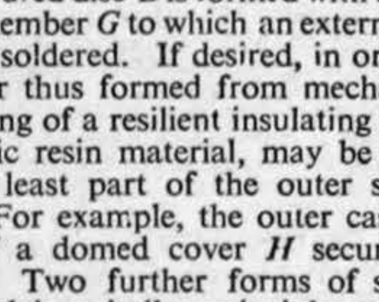


No. 824,255

transistor comprises a wafer *A* of semiconductor material, such as germanium, mounted on an apertured metal disc *B* surrounding the wafer which is formed with an emitter electrode *C* and a collector electrode *D* respectively on opposite sides extending over the aperture of the disc. The disc *B* forms the base electrode of the transistor. On each side of the disc supporting the germanium wafer is arranged a plate-like contact member in the form of a metal disc *E* of similar size to the apertured disc *B*, and provided with a dished or indented central portion which is arranged to contact the emitter and collector electrodes. The discs *B* and *E* are made of " Kovar " or another metal having a similar coefficient of expansion to glass. Silvered glass rings *F* are arranged between each surface of the disc *B* and the adjacent metal plate *E* and heat is applied to the peripheral edges of the metal plates in order to seal them to the adjoining metal surfaces and thereby form a hermetically sealed casing around the wafer of semiconductor material. The electrical connection between the emitter and collector electrodes and the adjacent metal plates may also be formed by applying heat to the dished or indented area of each metal plate. Each of the metal plates *E* and the apertured disc *B* is formed with a radially projecting tag member *G* to which an external connecting wire may be soldered. If desired, in order to protect the transistor thus formed from mechanical shocks, an outer casing of a resilient insulating material, such as a synthetic resin material, may be formed so as to cover at least part of the outer surface of the transistor. For example, the outer casing may take the form of a domed cover *H* secured over each metal plate. Two further forms of semiconductor device embodying similar principles of construction are illustrated in the specification.—*November* 25, 1959.

824,762. January 27, 1955.—THYRATRONS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2. (*Inventors : Henry de Boyne Knight and Norman Robert McCormick.*)

The object of this invention is to provide an improved electrode structure favouring rapid establishment of the anode-to-cathode arc in a thyratron device after the application of the firing pulse. The drawing illustrates the simplest form of the con-



No. 824,762

struction according to the invention. Aperture *A* through which the arc passes in the neighbourhood of the anode is formed by the spacing between a metal annulus *B*, shown fixed to cylinder *C*, and a metal disc *D* which is insulated from, and axially located with respect to, the annulus. The disc *D* is located at the side of the annulus nearer to the cathode *E* and is preferably of a diameter greater than that of the hole in the annulus. In the operation of the device, a priming discharge is passed between either annulus *B* or disc *D* and the cathode in advance of the application of the firing pulse to disc *D* or annulus *B* respectively. The dimensions of the aperture *A* and its disposition in relation to the anode *F* and the cathode determine the control characteristics of the valve ; they should be such that the main arc does not pass between anode and cathode on the establishment of the priming discharge and prior to the application of the firing pulse ; it may sometimes be acceptable for the latter to be superimposed on a negative voltage bias to assist control. Control is facilitated when the disc *D* has a greater diameter than that of the hole in annulus *B* because the anode cannot " see " the cathode. The specification illustrates preferred arrangements, in one of which the central disc electrode *D* is formed of two parts joined together, one in the plane of annulus *B* and the other nearer to the cathode. Rapid establishment of the arc between anode and cathode is facilitated if the discharge occasioned by the firing pulse takes place in the neighbourhood of aperture *A*. For this purpose a shield baffle may be fitted which substantially shields all electrodes from the cathode except for a portion near the aperture. Tne structural arrangement of a high power, hydrogen-filled thryratron embodying these principles is illustrated in the specification.—*December* 2, 1959.

AIRCRAFT ENGINES

824,332. July 4, 1957.—AIRSCREW-DRIVING GAS-TURBINE ENGINES, Rolls-Royce, Ltd., Nightingale Road, Derby. (*Inventors : Lionel Haworth and Jack Palfreyman.*)

According to the present invention, in an airscrew-driving gas-turbine of which the airscrew has a hydraulic pitch-change mechanism in its hub, the airscrew shaft is connected with the engine shaft through an epicyclic reduction gear the planet carrier of which is secured to rotate with the airscrew shaft. The planet carrier has projecting towards the engine, a tail shaft carrying no substantial torque and encircling the engine shaft. The means provided to supply pressure oil to the pitch-change mechanism comprise a stationary muff closely surrounding the tail shaft and feeding pressure oil to ducts in the shaft, an oil distributor member mounted in the planet carrier at its connection with the airscrew shaft and connected with supply ducting in the airscrew shaft. Oil transfer ducts and pipes within the planet carrier interconnect the ducts in the tail shaft and those in the distributor member. The muff is preferably also employed for the supply of lubricating oil to the bearings of the planet gears and other bearings within the planet carrier. It will be appreciated that since the tail shaft carries no substantial torque and the engine shaft, which the tail shaft encircles, carries a low torque as compared with the airscrew shaft, the tail and engine shafts may be of a substantially smaller diameter than the airscrew shaft. Thus oil leakage can be markedly reduced as compared with known arrangements. Also since the tail shaft carries no substantial torque, the possibility of high stress loadings in the shaft due to transverse drillings in it is avoided. Again since the muff is between the reduction gear and the engine it may be accommodated without increasing the length of the engine.—*November* 25, 1959.

NUCLEAR REACTORS

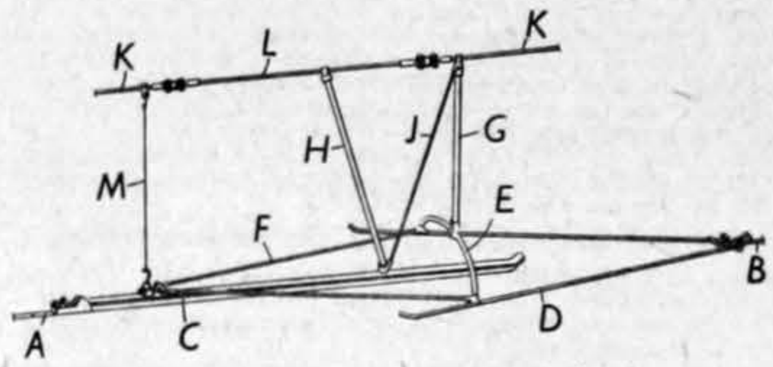
821,287. July 25, 1956.—IMPROVEMENTS IN CERMETS COMPRISING URANIUM AND URANIUM CARBIDE, United Kingdom Atomic Energy Authority, London.

This invention relates to cermets of uranium and uranium monocarbide, and to atomic reactor fuel elements comprising such cermets. Its objects are to provide cermet structures and atomic reactor fuel elements comprising such structures and having improved high temperature properties compared with uranium. In accordance with the invention a cermet comprises a continuous matrix of uranium monocarbide containing particles, or an intermeshing network, of uranium metal. A method of making said cermet comprises compacting an intimate mixture of powdered uranium and powdered carbon into a form-retaining structure (the carbon comprising less than 50 atomic per cent of the mixture) and sintering said structure by heating in an inert atmosphere at a temperature below the melting point of uranium, but sufficiently high to cause reaction between uranium and carbon. The carbon may, for example, comprise from 0·3 per cent to 4·5 per cent by weight of said mixture, to give cermets comprising 6·25 per cent to 93·75 per cent uranium monocarbide and correspondingly 93·75 per cent to 6·25 per cent uranium metal, by weight. Preferably compacting is carried out at a pressure of 10 to 15 tons per square inch and at a temperature of 650 deg. to 750 deg. Cent., and sintering is carried out at 1000 deg. to 1100 deg. Cent. In the invention, a fuel element for an atomic reactor consists wholly or in part of a cermet comprising a continuous matrix of uranium monocarbide containing within it particles, or an intermeshing network, of uranium metal. The nuclear fuel material of such a fuel element may, for example, consist of a cermet comprising 6·25 per cent to 93·75 per cent by weight uranium monocarbide and correspondingly 93·75 per cent to 6·25 per cent by weight uranium metal. Creep tests, in both compression and tension, have shown that the strength, and resistance to flow, of the cermet structures according to the invention are greater than those of pure uranium metal, at temperatures up to within 17 deg. Cent. of the melting point of uranium. These properties make them advantageous for use as the nuclear fuel material of fuel elements for atomic reactors operating at high temperatures, e.g. at temperatures up to about 1100 deg. Cent.—*October* 7, 1959.

RAILWAY ELECTRIFICATION

824,415. April 23, 1957.—SECTION INSULATORS FOR USE IN OVERHEAD CONDUCTORS, British Insulated Callender's Cables, Ltd., Norfolk House, Norfolk Street, London, W.C.2. (*Inventors : Talbot Cottom Broom, Arthur George Sweetland and Joseph Littler.*)

For the purpose of sectionalising the overhead electric conductor system, or for other reasons, it is the practice to insert section insulators in the system. Such insulators as have hitherto been used have been of massive construction and unduly heavy. They have the disadvantage of forming in the contact wire a " hard " spot which gives rise to severe arcing as the collector runs through, especially when it runs through at a high speed. It is the principal object of this invention to provide an improved form of section insulator which is lighter than, and comparatively free from the defects of, the heavy existing types of section insulator and which will be satisfactory for systems in which vehicle speeds are high. Referring to the drawing, the neighbouring ends of the contact wires *A*, *B* of two neighbouring sections of the system are separated by an air gap which is incompletely bridged by a rigid contact conductor



No. 824,415

C forming a continuation of the contact wire of one section and suspended near its free end. This conductor is capable of withstanding the upward thrust of a passing collector without substantial bending, by reason of the strut *H* and dropper *J*. The section insulator is shown suspended from a catenary wire *K* in which is inserted an insulator *L* of high tensile strength. The fixed end of rigid conductor *C* is suspended from the catenary by dropper *M*. For transferring a collector across the gap between the free end of this rigid conductor and the contact wire of the neighbouring section a pair of guides *D*, is provided. At one end each guide of the pair is connected mechanically to the end of the second contact wire. From their points of connection the guides gradually diverge as they approach the free end of the rigid conductor and, held laterally apart by a bridge *E* suspended by the strut *G*, pass one on each side of the rigid conductor which they overlap. At or near their free ends the guides are secured through elongated insulating members *F* directly or through a part of the rigid contact conductor to the first contact wire. These mutually divergent guides and the mutually converging insulating members together serve to transmit the tension from the contact wire of the one section to that of the other.—*December* 2, 1959.

Calendars and Diaries

We acknowledge receipt of calendars and/or diaries for 1960 from the undermentioned firms :

Frederick Parker, Ltd., Leicester.
Aveling-Barford, Ltd., Grantham.
Crofts (Engineers), Ltd., Bradford, Yorkshire.
Dispro, Ltd., 36–38, Peckham Road, London, S.E.5.
Lang Pneumatic, Ltd., Owen Road, Wolverhampton.
Turner Brothers Asbestos Company, Ltd., Rochdale.
The D.P. Battery Company, Ltd., Bakewell, Derbyshire.
Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire.
Lindemann Kommanditgesellschaft, Dusseldorf, Germany.
J. C. Bamford (Excavators), Ltd., Rocester, Uttoxeter, Staffs.
Edwards High Vacuum, Ltd., Manor Royal, Crawley, Sussex.
C. A. Parsons and Co., Ltd., Heaton Works, Newcastle upon Tyne, 6.
Balding Engineering, Ltd., Beaver Works, Bessemer Road, Norwich.
The Cape Asbestos Company, Ltd., 114–116, Park Street, London, W.1.
Caterpillar Tractor Company, Ltd., 55, St. James's Street London, S.W.1.
Associated Electrical Industries, Ltd., 33, Grosvenor Place, London, S.W.1.
Monsanto Chemicals, Ltd., Monsanto House, 10–18, Victoria Street, London, S.W.1.

Forthcoming Engagements

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

ANTIQUARIAN HOROLOGICAL SOCIETY

To-day, Jan. 8.—Science Museum, Kensington, London, S.W.7, " Bells and Bellfounding," Douglas Hughes, 7 p.m.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Jan. 8.—Liverpool and District Branch : Industrial Development Centre, M.A.N.W.E.B., Paradise Street, Liverpool, 1, " Control Centres for Modern Industry," R. Ritchie, 7.30 p.m.

Mon., Jan. 11.—Bournemouth and District Branch : Grand Hotel, Firvale Road, Bournemouth, Melling Regional Lecture, " New Methods and Technique in the Electrical Industry," H. G. Taylor, 8 p.m. ★ Central London Branch : White Hall Hotel, Bloomsbury Square, London, W.C.1, " Present-day Computers," W. F. M. Payne, 7.15 p.m. ★ North West London Branch : Century Hotel, Wembley, " Recent Developments in Telecommunications," H. E. J. Butler, 8.15 p.m.

Tues., Jan. 12.—Glasgow Branch : Kenilworth Hotel, Queen's Street, Glasgow, C.1, " Modern Lighting Technique," M. J. Powley, 8 p.m. ★ Chester and District Branch : Westminster Hotel, City Road, Chester, " Flameproof Electrical Equipment," W. T. Partington, 7.45 p.m. ★ Portsmouth and District Branch : Offices of the Ministry of Labour and National Service, Lake Road, Portsmouth, " Industrial Lighting Design," 7.30 p.m. ★ South Wales Branch : South Wales Institute of Engineers, Park Place, Cardiff, Films Evening, 7.30 p.m. ★ York Branch : Georgian House, Blossom Street, York, Films, 7.30 p.m.

Wed., Jan. 13.—Birmingham Branch : Exchange and Engineering Centre, Stephenson Place, Birmingham, 2, " Transformers," F. Yates, 7.30 p.m. ★ South East London Branch : Eltham Green School, Queenscroft Road, Eltham, London, S.E.9, " The Engineer in Chemical Manufacturing," A. F. Hickford, 7.45 p.m.

Thurs., Jan. 14.—Bradford and District Branch : Midland Hotel, Bradford, " Photocells and their Uses in Industry," 7.30 p.m.

Sat., Jan. 16.—Essex Branch : Visit to National Physical Laboratory, Teddington, 10 a.m.

BRITISH COMPUTER SOCIETY

Wed., Jan. 13.—Birmingham Branch : Large Theatre, Electrical Engineering Department, The University, Edgbaston, Birmingham, Symposium on " The Use of Computers for the Solution of Logical Problems—(*a*) ' Examination Timetables,' and (*b*) ' Railway Timetables,' " 6.30 p.m. ★ Hull Branch : Chamber of Commerce, Samman House, Bowlalley Lane, Hull, " Sorting and Summarising Methods for Computers," C. M. Berners-Lee, 7.30 p.m.

Thurs., Jan. 14.—Belfast Branch : 29, University Square, Belfast, " The Use of a Computer in Business Planning," C. M. Berners-Lee, 7.15 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Mon., Jan. 11.—Merseyside Section : University Club, 2, Mount Pleasant, Liverpool, " High Frequency Propagation—Its Present and Future Use for Communication Purposes," A. F. Wilkins, 7 p.m.

Wed., Jan. 13.—London Section : London School of Hygiene, and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, " A Proposed Space-charge-limited Dielectric Triode," G. T. Wright, 6.30 p.m. ★ South Wales Section : Welsh College of Advanced Technology, Cardiff, " Television Broadcasting Methods," H. J. M. Hockley and N. Hughes, 6.30 p.m. ★ North Eastern Section : Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle upon Tyne, " Data Processing Machines," J. Allen and J. Keating, 6 p.m. ★ West Midlands Section : Wolverhampton and Staffordshire College of Technology, Wulfruna Street, Wolverhampton, " Electronics in Medicine," P. Styles, 7.15 p.m.

BRITISH INTERPLANETARY SOCIETY

Sat., Jan. 9.—Lecture Theatre, Science Museum, London, S.W.7, Film Show on " Astronautics," 7 p.m.

Sat., Jan. 16.—Schools Lecture : Hoare Memorial Hall, Church House, London, S.W.1, " The Scientific Exploration of Space," N. H. Langton, 3 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Wed., Jan. 13.—Northern Region : Royal Station Hotel, Paragon Square, Hull, " The Workings of the Clean Air Act," 2.30 p.m.

Thurs., Jan. 14.—Southern Region : St. Ermin's Hotel, Westminster, London, S.W.1, Discussion on " Factors Affecting the Choice of New Boiler Plant," opened by W. Short, 10.30 a.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Jan. 11.—Sheffield Centre : Grand Hotel, Sheffield, Presidential Address, H. G. Campbell, 6.30 p.m.

Tues., Jan. 12.—Glasgow Centre : Kenilworth Hotel, Queen Street, Glasgow, " Modern Lighting Techniques," M. J. Powley, 8 p.m.

Wed., Jan. 13.—Edinburgh Centre : Y.M.C.A. Social Room, 14, South St. Andrew Street, Edinburgh, " Hospital Lighting," G. R. N. Chalmers, 6.15 p.m.

Thurs., Jan. 14.—Manchester Centre : Demonstration Theatre, Town Hall Extension, Manchester, " Lighting as an Aid to Police Photography," H. Martin, 6 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., Jan. 13.—Southampton Section : Technical College, St. Mary's Street, Southampton, Film, " The Foundryman's Raw Materials," 7.30 p.m.

Thurs., Jan. 14.—Beds and Herts Section : Town Hall, Luton, " Properties of Copper-Base Alloy Castings," F. Hudson, 7.30 p.m.

Mon., Jan. 18.—East Anglian Section : Lecture Hall, Public Library, Ipswich, " Production of Foundry Sands," A. R. Abraham, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Jan. 11.—Merseyside and North Western Section : Stephenson Room, Engineers' Club, Albert Square, Manchester, 2, " Human Problems in Marine Engineering," C. C. Pounder, 6.45 p.m.

Wed., Jan. 13.—Merseyside and North Western Section : International Library, Central Libraries, William Brown Street, Liverpool, " The Docks and Sea Channels of the Port of Liverpool," R. H. Stevenson, 7.30 p.m.

INSTITUTE OF METAL FINISHING

Wed., Jan. 13.—British Institute of Management, 80, Fetter Lane, London, E.C.4, " Stoving Paint Systems," A. W. Greig and F. G. Randall, 6.30 p.m.

INSTITUTE OF NAVIGATION

Fri., Jan. 15.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, " Heading Definition in Commercial Aircraft," J. F. Green and A. P. Glenny, 5.15 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., Jan. 11.—Scottish Centre : Institute of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, " Taking Stock on Maintenance," P. H. Wyke-Smith, 7.30 p.m.

Tues., Jan. 12.—Midlands Centre : Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, Film, " Wheels Round the World," W. K. Parker, 7.30 p.m. ★ South Western Group : Duke of Cornwall Hotel, Plymouth, " Research on the Testing and Performance of Commercial Vehicle Brakes," H. J. H. Starks, 7.30 p.m.

Wed., Jan. 13.—South Eastern Group : The Wig and Gown Hotel, Maidstone, " The Design of Radial-Flow Turbo-Chargers and their Application to Road Transport," E. Kellett, 7.30 p.m.

INSTITUTE OF SHEET METAL ENGINEERING

Wed., Jan. 13.—Midland Branch : Byng Kenrick Suite of the College of Technology, Gosta Green, Birmingham, Forum " Presses and Press Shop Equipment," 6.45 p.m.

INSTITUTE OF WELDING

Wed., Jan. 13.—South London Branch : 54, Princes Gate, London, S.W.7, " High Temperature Brazing—A Modern Joining Method," E. R. Perry, 7.30 p.m.

INSTITUTION OF AGRICULTURAL ENGINEERS

Tues., Jan. 12.—London Branch : 6, Queen Square, London, W.C.1, " New Methods in Silage Handling," F. S. Mitchell, and N. W. Dilke, 2.15 p.m.

Mon., Jan. 18.—Northern Centre : N.E. Electricity Board's Lecture Theatre, Carliol House, Newcastle upon Tyne, " Compaction of Soil by Cultivation Operations," E. R. Fountaine, 6.45 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Jan. 12.—Great George Street, London, S.W.1, " Some Experiments in Artificial Recharge in the Lower Lee Valley," E. S. Boniface, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Jan. 8.—Medical Electronics Discussion Group : Savoy Place, London, W.C.2, Discussion on " Electrical and Electronic Techniques in Respiratory Research," opened by R. Woolmer and D. W. Hill, 6 p.m.

Mon., Jan. 11.—Electronics and Communications Section : Savoy Place, London, W.C.2, " A Quadrature Network for Generating Vestigial-Sideband Signals," G. G. Gouriet and G. F. Newell ; " The Input Impedance of Rectifier Modulators," D. G. Tucker ; and " Rectifier Modulators with Frequency-Selective Terminations, with particular reference to the Effect of Even-Order Modulation Products," D. P. Howson and D. G. Tucker, 5.30 p.m. ★ North-Eastern Centre : Neville Hall, Westgate Road, Newcastle upon Tyne, " Research on the Performance of High-Voltage Insulators in Polluted Atmospheres," J. S. Forrest, P. J. Lambeth and D. F. Oakeshott, 6.15 p.m. ★ South Midland Supply and Utilization Group : College of Technology, Gosta Green, Birmingham, " Electrical Supplies to Power Station Auxiliaries," D. A. Dewison, 6 p.m. ★ Western Centre : The University, Bristol, " The Application of Low-Pressure Resins to Some High-Voltage Switchgear Designs," T. R. Manley, K. Rothwell and W. Gray, 6 p.m.

Tues., Jan. 12.—North-Eastern Centre : College of Further Education, Workington, " Submersible Pumping Plant," H. H. Anderson and W. G. Crawford, 7 p.m. ★ North Western Utilization Group : Engineers' Club, Albert Square, Manchester, " The Characteristics and Protection of Semiconductor Rectifiers," D. B. Corbyn and N. L. Potter, 6.15 p.m. ★ Northern Ireland Centre : David Keir Building, Queen's University, Stranmillis Road, Belfast, " Generator/Motor Problems in Pumped-Storage Installations," J. H. Walker, 6.30 p.m.

Wed., Jan. 13.—Supply Section : Savoy Place, London, W.C.2, " Gaseous Discharge Phenomena in High-Voltage D.C. Cable Dielectrics," E. C. Rogers and D. J. Skipper, 5.30 p.m. ★ North Lancashire Sub-Centre : North-Western Electricity Board Demonstration Theatre, Friargate, Preston, " Electrification of the U.K.A.E.A. Industrial Group Factories," J. W. Binns and W. J. Outram, 7.15 p.m.

Thurs., Jan. 14.—West Wales (Swansea) Sub-Centre : Conference Room, S.W.E.B. Showrooms, The Kingsway, Swansea, " Silicone Electrical Insulation," J. H. Davis, 6 p.m. ★ North Scotland Sub-Centre : Electrical Engineering Department, Queen's College, Dundee, " The 'Deltic' Locomotive," C. M. Cock, 7 p.m.

Fri., Jan. 15.—North Scotland Sub-Centre : Robert Gordon's Technical College, Aberdeen, " The ' Deltic ' Locomotive," C. M. Cock, 7.30 p.m.

INSTITUTION OF ENGINEERS IN CHARGE

Wed., Jan. 13.—Lancaster Room, Caxton Hall, London, S.W.1, " Water Treatment and its Control," C. J. Hasler, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Sat., Jan. 9.—Eastern Graduates' Section : Visit to Reavell and Co., Ltd., Ipswich, 9 a.m. ★ London Graduates' Section : Visit to Arthur Guinness, Son and Co., Ltd., Park Royal, 10.30 a.m.

Tues., Jan. 12.—Automobile Division : 1, Birdcage Walk, London, S.W.1, Crompton-Lanchester Lecture, " Combustion Chamber Design and the Influence of Fuel Quality," D. Downs, 6 p.m.

Wed., Jan. 13.—London Ordinary Meeting : 1, Birdcage Walk, London, S.W.1, " The Strength of Rails with Particular Reference to Rail Joints," S. Wise, D. Lindsay and I. G. T. Duncan, 6 p.m.

Thurs., Jan. 14.—East Midlands Branch : Room C4, Engineering Building, The University, Nottingham, Joint meeting with the East Midlands Graduates' Section, " Some Elements of Refrigeration," T. F. Roylance, 7.15 p.m. ★ Industrial Administration and Engineering Production Group : Engineers' Club, Albert Square, Manchester, " Use of Small Models in Engineering," L. Marsden, 6.45 p.m. ★ Scottish Branch : Royal College of Science and Technology, Glasgow, Annual General Meeting, and " Nuclear Power, Past, Present and Near Future," J. Diamond, 7.30 p.m. ★ Yorkshire Branch : The University, Leeds, Annual General Meeting, 6.30 p.m.

Fri., Jan. 15.—Scottish Branch : North British Hotel, Edinburgh, " Nuclear Power, Past, Present and Near Future," J. Diamond, 6.30 p.m.

Sat., Jan. 16.—London Graduates' Section : 1, Birdcage Walk, Westminster, London, S.W.1, " The Future of the High-Speed Reciprocating Internal Combustion Engine," J. H. Pitchford, 3 p.m.

INSTITUTION OF PLANT ENGINEERS

Mon., Jan. 18.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, " The Engineering Problems Anticipated in Space Travel," M. J. Brennan, 7 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Jan. 11.—East and West Ridings Region : Hotel Metropole, King Street, Leeds, 1, " Production Engineering Problems in Connection with the Manufacture of Tubes," D. B. Such, 7 p.m.

Tues., Jan. 12.—East and West Ridings Region : Technical College, Doncaster, " Designing and Applying Carbide Tools," 7 p.m.

Wed., Jan. 13.—Midlands Region : Star and Garter Hotel, Victoria Street, Wolverhampton, " The Return of Quality as a Production Responsibility," R. K. Grunau, 7.15 p.m. ★ North Western Region : Exchange Hotel, Tithebarn Street, Liverpool. 1, " Impact Extrusion," F. Howard, 7.30 p.m. ★ Wales Region : Central Library, Swansea, Forum, " Craft and Technical Training of Apprentices to meet the Modern Industrial Trend," 7 p.m.

Thurs., Jan. 14.—South Eastern Region : Harlow College of Further Education, Town Centre, Harlow, " Production Engineering," K. J. Olney, 7.30 p.m.

Fri., Jan. 15.—Eastern Region : Golden Lion Hotel, Cornhill, Ipswich, " The Contribution of Epoxide Tooling to Engineering," E. M. White, 7.30 p.m.

Mon., Jan. 18.—North Midlands Region : Louis Room, St. James's Restaurant, St. James's Street, Derby, " Production of the A.W.A. ' Argosy ' Aircraft," R. A. Courtman, 7 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Jan. 11.—Leicester Section : Grand Hotel, Leicester, " Some Recent Developments in Rubber and Plastics Machinery," K. M. Wilson, 6.45 p.m. ★ Manchester Section : Newton Heath Technical College, Manchester, " White Reinforcing Filler," J. D. Harris, 6 p.m. ★ Midland Section : James Watt Memorial Institute, Great Charles Street, Birmingham, " The Physical Structure of Rayon Tyre Yarns," E. V. Reeves, 6.45 p.m.

Tues., Jan. 12.—London Section : Royal Society of Tropical Medicine and Hygiene, Manson House, 26, Portland Place, London, W.1, " Chemical Plant Lining," J. Westhead, 5.30 p.m. and " Hypalon Coatings," J. N. Milne, 7 p.m. ★ Scottish Section : Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, C.2, " The Newer Polymers," D. A. W. Izod, 7.30 p.m.

Wed., Jan. 13.—Southern Section : Polygon Hotel, Southampton, " Some Recent Developments in Rubber and Plastics Machinery," K. M. Wilson, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Jan. 8.—Western Counties Branch : University Engineering Laboratories, Bristol, " Practical Applications of the Engineer's Training," C. E. Saunders, 6 p.m.

Wed., Jan. 13.—Yorkshire Branch : Royal Victoria Hotel, Sheffield, " The Clifton Bridge, Nottingham," R. M. Finch and A. Goldstein, 6.30 p.m.

Thurs., Jan. 14.—London Branch : 11, Upper Belgrave Street, London, S.W.1, " The Design and Construction of the New Assembly Building for the Ford Motor Company, Ltd., Dagenham," D. Lax and F. T. Bunclark, 6 p.m. ★ Lancashire and Cheshire Branch : College of Building, Liverpool, " A Swiss System of Prestressed Concrete and Some British Applications," J. B. Ashton, 6.30 p.m.

Fri., Jan. 15.—Midland Counties Branch Graduates' and Students' Section : Birmingham Exchange and Engineering Centre, Birmingham, " Extension to the Isle of Grain, Kent Refinery, for British Petroleum Company, Ltd.," R. Adams, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Jan. 8.—North Western Section : Engineers' Club, Albert Square, Manchester, " Human Relations in the Electricity Supply Industry," 7.30 p.m. ★ London Section : Pepys House, 14, Rochester Row, London, S.W.1, " Coastal Shipping," H. Higgs, 7 p.m.

Mon., Jan. 11.—Sheffield Section : Livesey Clegg House, 44, Union Street, Sheffield, 1, Film, " The Inquisitive Giant," 7.30 p.m.

Fri., Jan. 15.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, " A Radio Navigation Aid for Ships and Aircraft," C. Powell, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Jan. 15.—Engineers' Club, Albert Square, Manchester, 2, " Aircraft Blind Landing Systems," J. S. Shayler, 6.45 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Jan. 15.—Lecture Theatre, Mining Institute, Neville Hall, Newcastle upon Tyne, " Off-Shore Drilling Barges," W. Pratt, and W. A. Roy, 6.15 p.m.

PLASTICS INSTITUTE

Mon., Jan. 11.—Midlands Section : Grand Hotel, Leicester, " Some Recent Developments in Plastics and Rubber Machinery," K. Wilson, 6.45 p.m.

Wed., Jan. 13.—S. Wales and Monmouthshire Section : Angel Hotel, Cardiff, " Plastics in Building," V. H. Wentworth, 7 p.m. ★ Southern Section : Polygon Hotel, Southampton, " Recent Developments in Rubber and Plastics Machinery," K. M. Wilson, 7.30 p.m. ★ Yorkshire Section : St. Mark's House, 186, Woodside Lane, Leeds, 2, " P.T.F.E. Applications and Uses," G. W. Bowley, 7.15 p.m.

Fri., Jan, 15.—Midlands Section : James Watt Memorial Institute, Great Charles Street, Birmingham, 3, " Plastics in Electronics," H. A. K. Eden, 6.30 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Wed., Jan. 13.—Corrosion Group : 14, Belgrave Square, London, S.W.1, " Corrosion Problems of High Temperature Pressurised Water Reactors," J. N. Wanklyn, 6 p.m.

SOUTH WALES INSTITUTE OF ENGINEERS

Thurs., Jan. 14.—Institute Buildings, Park Place, Cardiff, " The Construction of Shallow Tunnels and Deep Culverts," G. A. Jones, 6 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

Fri., Jan. 15.—39, Elmbank Crescent, Glasgow, Joint Meeting with the Iron and Steel Institute, Engineers' Group, " Engineering Aspects of a Modern Open-Hearth Steel Plant," J. A. Kilby, and J. C. Gordon, 6.45 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., Jan. 13.—London Branch : Hope House, 45, Great Peter Street, Westminster, London, S.W.1, " Health Physics and Nuclear Power," B. C. Godbold, 7 p.m.